Kenya’s Animal Agriculture: Macro-Trends and Future Prospects

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Preface

The annual scientific symposium is the main mechanism through which the APSK objectives are met, that is, providing a forum for stakeholders – professionals and practitioners - to get together and share views on issues germane to livestock production. Therefore, every one of these annual meetings focuses on a major contemporary issue or sets of issues which require attention. These may be new technologies or approaches, emerging challenges, controversial issues with implications for livestock production that require rational conversation, national or regional trends which may have consequences for animal agriculture. The APSK 2015 symposium focused on examining macro trends that underpin livestock production in Kenya.

The livestock sub-sector contributes over 30% of the farm gate value of agricultural commodities, about 10% of the national GDP, and at least 50% of the agricultural GDP. Domestic livestock also supply the local requirements of meat, milk, dairy products and other livestock products while accounting for about 30% of the total marketed agricultural products. However, the supply and demand for livestock products is affected by increasing population, urbanization, policy environment and, the import/ export markets among other factors. Particularly, urbanization will offer opportunities for business throughout the country and will require the development of innovative products to meet the specific needs of an emerging consumer class. At the same time, it is clear that rural incomes will not be substantially increased by exclusive emphasis on subsistence livestock production; rather, more market-oriented production systems will be needed. This, therefore, implies that revitalization of livestock industry is likely to yield a wide range of positive impacts/ effects throughout the country.

The APSK 2015 symposium provided opportunity for rational discussions on these livestock trends and sought ways of addressing the associated challenges while harnessing existing opportunities. Under the overarching theme “Kenya’s Animal Agriculture: Macro-Trends and Future Opportunities”, specific attention was given to: Dairy and poultry production systems, Alternative livestock feed resources, Animal Genetic resources, Pastorals systems; options for tomorrow, Emerging livestock and alternative sources of livelihood and, Policy, value chains and markets.

We would like to express our gratitude to the sponsors of the conference. Special thanks are due to presenters and authors of papers and posters, our colleagues on the symposium organizing committee, institutions and individuals who assisted in one way or the other, and the esteemed conference participants. The venue, setting and the overall conference atmosphere provided opportunity for networking by participants from across the country. After the symposium, presenters were asked to submit or revise their papers, taking into account the issues raised during the symposium discussions. The papers were then subjected to light technical reviews and language editing, therefore, ensuring that intellectual content remains that of the authors. APSK does not necessarily share the views expressed in this proceedings; responsibility for its content rests entirely with the authors.
It is our hope that the APSK 2015 symposium proceedings will provide useful reference material for those interested in understanding the major trends and associated issues covered during this conference.

Rophin K. Nyange

Chairman, Animal Production Society of Kenya (APSK)
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Sub-theme: Policy, value chains and markets
Competitiveness of smallholder milk production systems in Uasin Gishu county of Kenya

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Abstract

In Uasin Gishu County the rapidly declining household land sizes are a pre-requisite to increased intensification in dairy production. Although various dairy production pathways are used by farmers in the County, it has not been established which one of them would be comparatively competitive to enhance commercialization process and lead to attractive returns to smallholders investing in milk production. The objective of this paper is to estimate competitiveness in the smallholder dairy production sector in Uasin Gishu County of Kenya. Stratified sampling and proportional sampling followed by random sampling within the stratum were employed to select 246 smallholder dairy farmers. The Zero grazing, semi-zero grazing and open grazing production systems are analyzed separately using the gross margin, net margin and return on investment. The results indicate that the gross margin and net margin in smallholder milk production (Kshs/liter) were significantly influenced by the intensification pathway adopted. The gross margin and profit per liter decreased with an increase in the level of intensification with free grazing system and zero grazing having mean net margin of Kshs. 20.19 and Kshs. 8.25 respectively. The returns on investment for free grazing, semi-zero grazing and zero grazing milk production systems were 34.07%, 40.22%, 25.67% respectively. The profitability of milk production/liter however reduced with intensification due to the higher feed and labor costs in more intensive systems. In conclusion, smallholder dairy production was an economically viable enterprise in Uasin Gishu County. Milk producers need extension services and finance to improve on feed production and utilization technologies in order to increase their efficiency and profitability. There is need for strengthening of producer associations like cooperatives to increase the economic efficiency. Further research is needed to determine the options of improving market access so that its positive contribution to technical and economic efficiency is strengthened.

Keywords: Milk production; competitiveness and intensification

Introduction

The dairy industry in Kenya forms a significant part of the rural economy in the country accounting for 14% of agricultural GDP as well as being the primary source of livelihood for many smallholders who account for over 70% of the total marketed milk in the
Competitiveness of smallholder milk production systems in Uasin Gishu county of Kenya

country (IFAD, 2006). The potential of increasing the contribution of livestock to the economy needs to be explored. Improving livestock productivity is key to achieving the Millennium Development Goals (MDGs) of cutting the proportion of people living in poverty from 22% to 11% by 2015 (GOK, 2005; Amoako, 2003; Pingali, 2004). This improvement can be achieved through promotion of new technologies that are competitive (Ellis, 1992). Available milk production technologies include free grazing, semi-zero grazing and zero grazing and their relative competitiveness needs to be evaluated.

Breeding options include the breeds, in-calf heifer and cull cow replacement costs, and the costs of artificial insemination (A.I.) and bull services. The dominant breed in the herd was considered. The breeds were categorized as: Friesian and its crosses; Ayrshire and its crosses; Guernsey and its crosses; and other genotypes. Breeds vary in terms of milk production levels and this has an effect on milk productivity and hence competitiveness of milk production. Herd health management is critical to reduce the risks of death and/or low milk productivity for the herd. This study considered both animal preventive and curative health costs.

Housing and equipment costs are critical for efficient milk production. Housing is needed for zero grazing units, feed and water troughs, calf pens and stores. Various equipment are required for routine management of the animals and also for milk handling at farm level and for marketing. Low investment in housing and equipment was hypothesized the reduce competitiveness through low milk production or milk losses. Finally, the intensification level of hired and family labour use was estimated to determine their costs. Labour is a critical factor of production that needs to be utilized efficiently to obtain competitiveness in milk production. The intensification pathways were evaluated to determine their influence on the competitiveness of milk production. Adoption of gross bred cows and complementary feed and management technologies along with labour supply and use of inputs is a significant determinant of per capita income (Nicholson et al., 1999; Ahmed et al., 2003).

In this study, competitiveness is a measure of productivity with which a dairy farm utilizes its human, capital and natural resources. The competitiveness of smallholder milk production was measured by technical and economic efficiencies of the dairy farms, cost of milk production per liter, and gross margin and profit per liter of milk produced. Production refers to the economic process of converting of inputs into outputs. A non-optimal use of production factors, which can be put forward for milk production, implies a technical inefficiency (Marchand, 2010), that is a measure of returns to input use. Returns to capital invested were given by profit and gross margin analysis. Profitability considers the income from dairy farming, cost of variable inputs, paid costs for land and capital, and capital depreciation. The cost of milk production and profitability measurements enable the study to achieve the goal of determining intensification pathways influencing competitiveness of smallholder milk production in Uasin Gishu County of Kenya.
Literature review

In order to assess the link between the level of intensification and competitiveness in dairy farming in the Greater Nairobi milk-shed, two indicators were calculated (Baltenweck et al., 2000). The first is the net cash flow derived from dairy activities; the second indicator is the return to family labour from dairying. Net cash flows are calculated as the sum of the income from milk sales and from sales of animals minus the cost of hired labour, feed expenditures, health services and purchases of animals (Baltenweck et al., 2000). Because labourers do not work exclusively on dairying, only a portion of the total cost of hiring external labourers (corresponding to the proportion of hours spent working on dairy activities in the total number of working hours) is taken into account in the calculation of the cash flows. Net cash flows are calculated by household, per cow (net cash flows divided by the number of cows) and per ton of milk produced (net cash flows divided by the annual milk production). The second indicator is the return to family labour from dairy activities. This indicator takes into account the opportunity value of the milk consumed by the household and the opportunity cost of the feed produced on-farm. More precisely, the returns to family labour are computed as the cash flows calculated previously augmented by the market value of the milk consumed minus the rental value of land planted in fodder and pasture. Returns are calculated per farm, per cow and per ton of milk produced, in the same way as the net cash flows.

The Smallholder Dairy Project (SDP) utilized time series data from Kiambu, Nyandarua and Nakuru districts of Kenya to estimate costs, income and profitability of dairy enterprises as measures of competitiveness (SDP, 2000). The results showed that the cost of milk production rose as milk production systems became more intensive. The highest returns from the dairy enterprise were realized in the least-intensive system, in Nyandarua district, and lowest returns in the medium-intensive system, in Nakuru District (SDP, 2000). These returns would be even higher with inclusion of non-marketed benefits to the smallholder dairy enterprise.

Smallholder competitiveness in dairy production can be measured by efficiency and profitability (Staal, 2002; 2003; Wilson et al., 2011). According to Valk and Tessema (2010) and Staal (2002) the competitiveness of smallholder dairy production partially dependent on low opportunity costs for labour. However, other measures of competitiveness have been used. Delbridge et al. (2011) found an interesting implication of calculating farm profitability in that small conventionally managed farms may be able to earn greater net returns if transitioned to organic production instead of conventional use. A whole farm economic analysis was conducted to provide a detailed assessment into the economic, risk, and production implications due to the adoption of auto-steer navigation (Shockley et al., 2011). Automated steering (auto-steer) is a navigation aid that utilizes the global position system (GPS) to guide agricultural equipment. They determined that auto-steer navigation was profitable for a grain farmer in Kentucky, U.S.A. with net returns increasing up to 0.90% ($8.28/hectare). This study will measure competitiveness of the dairy production systems using technical and economic efficiency and profitability calculation.
Methodology

3.1. Study area

Uasin Gishu County was selected for this study because it is a leading milk producing area with the highest population of dairy cows in Kenya (GoK, 2010c). There are three dairy production systems/pathways and it covers both rural areas (Soy and Turbo Divisions) and a peri-urban area (Kapsaret). The County had a human population of 894,179 persons and an average household size of 4.2 persons during the 2009 census (G.O.K, 2010a). The annual rainfall is 900 mm to 1,200 mm per year. For the purpose of this study, a smallholder dairy farmer is defined as one with at least one cow up to a maximum of 10 cows and an average of 2 hectares of land (IFAD, 2006).

3.2. Sample size determination

All the dairy farmers in Uasin Gishu County currently implementing the Smallholder Dairy Commercialization Programme (SDCP) were the sample frame for this study as shown in Table 1. The SDCP records show that there were more than 10,000 dairy farmers and when sample frame is in excess of 10,000, Sekaran, (2006) recommends computing the needed sample size from:

\[ n = \frac{z^2}{d^2}pqn = \frac{z^2}{d^2}pq = \frac{(1.96)^2(0.80)(0.20)}{0.05^2} = \frac{(1.96)^2(0.80)(0.20)}{0.05^2} = 246 \]

Where,

\( n \) = the desired sample size, computed to 246

\( z \) = the degree of confidence chosen at 95% confidence interval.

\( p \) = the proportion in the target population estimated to have characteristics being measured (The smallholder dairy farms contribute over 80% of the marketed milk output in Kenya (Muriuki, 2001).

\( q \) = the proportion in the target population estimated to having no characteristics being measured (large scale dairy farmers).

\( d \) = level of statistical significance set at 5%.
Table 1: Distribution of the sample of the respondents

<table>
<thead>
<tr>
<th>Production System</th>
<th>Population of Smallholders</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensive</td>
<td>5,501</td>
<td>66</td>
</tr>
<tr>
<td>Semi zero grazing</td>
<td>11,626</td>
<td>138</td>
</tr>
<tr>
<td>Zero grazing</td>
<td>3,633</td>
<td>43</td>
</tr>
<tr>
<td>Total</td>
<td>20,760</td>
<td>247</td>
</tr>
</tbody>
</table>

Source: G.O.K., 2010b

3.3. Sampling procedure
Stratified random sampling was employed to select individual households proportionately to the population size in Uasin Gishu County using the list of dairy farmers in the office of the Divisional Programme Implementation Team (DivPIT). Stratification was by Division (Kapseret, Soy and Turbo Divisions) and production system (free grazing, semi-zero grazing and zero grazing). The respondents were chosen randomly from the selected strata. Whenever a selected smallholder dairy farmer did not respond, then the next one was chosen.

3.4. Data collection
Collection of data involved administration of pre-tested structured questionnaires, observations, focused group discussions and use of key informants. The study combined primary and secondary data. The data included the quantities and prices of all inputs and outputs of milk production. Outputs included milk and live animals sold. Inputs were feeds, breeding costs, herd health management costs, investment in housing and equipments and labour costs.
Under feeding costs, the value of own-produced feed, purchased forage and concentrates were measured in Kenya shillings. Breeding costs included in-calf and cull cow replacement costs, and bull and artificial insemination service costs. The cost of animal preventive and curative health costs per animal was measured in Kenya shillings to give the level of animal health management. Similarly, housing and equipment costs were valued. Hired and family labour used for milk production was quantified and valued in Kenya shillings.

Estimating gross margin and net margin of milk production
Gross margin analysis involved computing of the variable costs and revenue of milk production. The formula is given by Lipsey, et al., (2004):

\[
\text{Gross Margin} = \text{Income} - \text{Variable costs.}
\]

According to Cramer et al., (1985) and Lipsey, et al., (2004), production of goods and services by firms cannot be done when total variable cost is greater than total revenue.
But \[ GM = R - TVC \]

Where

- \( GM \) = Gross Margin
- \( R \) = Revenue
- \( TVC \) = Total Variable Cost

This means that the gross margin derived by a smallholder farm is a measure of its performance. Revenue in this study considers the value of the milk produced on the farm.

In the case of milk revenue,

\[ R = p \cdot q \]

Where \( R \) = Revenue

- \( p \) = Price of milk per litre
- \( q \) = Milk output (litres)

Assuming that the smallholder dairy producers are operating in a perfectly competitive market structure, the only option for increasing revenue from dairy production is to increase milk output. The price, \( p \), is determined by the market. Economic efficiency will occur when the following condition is achieved:

\[ GM \geq 0. \]

The higher the gross margin, the greater the level of economic efficiency. So, for the purpose of this study, a smallholder dairy farmer is considered economically efficient if the gross margin of that farm is equal to or greater than zero. Hence, such a farm is not economically efficient when it has a gross margin that is negative. The net margin function was given by (Garcia et al., 2008; Lipsey and Chrystal, 2004):

\[ \Pi_i = \sum_{j} y_{ij} \cdot p_{ij} + \sum_{j} x_{ij} \cdot w_{ij} \]

Where,

- \( \Pi_i \) = net margin of the \( i \)-th dairy farm
- \( y_{ij} \) = Quantity of \( j \)-th output in the \( i \)-th dairy farm
- \( p_{ij} \) = Price of the \( j \)-th output in the \( i \)-th dairy farm
- \( x_{ij} \) = Quantity of \( j \)-th input in the \( i \)-th dairy farm
- \( w_{ij} \) = Price of the \( j \)-th input in the \( i \)-th dairy farm

Net margin is given by total income less total costs of milk production. The gross margin and net margin were calculated per liter for the three milk production systems.
Results

Gross margin and net margin of milk production

The gross margin and net margin of producing one liter of milk was calculated for the three systems. Gross margin refers to the total income derived from an enterprise less the variable costs incurred in the enterprise. It enables producers to evaluate their existing enterprise performance, and for those who are contemplating investing in a new enterprise, it provides a guide to estimating the viability of the contemplated investment. Data collected on various components of the variable and fixed costs of production was classified into various categories for ease of analysis (Tables 2, 3 and 4). The feeds used by the milk producers included pastures, fodder, hay, silage, other roughage, dairy meal, other supplements and water. The cost of pastures was estimated using the value of renting pastures for 1 cow per month. The value for own labour as well as fixed costs associated with dairy enterprises were included in the analysis. The milk consumed by the household and the calf, and that which was sold was considered in the study as contributing to the revenue of the dairy enterprise.

Table 2 shows that in the zero grazing system, the cost of milk production was Kshs. 32.14 /liter. The gross margin and net margin was Kshs. 9.58/liter and Kshs. 8.25/liter respectively. This production is associated with high cost of feed and labour. The zero grazing system gave 25.67% return on investments. The positive economic benefits are strongly supported by the milk price of Kshs. 40.39 /liter. The relatively high milk price suggests that this type of production system is common in urban and peri-urban settings with better market access.
Table 2: Gross margin and net margin of milk production (Kshs/liter) in zero grazing system

<table>
<thead>
<tr>
<th>Item</th>
<th>unit</th>
<th>no. of units/ cow</th>
<th>no. of cows</th>
<th>cost/unit Kshs</th>
<th>value/cow Kshs</th>
<th>total value Kshs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>liters</td>
<td>2,043.20</td>
<td>75</td>
<td>40.39</td>
<td>82,518.92</td>
<td>6,188,918.71</td>
</tr>
<tr>
<td>Variable costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeds</td>
<td>Kgs</td>
<td>658.11</td>
<td>75</td>
<td>67.74</td>
<td>44,581.57</td>
<td>3,343,617.44</td>
</tr>
<tr>
<td>Herd replacement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37,550.00</td>
</tr>
<tr>
<td>Health management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>149,700.00</td>
</tr>
<tr>
<td>Labour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,189,504.64</td>
</tr>
<tr>
<td>Total variable costs</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>4,720,372.08</td>
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<tr>
<td>Gross margin</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1,468,546.63</td>
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<tr>
<td>Gross margin/liter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.58</td>
</tr>
<tr>
<td>Fixed costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation on housing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>191,680.00</td>
</tr>
<tr>
<td>Depreciation on equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12,810.00</td>
</tr>
<tr>
<td>Total fixed costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>204,490.00</td>
</tr>
<tr>
<td>Total production cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>65,664.83</td>
</tr>
<tr>
<td>Total production cost/liter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>32.14</td>
</tr>
<tr>
<td>Net margins</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16,854.09</td>
<td>1,264,056.63</td>
</tr>
<tr>
<td>Net margin/liter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.25</td>
</tr>
<tr>
<td>Returns on investments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25.67%</td>
</tr>
</tbody>
</table>
### Table 3: Gross margin and net margin of milk production (Kshs/liter) in semi-zero grazing system

<table>
<thead>
<tr>
<th>Item</th>
<th>unit</th>
<th>no. of units/ cow</th>
<th>no. of cows</th>
<th>cost/unit</th>
<th>value/cow</th>
<th>total value</th>
</tr>
</thead>
<tbody>
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<td><strong>Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>Litres</td>
<td>1,012.69</td>
<td>423.00</td>
<td>28.67</td>
<td>29,038.04</td>
<td>12,283,091.42</td>
</tr>
<tr>
<td><strong>Variable costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeds</td>
<td>Kgs</td>
<td>282.43</td>
<td>423.00</td>
<td>24.31</td>
<td>6,865.82</td>
<td>2,904,240.47</td>
</tr>
<tr>
<td>Herd replacement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>91,900.00</td>
</tr>
<tr>
<td>Health management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>181,529.33</td>
</tr>
<tr>
<td>Labour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,445,198.46</td>
</tr>
<tr>
<td>Total variable costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8,622,868.27</td>
</tr>
<tr>
<td>Gross margin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3,660,223.15</td>
</tr>
<tr>
<td>Gross margin/liter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.54</td>
</tr>
<tr>
<td><strong>Fixed costs</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation on housing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>76,340.00</td>
</tr>
<tr>
<td>Depreciation on equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60,444.00</td>
</tr>
<tr>
<td>Total fixed costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>136,784.00</td>
</tr>
<tr>
<td>Total production cost</td>
<td></td>
<td></td>
<td></td>
<td>20,708.40</td>
<td></td>
<td>8,759,652.27</td>
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<tr>
<td>Total production cost/liter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20.45</td>
</tr>
<tr>
<td>Net margins</td>
<td></td>
<td></td>
<td></td>
<td>8,329.64</td>
<td></td>
<td>3,523,439.15</td>
</tr>
<tr>
<td>Net margins/liter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.23</td>
</tr>
<tr>
<td>Returns on investments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40.22%</td>
</tr>
</tbody>
</table>
Table 4: Gross margin and net margin of milk production in free grazing system

<table>
<thead>
<tr>
<th>Item</th>
<th>unit</th>
<th>no. of units/no of cows</th>
<th>cost/unit</th>
<th>value/cow</th>
<th>total value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>litres</td>
<td>650.08/915</td>
<td>28.09</td>
<td>18,258.86</td>
<td>16,706,860.64</td>
</tr>
<tr>
<td>Variable costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeds</td>
<td>Kgs</td>
<td>39.17/915</td>
<td>117.00</td>
<td>4,583.08</td>
<td>4,193,514.00</td>
</tr>
<tr>
<td>Herd replacement</td>
<td></td>
<td></td>
<td></td>
<td>99,900.00</td>
<td></td>
</tr>
<tr>
<td>Health management</td>
<td></td>
<td></td>
<td></td>
<td>228,069.38</td>
<td></td>
</tr>
<tr>
<td>Labour</td>
<td></td>
<td></td>
<td></td>
<td>62,118.40</td>
<td></td>
</tr>
<tr>
<td>Total variable costs</td>
<td></td>
<td></td>
<td></td>
<td>4,583,601.78</td>
<td></td>
</tr>
<tr>
<td><strong>Gross margin</strong></td>
<td></td>
<td></td>
<td></td>
<td>12,123,258.86</td>
<td></td>
</tr>
<tr>
<td>Gross margin/liter</td>
<td></td>
<td></td>
<td></td>
<td>20.38</td>
<td></td>
</tr>
<tr>
<td>Fixed costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation on housing</td>
<td></td>
<td></td>
<td></td>
<td>68,658.00</td>
<td></td>
</tr>
<tr>
<td>Depreciation on equipment</td>
<td></td>
<td></td>
<td></td>
<td>43,832.00</td>
<td></td>
</tr>
<tr>
<td>Total fixed costs</td>
<td></td>
<td></td>
<td></td>
<td>112,490.00</td>
<td></td>
</tr>
<tr>
<td>Total production cost</td>
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<td></td>
<td></td>
<td>5,132.34</td>
<td>4,696,091.78</td>
</tr>
<tr>
<td>Total production cost/liter</td>
<td></td>
<td></td>
<td></td>
<td>7.89</td>
<td></td>
</tr>
<tr>
<td><strong>Net margins</strong></td>
<td></td>
<td></td>
<td></td>
<td>13,126.52</td>
<td>12,010,768.86</td>
</tr>
<tr>
<td>Net margin/liter</td>
<td></td>
<td></td>
<td></td>
<td>20.19</td>
<td></td>
</tr>
<tr>
<td>Returns on investments</td>
<td></td>
<td></td>
<td></td>
<td>34.07%</td>
<td></td>
</tr>
</tbody>
</table>
Table 3 gives the gross margin and net margin calculations for the semi-zero grazing system. For one liter of milk, the cost of production, gross margin and profit was Kshs. 20.45, Kshs. 8.54 and Kshs. 8.23 respectively. This system had the highest return on investment of 40.22%. However, the profitability is constrained by the relatively lower milk price. The major costs of production are feeds and labour, just like in the zero grazing system. Free grazing system had a gross margin of Kshs. 20.38/liter and a profit of Kshs.20.19/liter as shown in Table 4. Here, the capital investment levels appear to be low. The return on investment was 34.07%. Producers using free grazing system faced a low milk price. But the cost of labour and feed was similarly low.

A comparison of the three milk production system shows that the free grazing system is the most profitable (Kshs. 20.19/liter), followed by zero grazing (Kshs. 8.25 /liter) and finally by the semi-zero grazing system (Kshs. 8.23 /liter). Households practicing the zero grazing and semi-zero grazing system incurred higher variable costs than the free grazing system. As expected, the cost of milk production was higher for the more intensive dairy production systems. Consequently, the gross margin in the zero grazing system was lower. These results are consistent with those of Mburu, et al. (2007) showing that in a zero grazing system, “on average, revenues significantly exceeded costs and the dairy enterprise returned a profit”. Using gross margin analysis, Wambugu et al. (2011) showed that dairying is an economically viable enterprise in the short-run, with the non-zero grazing system having higher gross margins and therefore, a financial advantage. This study has shown that free grazing had the highest gross margin. By giving an example of zero grazing for farmers selling milk through the Githunguri Farmers’ Cooperative Society in Kenya, Wambugu et al. (2011) indicated that this system can perform well under conditions of collective marketing, good linkage to markets in terms of processing, access to production information, credit as well as other benefits. Therefore, if the zero grazing system is faced with similar milk price levels like free grazing, then the latter would be more profitable. Intensification of milk production needs to be accompanied by an efficient milk marketing system. The present study corroborates with that of Biradar et al. (2012) where herd replacement, herd health management and depreciations costs are minimal in the three milk production systems. Similarly, Mogaka (1993) found that labour was the major production cost (46%) followed by supplementary feeds (27.5%) and animal health (10.4%).

This study found out that feed costs are the largest in the three production system compared to the other costs. Feeds constituted 67.89%, 33.15% and 89.30% of the cost of milk production per liter in zero grazing, semi-zero grazing and free grazing system respectively. Feeding constitutes the largest portion of the costs of milk production in market-oriented dairy farming and dairy animals in Kenya are underfed, resulting in low milk yields (Muriuki, 2011). Thus the United States Department of Agriculture uses feeds cost to estimate Livestock Gross Margin-Dairy (LGM-Dairy) which is a risk management tool that enables dairy producers to purchase insurance against decreases in gross margin (Burdine, 2014).

The feed costs are lower in the free grazing system, but farmers then become susceptible to the effects of seasonal weather patterns. The price of milk that dairy producers receive
is variable. Techno Serve Kenya (2008) reported a farm-gate price of Ksh 14 - Ksh 22 per liter and the informal market at Ksh 18 - Ksh 26 per liter. These milk prices are comparable to those received by the milk producers in this study.

References


Assessment of seasonal milk production, pricing and farmer trading practices in Limuru and North Kinangop divisions in Kenya

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Corresponding author: david.mbugua22@gmail.com

Abstract
A survey was carried out in August and December 2012 in Limuru and North Kinangop divisions in Kiambu and Nyandarua Counties respectively. The objectives were to assess milk production, sales and market channels preferred by farmers. Data collected were farmer and farm characteristics, herd characteristics, milk production and sales, concentrate feeding practices prices and market channels. Descriptive statistics was used in analysis. Results showed that mean herd size was 2.8 and 4.2 in Limuru and Kinangop Divisions respectively. Mean daily milk production was 10.8 and 7.6 litres in Limuru and Nyandarua south respectively. Use of concentrates was significantly higher in Limuru compared to Kinangop. Preferred prices during the wet season were Kshs 25 to Kshs 45 per litre with mode of Kshs 35 and a mean price of KES 33.60 per litre. Farmers preferred a mean price per litre of KES 33.60 and KES 42.60 for wet and dry seasons respectively. Farm gate prices were higher than off-farm prices in Limuru but the converse was true in Kinangop, showing that farmers in Kinangop had more incentives to seek for milk buyers. In Limuru, milk co-operative was the most preferred milk marketing channel in both wet and dry seasons while itinerant traders and restaurants least preferred. However, farmers sold more milk to itinerant traders than to co-operatives in both wet and dry seasons, as they offered better prices and also paid promptly. Milk co-operatives offered the least price in both wet and dry seasons. Itinerant traders obtained a surplus of KES 11.60 per litre which was 38% of milk purchase price.

Keywords: milk, market channel, price preference

Introduction
The dairy sector in Kenya has consistently faced changing economic environment since independence such as liberalization of the milk market in 1992. Liberalization ended price controls and monopoly in milk marketing facilitating entry of many actors in the industry (Staal et al., 2001). There are many market players who purchase farmers milk (SDP 2003). These include milk co-operatives, milk processors, itinerant traders (hawkers) and individual consumers. Progressive milk co-operatives have vertically integrated their operations to cover inputs supply, milk transport from the farms, bulking, cooling and processing and may offer better prices to members. At farm level, profitability depends on the relationship between the costs of input and price of milk offered in the market (SDP, 2003). Farmers have in the past complained of low milk prices compared to ever increasing costs of feed, minerals and drugs (D.N, 2013). This calls for an in-depth study of profitability within the entire raw milk chain in order to inform policy especially in milk pricing. Currently, there is no policy guiding milk pricing at farm
level. Well structured pricing regimes will encourage better commercialization of dairy farming, improve farm incomes and alleviate poverty in dairy households. A survey was carried out to establish milk production costs, pricing and marketing channels of raw milk by farmers.

Methodology

A survey was carried out in three locations each in North Kinangop and Limuru Sub-counties in Nyandarua and Kiambu Counties respectively. Nyandarua is an important rural dairy area while proximity to the Nairobi market makes Kiambu suitable as a peri-urban area. The researcher administered structured interviews to collect information on milk prices offered by co-operatives and itinerant traders. Population figures of Kenya population census in 2009 were used to determine the number of households required for the study. Respondents at farm level were the household head or the spouse. Data collected were farmer and farm characteristics, herd characteristics, milk production and sales, prices and market channels. Descriptive statistics was used in analysis.

Results and discussion

Mean farm size was 1.5 acres with Limuru Average herd size was 2.8 and 4.1 in Limuru and Nyandarua south sub-counties respectively. Main dairy cattle reared were Friesians (91%) and Ayrshires (9%) and their crosses. The average herd size was 3 and 4 in Limuru and North Kinangop divisions respectively. Average daily milk yield was higher in Limuru compared to North Kinangop divisions (Table 1).

Table 1: Average herd size and mean daily milk yield in Limuru and Kinangop Divisions

<table>
<thead>
<tr>
<th>Dairy Production System</th>
<th>Average herd size</th>
<th>Average daily milk yield per cow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limuru (n=57)</td>
<td>North Kinangop (n=58)</td>
</tr>
<tr>
<td>Intensive</td>
<td>2.7</td>
<td>5.9</td>
</tr>
<tr>
<td>Semi Intensive</td>
<td>4.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Traditional</td>
<td>2.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Extensive</td>
<td>3.0</td>
<td>8.0</td>
</tr>
<tr>
<td><strong>Study Area Mean</strong></td>
<td><strong>2.8</strong></td>
<td><strong>4.1</strong></td>
</tr>
<tr>
<td><strong>Limuru</strong></td>
<td><strong>10.8</strong></td>
<td><strong>7.6</strong></td>
</tr>
</tbody>
</table>

Use of dairy meal, wheat bran and molasses in Limuru was significantly higher compared to Kinangop (Table 2).
Table 2: Average quantities of concentrates used per cow per month in feeding dairy cattle in Limuru and Kinangop divisions

<table>
<thead>
<tr>
<th>Concentrate</th>
<th>Limuru Kgs</th>
<th>N</th>
<th>North Kinangop Kgs</th>
<th>N</th>
<th>Average (kgs)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy meal</td>
<td>136.0</td>
<td>45</td>
<td>73.9</td>
<td>48</td>
<td>104.0</td>
<td>93</td>
</tr>
<tr>
<td>Maize germ</td>
<td>145.1</td>
<td>37</td>
<td>51.3</td>
<td>4</td>
<td>136.0</td>
<td>41</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>80.3</td>
<td>29</td>
<td>33.3</td>
<td>3</td>
<td>75.9</td>
<td>32</td>
</tr>
<tr>
<td>Molasses</td>
<td>27.8</td>
<td>15</td>
<td>10.8</td>
<td>4</td>
<td>24.2</td>
<td>19</td>
</tr>
</tbody>
</table>

Milk utilization and marketing

The dairy cattle enterprise was regarded as an income generating activity with the highest proportion (60.6%) of milk produced, sold to generate income Fig.1. The mean quantity of milk marketed daily was 8.6 litres per household. The sampled households produced a mean of 11.2 litres of milk daily during the wet season, which was utilized as shown in Fig. 1.

Fig. 1: Utilization of milk in the wet and dry seasons

Milk pricing and market channels

During the wet season, raw milk price range given was Kshs 25 to Kshs 45 per litre while Kshs 30 and 35 had most responses at 33% (n=7)and 29% (n=6) respectively. Mean preferred price was KES 33.60 per litre. Farmer preference for raw milk prices during the dry season was Kshs 35 to Kshs 65, where Kshs 40 and KES 45 had the highest responses at 38% (n=8) and 19% (n=4) respectively. Mean preferred price was KES 42.6 per litre.
In the relatively dry season, the highest milk prices were offered by itinerant traders and neighbours at Kshs 35 and Kshs 33 per litre respectively. Lowest prices were reportedly offered by milk co-operatives and kiosks at Kshs 29.70 and Kshs 3.50 per litre respectively. During this period, the highest volume of milk was sold to traders and milk co-operatives at 16 litres and 13 litres respectively. Least volume of milk was sold to neighbours and kiosks at three and 12 litres respectively.

In the wet season in August 2012, restaurants and kiosks offered the highest mean prices to farmers at Kshs 39.5 and Kshs 39.3 per litre. The milk co-operatives, Itinerant traders and neighbours offered the least prices at Kshs 30.4, Kshs 35 and Ksh 36 per litre respectively.

Inputs into milk production considered in the study were basal feed (grass, hay, fodder), concentrates (dairy meal, wheat bran, maize germ, wheat pollard), calf pellets, water and labour (own and hired). Mean cost of milk production increased from KES 491 to 640 in wet and dry seasons respectively.

In itinerant trading, 63% of milk was collected in the morning and 37% in the afternoon. Milk purchases incurred 79% while the main transaction costs took 21% of the total costs. Transaction costs were in transport (6.2%), labour (5.2%), communication (4.1%), bulking (2.6%) and packaging (2.6%) compared to all costs. Traders mainly sold over 97% of milk purchased through one milk market channel and obtained a surplus of Kshs 11.60 per litre. The surplus was 38.6% of the purchase price.

The study revealed dairy cooperatives and kiosks were the most popular milk marketing channels used by 55.5% of the sampled households during the wet season while dairy cooperatives and neighbours comprised the most popular channels used by 60% of the households during the dry season. Traders and restaurants were less popular. Sampled households marketed milk through various channels as shown in Fig. 2.

Fig. 2: Milk marketing channels
The study showed that the highest milk quantities during the wet season were sold to kiosks (7.6 litres daily), traders and restaurants (7.0 litres) while the highest quantities during the dry season was sold to traders (16.07 litres), dairy cooperatives (13.4 litres) and kiosks (12.07 litres). Farm gate prices were higher in Limuru compared to Kinangop division (table 3).

Table 3: Farm gate and off-farm milk prices in Limuru and North Kinangop divisions

<table>
<thead>
<tr>
<th>System of production</th>
<th>Limuru (N=57)</th>
<th>North Kinangop (N=57)</th>
<th>Average prices in KES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Farm gate price</td>
<td>Off-farm price</td>
<td>Farm gate price</td>
</tr>
<tr>
<td>Intensive</td>
<td>32.2</td>
<td>29.0</td>
<td>22.6</td>
</tr>
<tr>
<td>Semi-intensive</td>
<td>29.1</td>
<td>28.2</td>
<td>23.0</td>
</tr>
<tr>
<td>Traditional</td>
<td>35.0</td>
<td>28.0</td>
<td>23.0</td>
</tr>
<tr>
<td>Extensive</td>
<td>23.0</td>
<td>23.0</td>
<td>23.0</td>
</tr>
<tr>
<td>Average</td>
<td><strong>31.9</strong></td>
<td><strong>28.9</strong></td>
<td><strong>22.9</strong></td>
</tr>
</tbody>
</table>

Milk co-operatives (45%) and itinerant traders (33%) were the most preferred market channels in Limuru (45%). In Kinangop, itinerant traders (83%) were the most preferred marketing channel for raw milk. Co-operatives provided credit facilities to farmers especially in Limuru. However, farmers interviewed also sold milk to itinerant traders who offered better prices and paid more promptly. In Kinangop, itinerant traders were popular than co-operatives due to regular payments and better prices compared to co-operatives.

**Conclusion and recommendations**

Mean daily milk production in Limuru was more than Kinangop. Concentrate use was more in Limuru than Kinangop divisions.

Milk cooperatives and kiosks were the most popular milk marketing channels with farmers in Limuru while itinerant traders most popular in Kinangop.

Farmers preferred a mean price of KES 33.60 and KES 42.60 per litre of milk in wet and dry seasons respectively. Milk co-operatives offered the least prices in both wet and dry seasons. Market prices should be commensurate with farmers expectations to encourage farmers.

Lower farm gate prices in Kinangop, provided more incentives for farmers to seek options in milk marketing.
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Performance of free scavenging indigenous chicken (IC) in Makueni County, Kenya

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Abstract

The Kenyan poultry population is estimated at 33,986,040 birds constituted by, 69, 26 and 5 % indigenous chickens (IC), exotic birds and emerging species respectively. Despite the huge number, IC which are raised under the free scavenging system accounts for less than 50 % of products and earnings. This is due to challenges characterizing the system, mainly poor feeding and nutrition. Makueni County usually reports the yield of a low volume of ICs and products. 128 day old high quality ICs were put on standard management for the first four weeks and used in a study conducted at Wote division, Makueni County, at selected households (hhs). The objective was to evaluate the performance of free scavenging IC in Makueni County. At the beginning of the fifth week, the chicks were distributed to 16 hhs across 4 villages and free ranged for one year. Weekly performance data including, body weight; weight gain, age at market weight for cockerels, age at first egg and number of eggs over the first egg clutch was collected, clustered into 4 week periods and analyzed. Mean body weight for cockerels was 1304.3 g with a mean weight gain of 130.8 g. Mean body weight of pullets was 943.3 g, with a mean monthly weight gain of 88.2 g. Age at first egg was 8.5 months, and 19.8 eggs were laid. Cockerels attained market weight at 9.8 months. Means for all parameters studied, did not differ significantly (p>0.05) across villages. Conclusion: there is need to evaluate locally available feedstuffs potential for mixing supplementary diets for ICs

Keywords: Indigenous chicken, free scavenging, low volume, poor feeding and nutrition

Introduction

Livestock industry constitutes a key component of the agricultural sector where it accounts for 10 % of the agricultural Gross Domestic Product -AGDP (GoK, 2004). The industry comprises several enterprises including the poultry industry (indigenous chicken and commercial birds). Commercial poultry makes a significant contribution to the AGDP, but indigenous chicken performs poorly. The national poultry population was estimated at 29,239,150 ICs (69 %); 4,167,360 broilers and 2, 449,470 layers (26 %) while all the other species stood at 587,530 or 5 % (GoK, 2010). Productivity was estimated at 25,694 metric tons of meat and 1.22 billion eggs, valued at 3.52 and 9.7 billion Kenya shillings respectively, with ICs accounting for 11,400 Metric tonnes of meat and 570,000 million eggs (GoK, 2010). Despite the huge number, IC contributed
less than 50% of both products and revenue. The low productivity is closely linked to the low levels of nutrients in free scavenging sites, hence poor feeding and nutrition.

Makueni County, an arid and semi-arid land (ASAL), covering an area of 8,009 KM$^2$, has a human population of 884,527 with 110 persons per KM$^2$ (GoK, 2009). The main economic activities are subsistence crop and livestock farming, but with a poverty index of 64.1%, the overall performance is poor (GoK, 2009). The poultry industry is constituted by 233,209 indigenous chicken and 15,639 commercial birds (GoK, 2003). The former is therefore popular amongst majority of the population, mainly small scale farmers. A survey of consumer preference for the Makueni ICs and products at designated market outlets indicated a very high rank for the Makueni ICs and products but farmers lacked the capacity to meet the market demand (Getembu, 2004). A baseline survey of the Makueni IC production system conducted by a consortium anchored at the Kenyatta University, using participatory rural appraisal tools (PRA), confirmed poor feeding and nutrition of the free ranged ICs (not published). The objective of the current study was to conduct an empirical evaluation of the effect of the current feed resource base (FRB) on performance.

Materials and methods

The study was conducted at sixteen households in four villages (Mwaani and Mangaoni, and Uviluni and Watuka) distributed in two sub locations (Kikumini and Kako) in a randomized block design. 128 day old ICs were procured from the Kenya Agricultural Research Institute (KARI), Naivasha station. The chicks were raised in a brooder for four weeks, where all standard management practices were administered. The birds were fed on a commercial chick starter diet for the first four weeks of life. At the beginning of the fifth week, they were weighed, sexed and wing banded, after which they were distributed to the sixteen households, where they freely scavenged. Housing facilities were provided for at night and throughout when extreme weather conditions were experienced, or during the planting season. Other management practices were observed except for formal diet supplementation. The birds were given one week to acclimatize, after which data collection commenced.

Data collection

Data on body weight was collected weekly over a period of one year at each hh. The weekly mean body weight for each village was computed across the four hhs and clustered into thirteen four-week periods, giving the monthly mean body weight/village. The overall mean monthly body weight was computed as the mean for the sixteen hhs in the experimental block. The weekly change in body weight was estimated as the difference in body weight between two consecutive weeks per hh. The mean weekly weight change per village was computed as mean for the four hhs and this was clustered as outlined earlier to give an estimate of the mean monthly weight gain/village. The overall mean monthly weight change was computed as the mean for the sixteen hhs. Further, the date and age in weeks during which the first hen to lay dropped an egg at each hh was recorded. Subsequent dates when other hens commenced lay were also
Performance of free scavenging indigenous chicken (IC) in Makueni County, Kenya

recorded. The mean age at first egg in weeks was computed as the sum of the ages in weeks at which each hen at a hh commenced lay divided by the number of hens. Mean age at first egg for each village was calculated as the mean for the four hhs and the overall mean was computed as the mean age for the sixteen hhs. The data was clustered as for other parameters to give the mean age at first egg in months. The age in months at which each cockerel attained a live weight of 1.8 kg was recorded at each hh and the mean was computed accordingly. This formed the basis of calculating the overall and village mean. The number of eggs laid by each hen at a hh was recorded over the first clutch. The mean number of eggs over the first clutch was calculated by dividing the total number of eggs by the number of hens per hh. The overall and village means were computed as the mean for the sixteen and four hhs for the block and village respectively. Means were computed using the excel programme, while all data was analyzed using the Statistical Programme for Social Scientists (SPSS).

Results and discussion

Results are summarized in the table 1;

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Villages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Body weight for cockerels (g)</td>
<td>1406.9</td>
</tr>
<tr>
<td>Body weight change for cockerels (g)</td>
<td>130.8</td>
</tr>
<tr>
<td>Body weight for hens (g)</td>
<td>994.0</td>
</tr>
<tr>
<td>Body weight change for hens (g)</td>
<td>85.3</td>
</tr>
<tr>
<td>Age at first egg (months)</td>
<td>8.1</td>
</tr>
<tr>
<td>Age at market weight for cockerels (months)</td>
<td>9</td>
</tr>
<tr>
<td>Number of eggs over the first clutch</td>
<td>20</td>
</tr>
</tbody>
</table>

At the end of the thirteenth period, mean body weight of cockerels and hens were 1304.3 and 943.3 g with mean monthly weight gains of 130.8 and 88.2 g respectively. Monthly mean body weight gain of 130.8 and 88.2 g could translate to daily gains of 4.7 and 3.2 g respectively. The mean age at first egg was 8.5 months while age at market weight for cockerels was 9.8 months. The mean number of eggs over the first clutch was 19.8. For all these parameters, the means did not differ significantly (p>0.05) across the research households. The low body weight; slow growth rate, and poor performance is a manifestation of the low nutrient levels in scavenging sites, which concur with findings by other researchers (Mwalusanya et al., 2002 and Rashid et al., 2004). In a study conducted at Morongoro, Tanzania, the mature body weight of un supplemented hens was found to be 1259 g (Mutayoba et al., 2012), which is similar to the results of this study. Low mean body weight gains for un supplemented IC have been reported by different researchers. A daily mean weight gain of 4.45 g, which could translate to a mean monthly weight gain of 71.2 g has been reported from an earlier study (Pousga et al., 2006). Okitoi (2006) reported a daily mean weight gain of 1.4g and these concurs with findings of the current study. Many reports have estimated laying performance of
un supplemented scavenging indigenous chicken to range from 16 to 20 eggs per clutch, which concur with findings of this study (Okitoi et al., 2006, Mutayoba et al., 2012 and Gok, 1994).

**Conclusion**

Results of this study show that the free scavenging sites in Makueni lack the potential to meet the energy and protein requirements of free scavenging indigenous chicken.

**Recommendation**

There is need to evaluate the potential of locally available energy and protein raw materials (that include sorghum and sunflower cake) in the mixing of high quality low cost diets to supplement free scavenging indigenous chickens.
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Indigenous chicken value chain analysis: the case of Makueni County, Kenya

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Abstract

The livestock sector in Kenya contributes about 10% of the Gross Domestic Product (GDP) and accounts for about 42% of the agricultural GDP. Poultry which is part of the sector comprises a population of 31 million birds, out of which 80% are indigenous chicken (IC), kept by over 80% of rural households. The IC contribute to household food security, income and social-cultural roles. Demand for white, low fat meat has enhanced preference for IC among urban consumers, in addition to a more desired flavour and texture. However, majority of producers of these birds have not benefited fully from the IC markets. Various challenges have hampered promotion of the IC value chain and participation of rural producers in high value urban markets. It was on this basis therefore, that a value chain analysis was conducted in Makueni, an ASAL county where most of the farmers keep IC. The aim was to identify the key stakeholders in the value chain, identify the challenges and opportunities, and make recommendations for improvement. The results showed that the main stakeholders were input suppliers, small holder producers, traders, financial institutions, Government institutions, policy makers and implementers, and IC consumers. Other actors included transporters, feed manufacturers, farmer groups, NGOs and private service providers. The production constraints included small flock sizes per household, low productivity due to poor feeding and disease control, and limited access to veterinary services. Marketing challenges included poor access to inputs, credit services and marketing, and weak linkages with other stakeholders. Opportunities for IC included; introduction of slaughterhouses, service provision and capacity building for farmers, supply of affordable, quality chicks and cost effective feed supplements. Marketing opportunities existed in improved market information system, formation of farmer groups and entrepreneur groups, and value addition. Efforts are needed to address the production and marketing challenges. It is recommended to increase enrollment in the existing farmer groups and introduce contracts. Innovation platforms should be introduced to improve partnerships and market linkages.

Keywords: Indigenous chicken, small holder, stakeholder, inputs, market
Introduction

Agriculture is an important sector in the economic growth and development of Kenya and contributes 25% to the country’s gross domestic product (Gitau, 2009; RoK, 2010a). This contribution is generated by both the crop and livestock sectors (RoK, 2010b). The Kenyan livestock sector contributes an estimated 10% of the Gross Domestic Product (GDP) and accounts for about 42% of the agricultural GDP (MoLD, 2013). Livestock contribute to income generation, household food security and provide raw materials for various industries, particularly in food processing (Kitayli, 1998; Kimani, 2006). There is an increase in the number of households involved in keeping of livestock (FAO, 2009). The increase is attributed to the rise in household incomes and demand for animal products in urban centres in Kenya (Delgado et al., 1999). Further, there is a change in the dietary preferences of consumers in the urban centres in Kenya (Upton, 2000).

The poultry industry occupies a strategic position in the livestock sector and in the national economy and represents considerable opportunities for enhancing rural livelihoods. Poultry production in Kenya is done at both subsistence and commercial levels (Nyaga, 2007). The commercial producers are classified into small scale and large scale producers based on the level of investments (Owuor and Bebe, 2009). These producers however, have large flock sizes compared to the small scale farmers found in rural areas of Kenya (Bett et al., 2012). In addition their production is mostly synchronized and based on demand from the markets (USAID, 2010). The small scale poultry farmers mainly produce for household consumption or for financial security (Okello et al., 2010).

The national poultry population comprises about 31 million birds (MoLD, 2009). Indigenous chickens (IC) constitute 80% of this population and are kept by over 80% of rural households. They contribute to food and nutritional security, income, social-cultural roles and employment creation. The birds are mostly owned and managed by resource poor farmers who are mainly women and children (Gichohi, 1992). The main advantages of these dual purpose birds are: low requirement for capital and other production inputs, hardiness, ease of management and integration with other farm enterprises.

Despite the high IC population, its national contribution is approximately 60 and 50% of total meat and eggs, respectively (MoLD, 2009). Promotion of indigenous poultry can create major impact by creating employment and improving incomes of small-scale farmers thus, providing a useful tool for poverty alleviation. Such contributions are key to realizing the country’s Vision 2030 and the Agriculture Development Strategy 2013-2018. However, IC has not received adequate attention relating to improved production and marketing as compared to exotic poultry.

Demand for white, low fat meat and preference for quality IC is on the rise among urban consumers, increasing the opportunities for niche markets. The range birds are liked for their special flavour and their products considered to be organic. Various challenges have however hampered promotion of the IC value chain and participation of rural producers in competitive urban markets. The main constraints commonly cited are: lack of organized market, high mortality from disease and predation, delayed sexual maturity, low mature body weights and low quality products. Emerging concerns include bio-safety of the product arising from lack of adequate bio-security measures during production and processing (MoLD, 2010). Exposure of birds to polluted environments could lead to build up of harmful residues.
Makueni County in Kenya is an area that produces a significant number of indigenous chickens (Muthee, 2009). The production of the indigenous chicken like in other areas of Kenya is mainly done by small holder farmers (ACF-USA, 2012). Despite the existence of high value markets for local poultry in the urban centres the farmers are seemingly not able to access such markets, hence fail to realize the full benefits from IC production. Consequently most of the households in Makueni still live below the poverty line and experience cases of food insecurity.

According to Karl et al., (2011), value chain analysis involves the examination of the processes that are involved in production, processing, marketing and consumption of goods and services. The support services, the enabling environments, and by products are also examined for each of the mentioned processes. In addition, the flow of information and incentives (money) between the groups of individuals is also analysed. Consequently the opportunities and challenges are identified to enhance on the efficiency of the value chains. It was on this basis therefore, that a value chain analysis for indigenous chicken was undertaken in Makueni County. The case of Makueni in this respect is expected to represent the status of the IC value chain in most of the counties in Kenya.

**Objectives**

In the wider context, the objective of the value chain analysis presented in this paper is to contribute to the strategy for improved production, marketing and stakeholder information sharing, in line with the Indigenous Chicken Value Chain Project (ICVCP) in Makueni, supported by the Kenya Agricultural Productivity and Agribusiness Project (KAPAP).

Based on the ICVCP study findings, this paper is specifically designed to:

1) **Describe the indigenous chicken value chain in Makueni County, Kenya**

2) **Identify the opportunities and challenges along the indigenous chicken supply chain in Makueni County**

3) **Determine the potential stakeholders and actors in the indigenous chicken value chain**

**Approach and Methodology**

The value chain analysis approach is designed to identify target markets for goods and services. Subsequently, the existing environment is analysed to understand the main actors, opportunities and constraints that may hinder the flow of goods, services and information between the actors in the chain.

The ICVCP in Makueni aimed largely at linking production and marketing of the indigenous poultry. Whenever there is a reliable and ready market for IC, the producers are motivated to produce more birds. The production of indigenous chicken is affected by both internal and external environment of the smallholder farmers. It is important to analyse the operating environments of the farmers to identify the constraints and opportunities. Based on this premise, it was essential to conduct a value chain mapping in Makueni County whose findings would inform and guide on the pertinent areas for intervention. The ICVCP team therefore undertook a comprehensive baseline survey at
all levels of the value chain. Meetings and interviews were conducted in Nairobi and Makueni Counties and in other areas along the chain.

Quantitative data was collected using structured questionnaires, which were pre-tested before the actual data collection took place. There were two sets of questionnaires; one set focused on production and covered seventy six households in Wote and Kako Divisions of Makueni. The second set focused on markets analysis and covered 80 households in Wote, Kaiti and Kee divisions. The market survey also covered indigenous chicken markets in Makueni and Nairobi, the later being one of the key terminal markets for IC from Makueni County.

Qualitative data was gathered using various participatory rural appraisal (PRA) tools that included focus group discussions (FGDs), key informant interviews (KII) and direct observations. Checklists were used to guide the semi-structured interviews. The interviews covered all the major stakeholders in the value chain, key amongst them being producers, input providers, farmer groups, brokers, traders and transporters. Other establishments covered were restaurants, hotels, abattoirs and open air markets. The terminal markets covered included processors, supermarkets, hotels, butcheries and other high end urban markets. Kariakor and Burma Maziwa which are key IC markets and slaughter slabs in Nairobi were visited, where trader groups and processors provided information.

Other stakeholder categories interviewed included policy level officials in the line ministries of livestock development, agriculture, public health, co-operatives and local government. Additionally, associations for poultry farmers and feed manufacturers such as KEPOFA and AKFEMA were interviewed, and also micro-finance institutions with interest in providing credit for poultry farming.

Results

Description of the indigenous chicken supply chain in Makueni County

The IC value chain map shows that the main actors can be classified according to the different stages in the chain. The input suppliers in Makueni primarily constitute of agro vets, who stock materials and equipments that are used by the IC producers. These include drugs, vaccines, biosecurity materials, compounded IC feeds, ingredients for formulating feed supplements, equipments such as feeders and watering cans. The other input suppliers are the breeders who supply fertile eggs for incubators and day old chicks. In addition this category includes the large scale suppliers of incubators and those that supply the brooder materials. The research institutions such as Kenya Agriculture and Livestock Research Organization (KALRO) play an important role in providing improved indigenous chicks and cocks used by farmers to improve existing local breeding stocks.

The production stage in the indigenous chicken value chain is dominated by the small holder farmers in Makueni County. These farmers procure their inputs from private suppliers alongside other services. For efficient production of IC, farmers access other important support services from various actors. Such services include credit, extension services and market information services. The main service providers include financial
institutions, veterinary officers, NGOs, Ministry of Livestock, traders and transporters. The farmers also receive some support from the farmer groups.

Marketing of indigenous chicken in Makueni County is done through different channels which starts at the farms. The farmers sell their indigenous chicken to the consumers or front line traders. The traders in turn sell to other bulking traders at different prices and forms. The latter have many outlets.

The processing stage of the indigenous chicken is currently done to a limited extent depending on the markets. Processing services are conducted at various markets such as Kariokor and Burma markets in Nairobi. There are few private slaughter facilities for chicken that are utilized by traders and small holder farmers. These facilities produce dressed chicken that are packed in polythene bags and placed in plastic crates. The processed chicken are consequently delivered to hotels, supermarkets or butcheries from where they are sold. The traders involved in this stage access credit from financial institutions and also use transport services. However the traders must ensure that the trading facilities meet health and quality standards. They also pay the requisite county levies. Consequently there is an interaction between the traders and public health department.

The smallholder farmers interact with other actors during the marketing of indigenous chicken. First, they pay a fee to the county councils in order to access the market. Secondly, they pay transportation and also pay for a movement permit to the Veterinary Department. Other charges paid by IC producers include, vaccination services, slaughtering facilities and extension advice. The other fees paid by traders include the subscription fees to the farmer groups and interest for accessing loans.

Figure 1 shows the various channels which IC go through. The channels vary in length, some are very short since they involve selling chicken at the farm gate. Others are long since they involve many actors along the value chain. For instance some traders buy chicken from the producers sell to the traders who on the other hand sell to traders in urban areas. There are traders who specialize in the transportation of indigenous chicken in Makueni County. These traders provide a critical link in the supply chain and ensure that indigenous chicken are available at the right place and time.
There are actors who have a cross cutting function in the IC value chain. These actors are mainly the government organizations that offer services that ensure that goods and services conform to laws and regulations, such as: KEBS, County Government, Ministry of Livestock and some NGOs. The other set of actors in this category include financial institutions such as Banks, Savings and credit Cooperatives (Sacco) and transporters.

**Opportunities in the indigenous chicken value chain**

Various opportunities were identified in indigenous chicken value chain in Makueni County. They include favourable environment and its location, that is near Nairobi which is the largest terminal market for IC. There are common interest farmer groups (CIGs) in Makueni County that have been in existence for a period. The CIGs are formed by farmers from within and across villages, mainly living in close proximity to each other. The groups differ in terms of numbers, age and regulations. However, they commonly have established governance structures with group officials. In addition they have regular meetings and members are required to pay an annual subscription fee. Currently some of the farmer groups are being used for labour supply, marketing and training of farmers on indigenous chicken production. These groups act as channels of training on animal husbandry and bio security issues. It is also easier to provide inputs, services and to
build capacity to the CIGs as opposed to individual farmers. The KAPAP ICVC Project is using these avenues to reach the farmers inorder to train them collectively on the new technologies, provision of inputs and linking them with partners and stakeholders.

There are no contract farmers in the indigenous chicken value chain. The reason given by those interviewed was the challenge of inconsistent supply. The presence of contractual agreements would ensure that farmers are producing on a schedule. This would also call for relay stocking to continuously provide replacement stock and sustainably supply birds to the market as required. In addition the contracts would ensure that the producers observe the requisite quality standards.

Makueni County has several NGOs that offer services related to agribusiness and they mainly target the small scale farmers. These NGOs offer training on agribusiness and advise on marketing of agricultural and livestock produce. However most of the services such as extension are offered at a fee, which is unaffordable to the smallholder farmers. Some of the NGOs previously supported some interventions such as distribution of improved indigenous chicken and establishing slaughter houses. However, they have not been able to sustain these interventions. Therefore, some of the farmers might have been trained on animal husbandry practices but had no links to markets. Some of the farmers lacked inputs and knowledge this being the case they just continued using their old technology, which produced low performing IC.

There are small scale entrepreneurs that are producing fabricated incubators and brooders within Makueni County. The entrepreneurs achieve this by improvising, using locally available materials such as hay-box brooders. Synchronised incubation and brooding would ensure that there is uninterrupted supply of indigenous chicken to the markets. In addition, this will promote synchronized and sustained production of indigenous chicken to the markets, which would further promote entering into contract marketing agreements. These entrepreneurs can be organized into groups so as to access credit services from banks or government institutions.

There were only few facilities that performed slaughter and packaging of indigenous chicken in Makueni County. The slaughter of IC was mainly done by individuals for their own consumption. A limited number of slaughter facilities were adjacent to markets where indigenous chickens were delivered in large numbers and they were later on delivered to big hotels. The processing facilities are adjacent to IC markets and they are operated by the county government, while public health officers offer the inspection services.

3.3 Challenges in the indigenous chicken value chain in Makueni County

There are few small scale farmers in Makueni who are able to have access to quality inputs for the production of indigenous chicken. This situation is predominantly due to high prices incurred while purchasing inputs used in the production of indigenous chicken. The result is that most of the farmers improvise or innovate ways to enable them produce indigenous chicken. For example most of the farmers use sub-standard housing structures for the IC chicken. These structures expose the birds to predators, pests and diseases. The standards of hygiene and sanitation are low. In addition, some birds are housed in kitchens, thus posing a risk to human health. The feeding and drinking equipments are mostly improvised containers that may easily get contaminated...
and further propagate disease transmission. Lack of clean water for IC production was also identified as a key constraint.

The smallholder farmers in Makueni County are constrained in accessing veterinary services. The consultation fees and the cost of the drugs are usually not affordable for the small scale farmers. Consequently the farmers resort to using local herbs to treat their indigenous. In many instances the herbs are not effective which lead to death of many flocks. In addition, lack of knowledge on disease control and biosecurity practices, leads to spread of diseases within and across the flocks. The result is the loss of many birds and quarantines which affect the marketing of the indigenous chicken in Makueni County.

At producer level, the household flock sizes in Makueni have small size, a factor that impedes sustainable marketing of IC under contractual agreements, hence limiting access to terminal urban markets. Results of the ICVCP survey showed that the average flock size was 14 birds per household. The lack of large, commercial flocks was attributed to challenges which includes diseases and parasites that adversely affected the birds often causing high mortality, and predators that attacked chicks particularly during the brooding period.

The small scale farmers had inadequate knowledge relating to available markets. Consequently, most of them were not keen on rearing large flocks due to inadequate extension services and lack of information on best practices for chicken production. Most of the producers received information from other farmers, print and electronic media and private extension agents. However most of the resource poor smallholder farmers were unable to access these services.

The farmers in Makueni County faced various challenges in marketing their IC. The prices of IC are usually determined by the buyers there is no standard unit of determining the prices. This is only limited to the producers since the traders sell their flocks using kilograms as the measuring unit. Therefore, the traders benefited more after selling the birds compared as compared to the producers.

Further, the farmers incurred losses during transportation of IC to markets due to poor handling, carriage and storage. There were cases of infections during transportation of IC to the markets. In some instances farmers incurred charges due to moving across counties. Poor storage affected the birds and this leads to some birds becoming rejected by the traders.

One of the ICVCP studies showed that indigenous chicken carry zoonotic organisms like Campylobacter species, pathogenic E.coli and Salmonella, associated with the low hygienic standards in IC production and marketing. The presence of zoonotic bacteria and pathogenic contaminants therefore make indigenous chicken a possible source of foodborne bacterial infections. There is need to train the stakeholders along the value chain on biosecurity measures to prevent introduction of disease organisms into the indigenous flocks and biosafety requirements to prevent transmission of the zoonotic bacteria to the humans from the chicken and their products. Critically required also is improvement of the infrastructures for indigenous chicken slaughter to ensure food safety.
The survey also showed weak linkages between the smallholder farmers in Makueni County and the service providers. The organizations lacked clear channels of informing the smallholder farmers in Makueni County about their activities and functions. Therefore despite the existence of farmer groups they were mainly ineffective due to lack of information on marketing, credit provision and extension access in Makueni County.

4.0 Conclusions

The analysis of the IC value chain in Makueni showed that the main actors included input suppliers, small scale producers, financial institutions, Government institutions, transporters, policy makers and policy implementers. Other actors include traders, feed manufacturers, farmer organizations, NGOs, agro-vet outlets, veterinary staff and consumer organizations. This study indicates that there were some opportunities that favoured the production of IC. They include, Maakueni being near Nairobi the largest market for chicken, presence of common interest farms groups, having many NGOs which offer support availability of financial institutions and getting support from the County government. Challenges faced when rearing the IC as indicated in this study includes, limited access to IC inputs due to high prices, inadequate skills in IC production and marketing, low production of ICs, diseases, poor means of transportation, exploitation by IC traders and weak linkages between producers, IC related organizations, and competitive urban markets.

5.0 Recommendations

Based on the conclusions from the value chain analysis it is recommended that the above stated challenges be addressed at the various levels so that the small holder producers can sustainably increase their flocks, improve on IC quality and gain access to high value terminal markets for higher profits. The production of ICs should be at levels that meet thresholds necessary for agribusiness (>50 birds) to put farmers into a gainful occupation. Sustainability can be enhanced through mobilization of farmers to form collective marketing groups to avoid exploitation by traders. Deliberate efforts to up-scale production are necessary. The IC producers need to work hand in hand with the existing livestock officers to avoid massive death of IC due to diseases and poor handling. There is also need for the policy makers to consider improving the transportation system of the County. There is need to train the IC producers on appropriate methods of producing and marketing Indigenous chicken.

Acknowledgement

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Indigenous chicken value chain analysis: the case of Makueni County, Kenya

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Analysis of milk production trends in Kenya and its implication on consumption

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Abstract

Despite many years of intervention in livestock very few countries are self-sufficient with regard to milk is increasing becoming an important component in peoples’ diet in Kenya. The ever-increasing human population is one of the key drivers of increasing milk demand. The study was carried out to examine trends in production, yield per animal, number of dairy comes, exports and imports in Kenya from the period 1961-2012. Secondary data was collected from the FAOstat for 52 years. Descriptive statistics and exponential trend equations were fitted to analyse the patterns of growth. The growth rates were number of dairy animals milk production grew by 3.1% (0.031\(t=1.84^{*}\)), yield per cow animal was about 0.7% (0.007\(t=0.76\)). The milk production grew by about 3.7 (0.037\(t=0.76\)). The computed growth trend for number of animals was negative (3.02) and significant (p<0.05) while that for milk yield per cow was also negative (0.67) and significant at (p<0.01). However, the quadratic time term indicated a stagnated growth in milk production and per capita milk production, and an accelerated growth in number of dairy animals. It was suggested that the process of decline in milk yield should be reversed through expansion of proper animal husbandry and breeding for enhanced milk yield per animal coupled with increased use of advisory services and provision of input supports to the farmers.

Keywords: Milk production, growth rates, trend.

Introduction

Despite many years of intervention in livestock very few countries are self-sufficient with regard to milk. The main milk-surplus countries are Argentina, Australia, New Zealand, USA, Uruguay. The Kenyan milk production, imports and exports keeps on fluctuating over years. Kenya Sudan, Egypt, South Africa and Algeria are among the top five African milk-producing producing about more than half of the total volume of milk (Shittu et al., 2008). Milk is increasing becoming an important component in peoples’ diet. The ever-increasing Kenyan population (RoK., 2009b) is one of the key drivers of increasing milk demand. It is perceived that the milk production, per capita production and consumption is increasing over years to cater for the increasing demand.

In partnership with stakeholders the Kenyan Government has continuously funded livestock interventions designed to increase production (RoK., 2009a; RoK., 2008). The growth parameters of production yield per animal, number of dairy comes, exports and
imports need to be reviewed and documented in order to assess the status and projections. Raw figures from FAOstat (FAOSTAT, 2012) show an increasing trend in milk production and livestock numbers including derived parameters of yield per cow and per capita production. The increase in milk production from pre to post independence cannot be conclusively considered as significant. Time series data is an arrangement of statistical in accordance with time of occurrence. The data can exhibit four key components secular trends (T), seasonality (S), cyclical (C), and irregular (I). These components are not fully established for milk production, area under production, yield per cow, and pricing and its effect on human population. In addition, the growth rate for these variables (production area, yield and prices) has not been studied. This study was designed to contribute to this. The main objectives of the study included to; i) analyze trends in number of dairy animals, production, yield imports and exports of milk; 2) reveal milk production trends and 3) forecast future patterns of milk events.

Methodology
Milk in Kenya is produced from all the 47 counties from cattle, camel, and goats. The milk is consumed in all the counties with some counties being net importer while others being net exporter. However, the distribution is not efficient and effective leading to surplus and deficit in some regions.

Data type, sources and analysis
This study was based on a time series data on production trend collected from the FAO stat, Kenya National Bureau of Statistics (KNBS), Ministry of Agriculture Livestock & Fisheries among other websites and published materials (RoK., 2013). The type of data collected included number of dairy animals, annual milk yield per animal, annual milk production levels, import and export milk levels over years from 1961 to 2013. Based on milk equivalent (ME), the production is below the average per capita global milk consumption of about 100 kg of milk/year, with very significant differences among years. Data collected was subjected to descriptive and regression analyses. The descriptive statistics included; mean, standard deviation the range (minimum & maximum values), and proportion (percentages). In order to assess the trend we used three year moving average and exponential trend function (Nmadu et al., 2009; Samuel and Patil, 2013; Maikasuwa and Ala, 2013 ).

The three-year-moving average was calculated from the data given by and these total to be written beside the year 1963, 1963, 1964, 1965… 2011 for all the years (equation 1).

\[ Y_{mov\_3} = \frac{1961 + 1962 + 1963}{3}, \frac{1962 + 1963 + 1964}{3}, \ldots, \frac{2011 + 2012 + 2013}{3} \]

(1)

where \( Y_i \) is milk production level for a given year \( i \). \( \forall i = 1, 2, 3, \ldots, 39 \)

The growth rate of milk two models were fitted to the data set annual growth was computed as

\[ \% \text{change growth} = \left( \frac{Y_{i+1} - Y_i}{Y_i} \right) \times 100 \]
where \( Y_i \) is milk production level for a given year \( i \) \( \forall \ i = 1, 2, 3, \ldots, 52 \)

The data was also fitted to the exponential growth function or log-linear as employed by Maikasuwa & Ala (2013), Ahmed et. al, Nmadu et. Al (2009) and Samuel et. al (2013) was used.

The general exponential trend production function was specified as;

\[
Y_i = e^{(\alpha_0 + \varepsilon)} \quad (2)
\]

For ease of running the exponential function as an Ordinary least square (OLS) the milk data was log-linearised by by taking the natural logarithms on both sides of equation 1. The log-linearized (OLS) equation is shown in equation 3 (Double log model);

\[
\log Y_T = \alpha_0 + \alpha_1 T + \varepsilon_T \quad (3)
\]

Where: \( Y_T \) = number of dairy animals, production per animal, production, imports and exports, \( T \) = Time trend variable 1961 to 2012, \( \alpha_0 \) =Intercept of the milk trend equation, \( \alpha_1 \) = trend coefficient, \( \varepsilon_T \) =error term.

This measure has been proven to be more realistic in computing growth rates as it takes into account the entire observation when compared to other alternative methods that uses data at the beginning and at the end of a period which tend to ignore vital information. From equation 2 the compound growth rate (\( r \)) was by multiplying \( \alpha_1 \) by 100 and the percentage growth rate is obtained as shown below;

\[
CGR \ (r) = \left( \text{antilog} \alpha_1 - 1 \right) \times 100 \quad (4a)
\]

or

\[
r = (e^{\alpha_1} - 1) \times 100 \quad (4b)
\]

Where: \( r \) = compound growth rate, \( \alpha_1 \) = estimated coefficient from equation 3, \( e \) = euler’s exponential constant \( (e=2.71828) \).

Doubling the period was computed using the rate of growth as;

\[
DT = \Theta \ / r \quad (5)
\]

Where: \( DT \) = doubling period, \( r \) = compound rate of growth as in equation-4,

Borrowing from Nmadu et al (2009) and Samuel et. al (2013), in order to estimate the of growth pattern so as to determine whether there is acceleration, deceleration or stagnation in milk production in the country, quadratic equation in time trend variable
was fitted as follows:

\[ Y_i = \alpha_0 + \alpha_1 T_i + \alpha_2 T_i^2 + \varepsilon \]  

(6)

\( \alpha_0, \alpha_1, \) and \( \alpha_2 \) are parameters to be estimated. In the specification of equation 5, the linear and quadratic time terms indicate the circular path in the dependent variable \( Y_t \). The quadratic time variable \( T_i^2 \) allows for the possibility of determining whether there was acceleration, deceleration or stagnation in milk production during the period 1961-2013 as stipulated by Maikasuwa & Ala (2013). In determining the pattern of growth, our main concern is on \( \alpha_2 \) (coefficient of \( T_i^2 \)) which reveals a measure of the growth pattern (Maikasuwa and Ala, 2013). If \( \alpha_2 > 0 \) and statistically significant, then there is acceleration in growth, if \( \alpha_2 < 0 \) and statistically significant, then there is deceleration in growth, if \( \alpha_2 \) is positive or negative but not statistically significant, then there is stagnation in growth and Samuel et al.

**Results and Discussion**

**Production characteristics**

Figure 1 shows the trends in milk production and population increase. The human population which is one of the demand shifters progressively increased while the milk production keeps on fluctuating over years. Prior to 2000 the milk production fluctuated over and above the population but after 2000 the milk index was above the population.

![Figure 1: Trends in population, production and yield of milk growth index](image)

The average number of animals form 1961 ranged from 1.5 million animals to about 7.5 million animals with an average of 3.5 million animals over the years. The amount
of milk produced ranged from 663 thousand litres (1961) to a maximum of 3.8 million litres (in 2005, 2011 and 2013). The milk imports ranged from zero in some years to about 7.4 million litres annually. The per capita milk production ranged from 56 to 117 litres with an average of 82 This is below the world average per capita consumption of 100 litres per anum. This implies that the deficit is made through imports. The number human population which is one of the milk demand curve shifters increased from 8.6 million in 1961 to about 40 million 2013.

Table 1: Mean number of animals, production (MT) and yield of milk in Kenya 1961-2013

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producing Animals</td>
<td>52</td>
<td>1500000.0</td>
<td>7500000.0</td>
<td>3503572.0***</td>
</tr>
<tr>
<td>Yield(Hg/An)</td>
<td>52</td>
<td>4193.0</td>
<td>7275.0</td>
<td>4963.8***</td>
</tr>
<tr>
<td>Production Quantity (tonnes)</td>
<td>52</td>
<td>663000.0</td>
<td>3752200.0</td>
<td>1809806.5***</td>
</tr>
<tr>
<td>Import Quantity (tonnes)</td>
<td>51</td>
<td>0.0</td>
<td>7379.0</td>
<td>316.3*</td>
</tr>
<tr>
<td>Export Quantity(tones)</td>
<td>51</td>
<td>4.0</td>
<td>34459.0</td>
<td>5329.8***</td>
</tr>
<tr>
<td>Per capita milk production</td>
<td>52</td>
<td>56.1</td>
<td>117.8</td>
<td>82.1***</td>
</tr>
</tbody>
</table>

Authors’ computation from FAO stat, 2013

The per capita milk production showed an increasing trend with over though slowly over the years. The per capita milk consumption seemed to have changed much.

![Figure 2: Per capita milk production 1961-2012](image)

**Milk Growth rates**

The growth rates were number of dairy animals milk production grew by 3.1% (0.031 \(t=1.84^*\)), yield per cow animal was about 0.7% (0.007 \(t=0.76\)). The milk production grew by about 3.7 (0.037 \(t=0.76\)). The trend analysis using quadratic function is given in Table 2. The compound growth rates for number of dairy animals was 3.02%, while that for
growth rate in milk production grew by 3.63%. The growth rates for yield per cow animal was about -0.67%. The compound growth rate for per capita milk production was -0.44%. This implies that all the variables a negative and significant growth in production and productivity of milk and number of animals producing the milk and low growth in the variables. This calls for strategies to fully integrate the milk production in farming systems probably through improving the genetic quality of the breeding animals and general management of the dairy animals.

Table 3: Compound growth rate of area, production and yield of Milk in Kenya 1961-13

<table>
<thead>
<tr>
<th></th>
<th>CGR</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln Number of animals</td>
<td>3.02**</td>
<td>1.84</td>
</tr>
<tr>
<td>Ln Milk production</td>
<td>3.63NS</td>
<td>0.76</td>
</tr>
<tr>
<td>Ln Milk yield per cow</td>
<td>0.67***</td>
<td>4.16</td>
</tr>
<tr>
<td>Ln per capita milk</td>
<td>0.44NS</td>
<td>0.565</td>
</tr>
</tbody>
</table>

NB *** = significant at 1%, ** = significant at 5%, * = significant at 10%, NS = not significant

Nature of growth

In order to investigate for the existence of acceleration, deceleration or stagnation in the milk growth variables (number of animals, production and yield/animal/year), the quadratic function in time trend variable was fitted. The quadratic term (T²) allowed for detecting acceleration, deceleration or stagnation in the milk variables (area, production and yield). Result in Table 4, revealed the value of the coefficient of (T²) for number of animals was negative and significant (p<0.1) implies that growth is decelerating (increasing at a decreasing rate. The value of the coefficient of (T²) for the yield per dairy animal was positive and significant implying acceleration. The production variable was positive and significant (P<0.01) implying acceleration in trend in milk production.

Table 4: Compound growth rates, doubling time and nature of growth area, and yield productivity of milk in Kenya

<table>
<thead>
<tr>
<th></th>
<th>Compound growth rate</th>
<th>Doubling time (years)</th>
<th>Year would be achieved</th>
<th>t-value</th>
<th>Current nature of growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln Number of animals</td>
<td>2.11</td>
<td>22.8</td>
<td>2038</td>
<td>1.8</td>
<td>acceleration</td>
</tr>
<tr>
<td>Ln Milk production</td>
<td>4.03</td>
<td>19.0</td>
<td>2034</td>
<td>0.8</td>
<td>stagnation</td>
</tr>
<tr>
<td>Ln per capita milk</td>
<td>-0.72</td>
<td>158.3</td>
<td>2173</td>
<td>-1.4</td>
<td>stagnation</td>
</tr>
<tr>
<td>Ln Milk yield per cow</td>
<td>-1.96**</td>
<td>102.8</td>
<td>2118</td>
<td>4.2</td>
<td>deceleration</td>
</tr>
</tbody>
</table>

NB *** = significant at 1%, ** = significant at 5%, * = significant at 10%, NS = not significant
Conclusion and recommendation

The results from the analysis indicate that given the current trends, we can double production of milk by 2034 and double our number of animals in 2038 if no other intervention is done now. The per capita milk production has stagnated. We need to accelerate milk production per cow by giving incentives to farmers to improve management and also other actors along the APVC to invest in interventions. Thus the need to enhance yield through technology innovation development and transfer.

References


Processors’ management of mycotoxin in maize for food and feed products in Kenya

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Abstract

In Kenya, maize is for food and feed. However the maize grains used by processors are prone to being infested with mycotoxin producing fungi. The status of mycotoxin management among the processors is limited in Kenya. This study was designed to provide this information. A survey was carried out in five Counties and 79 processors were interviewed using a semi-structured questionnaire. Processed samples were also taken from each farmer for fungi characterization. The results showed that processors were fully aware of mycotoxin in maize grain products as food and feed. Majority of processors tested for mycotoxins in their products. However there is need to enhance the testing. The testing methods used were mainly elisa and proximate methods. The type of mycotoxins tested were mainly aflatoxins. Most of the processors are willing to test for mycotoxins that were not expensive. Very few regulators make follow-ups to enforce the quality issues. This calls for frequent monitoring by quality regulators during and after processing the products.

Keywords: processors, maize processed products, test, mycotoxins, Kenya.

Introduction

In Kenya, maize (Zea mays L.) is used for food and feed. About 90% of Kenya’s rural population depends on it as food and an income-generating commodity and therefore any contamination may lead to a significant number being affected. However the maize grains used by processors are prone to being infested with mycotoxin producing fungi. Mycotoxins include several groups of toxic secondary metabolites produced by a diverse number of fungal species which occurs in maize grains and derived products (Fandohan, 2003; World Health Organization., 2006).

The crop is raw material for industrial processes (Republic of Kenya, 2004a). Some of the by-products are used as raw materials for processing other final products. The status of mycotoxin management among the processors is limited in Kenya. This study was designed to provide this information. The study objectives were to evaluate the testing procedures used by processors and to assess their perception of mycotoxins in maize grains and derived products.
Methodology

Survey design

The counties sampled were West Pokot, Uasin Gishu, Trans Nzoia and Bungoma. These counties represented low and medium altitude zones (Bungoma) and the high altitude zones (Trans Nzoia, Uasin Gishu and West Pokot). The low and medium zones are warmer and were hypothesized to promote the growth of mycotoxin producing fungi while high altitude zone were expected to negatively influence the growth of mycotoxin producing fungi. Bungoma 0°25’-0° 53´ S, 34°21´ - 35°04´E; Trans Nzoia; 0°52´-1°18´S, 34°38´-35°23´E; West Pokot 0 10’ and 30° 40´N and 340 50’and 350 50´E and Uasin Gishu longitude 34° 50’ - 35 º 37´ E and 0° 03´ and 0° 55N. with approximately 3,856,560 people with an altitude of 900 to 3,800 metres above sea level (Jaetzold et al., 2005). The mean minimum and maximum annual rainfall is 600mm and 1,200 mm, respectively. The temperature ranges between 9°C and 30°C. The farmers practice mixed farming of growing crops (wheat, maize, sugarcane, horticultural crops and livestock rearing (dairy cattle, goats, sheep, and poultry).

All processors identified in the Counties were selected and interviewed though some of them were reluctant. The type of data collected included processor profiles (year established), quantities and prices of raw materials used, testing for mycotoxin including methods used, Their perceptions on type of maize in relation to mycotoxins and their effect on health was also asked for.

Data analysis

Descriptive and regression analysis were used to analyze the data. The t-test and chi-square test were used to test the relationships across variables.

Results and discussions

Processor profiles

The number of years processors had been in existence ranged between one and 17 years with a mean of 4.4 ± 4.0. Majority of the processors (71%) were established in the last five years (Figure 1). This indicated that more actors along the maize value chain are joining the value addition in maize based products.

Figure 1: Profile of processors
**Type of maize grains**

Different types of maize grains were used by processors to make maize based products (food and feed). Majority of traders used clean maize (86%) while only 13% used mixed maize grains in processing (Figure 2). Mixed mouldy and clean grains were only used in making feeds. However, clean maize may or may not have dangerous mycotoxins and also mouldy maize may or may not have dangerous mycotoxins. The surest way to establish the levels of toxins is to test for them.

![Figure 2: Type of maize products used in processing feed](image)

**Quantities of maize used**

The average quantities of maize grain processed per processor progressively increased over years from 376 to 811 bags (1 bag = 90kg) in 2010 with an average of 445 bags (Table 1).

<table>
<thead>
<tr>
<th>years</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>64</td>
<td>2</td>
<td>2520</td>
<td>376</td>
</tr>
<tr>
<td>2012</td>
<td>50</td>
<td>25</td>
<td>3000</td>
<td>369</td>
</tr>
<tr>
<td>2011</td>
<td>28</td>
<td>20</td>
<td>2500</td>
<td>358</td>
</tr>
<tr>
<td>2009</td>
<td>13</td>
<td>60</td>
<td>1008</td>
<td>313</td>
</tr>
<tr>
<td>2010</td>
<td>19</td>
<td>15</td>
<td>10008</td>
<td>811</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td>445</td>
</tr>
</tbody>
</table>

**Maize prices**

Maize grains were sourced from both large and small scale farmers at varying prices.
The buying prices increased over years from 2009 (KES 900 per 90kg bag) to 3496 per bag in 2013 with an average of Ksh 2132 (Table 2). This implies that the cost of production increased over years and probably the prices of the products. However, to reduce average cost per unit there is need to increase the quantities produced.

Table 2: Buying price (Ksh/90bg) per unit of maize bought from traders

<table>
<thead>
<tr>
<th>Years</th>
<th>Frequency</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>25</td>
<td>3496</td>
</tr>
<tr>
<td>2012</td>
<td>15</td>
<td>2293</td>
</tr>
<tr>
<td>2011</td>
<td>11</td>
<td>1898</td>
</tr>
<tr>
<td>2010</td>
<td>8</td>
<td>2075</td>
</tr>
<tr>
<td>2009</td>
<td>4</td>
<td>900</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>2132</td>
</tr>
</tbody>
</table>

Mycotoxins testing

To be sure of presence and levels of mycotoxin in raw and processed products it is always good to test for toxin levels. The respondents were asked whether they were aware of mycotoxins and 61% of them indicated that were not aware while 39% were aware. The testing was done for various types of mycotoxins some were done daily, quarterly, monthly and on annual basis.

Types of mycotoxins

Aflatoxins were the most frequently occurring toxin. Those respondents who indicated that it was rarely found were 7 while those who said that it was often found were 11 and those who revealed that it was very often were 21. Other toxins found were zearalenon and fumonizin.

Table 4: Type of toxins found in sample

<table>
<thead>
<tr>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>mycotoxins rarely found</td>
<td>aflatoxin</td>
</tr>
<tr>
<td></td>
<td>zearalenon (zea),fumonizin</td>
</tr>
<tr>
<td>mycotoxins found often n=8</td>
<td>aflatoxin</td>
</tr>
<tr>
<td></td>
<td>deoxynivalenol (DON), ochratoxin</td>
</tr>
<tr>
<td>mycotoxins found very often</td>
<td>aflatoxin</td>
</tr>
</tbody>
</table>

Processors indicated that they sampled material at the reception point before processing (33%) and also at the end of processing the final products. However there is need to make sure the products are free from toxins to avoid post processing infections.
### Table 5: when sample grain mycotoxin test is done

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>At reception of goods(from farmers and traders)</td>
<td>33</td>
</tr>
<tr>
<td>In the end product</td>
<td>67</td>
</tr>
</tbody>
</table>

### Method of sampling

Processors used regulation and internal sampling systems (80%) (Figure 32). There were situations when the processors used contracted agents.

![Figure 3: Sampling system used by processors](image)

### Willingness to invest in mycotoxin testing

Processors were asked how much they were willing to invest in testing mycotoxins. Very few of them were willing to pay more than Ksh 5,000 and 49% indicated that they do not know the amount to pay (Table 4). This implies that there is need to have relatively low cost mycotoxin testing practices.

![Figure 4: Selected responses on product analysis](image)
Method of analysis

The widely used method of analysis was quantitative elisa method (67%). However, there were other processors who used proximate and bandage kit methods.

Table 6: Method of analysis do you use

<table>
<thead>
<tr>
<th>Method of analysis</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandage kit (Elisa semi quantitative)</td>
<td>17</td>
</tr>
<tr>
<td>Proximate analysis</td>
<td>17</td>
</tr>
<tr>
<td>Quantitative analysis(chromatographie en phase Gauzeuse-GC)</td>
<td>17</td>
</tr>
<tr>
<td>Quantitative analysis(Elisa)</td>
<td>50</td>
</tr>
</tbody>
</table>

Regulators in processing

Very few regulators visited the processors. Those who visited them included KEBS (80%) and Health officers (30%) from ministry of Health (Table 7). This demand for frequent visits by all regulators to enforce the regulatory laws.

Table 7: Regulatory bodies checked on standards

<table>
<thead>
<tr>
<th>Regulatory bodies</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health officer</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>KEBS</td>
<td>8</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Perceptions on mycotoxons

Majority (78%) of processors strongly disagreed with psychometric question that mouldy maize is not good for ugali (Table 8). However, some strongly disagreed (42%) and agreed/strongly (56%) that the same maize is good for livestock. About 58% of the processors agreed/strongly agreed that mouldy maize is good for brewing beer. About 62% of respondents revealed that even clean maize may be contaminated with mycotoxins. Some processors were reluctant to destroy mouldy maize.
### Table 8: Attitude/perception of processors on mycotoxin in maize products

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral (Don’t know)</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouldy maize good for livestock</td>
<td>26</td>
<td>16</td>
<td>3</td>
<td>37</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Mouldy maize good for <em>ugali</em></td>
<td>78</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Mouldy maize good for brewing beer</td>
<td>15</td>
<td>16</td>
<td>12</td>
<td>43</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Even clean maize is contaminated</td>
<td>4</td>
<td>13</td>
<td>16</td>
<td>49</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Mouldy maize should not be used for food</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>35</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Mouldy maize should be destroyed</td>
<td>10</td>
<td>33</td>
<td>11</td>
<td>31</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

### Conclusions and recommendations

The study showed that processors are fully aware of mycotoxin in maize grains for food and feed. Majority of processors test for mycotoxins however there is need to enhance the testing for quality standards. The testing methods used were mainly elisa and proximate. The type of mycotoxins tested were mainly aflatoxins. Most of the processors are willing to test for mycotoxins that were not expensive. Very few regulators make follow-ups to enforce the quality issues. This calls for frequent monitoring by quality regulators during and after the processed products.

### Acknowledgements

We acknowledge the financial support provided World Bank through EAAPP and KALRO. We thank processors who participated in this study. Special thanks to our colleagues in KALRO and the Ministry of Agriculture and Rural Development and Ministry of Agriculture Livestock development & Fisheries for their help in data collection.
References


Institutional issues affecting the dairy value chain in Western Kenya

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\textsuperscript{2}Kenya Agricultural and Livestock Research Organization.

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Abstract

This study examined institutional issues and agribusiness capacity of key institutions involved in dairy development in Western Kenya. Using checklists and interview guides, data was collected from Kenya Agricultural and Livestock Research Organization (KALRO), farmer groups, credit institutions, agro dealer feed stockists, Inseminators, County livestock department and dairy cooperatives. The results showed that despite developing many feed technologies, KALRO lacked agribusiness orientation which limited the scaling up and dissemination of improved technologies to target users. Fear to take loans on the part of farmers; and lack of tailor made loans targeting dairy farmers’ priority needs affected access to credit. The protein content of commercial dairy meal were not labeled on bags by feed companies and analysis showed that the Kenyan dairy farmer was exposed to low quality concentrate due to lack of an inspectorate service. The study also found that the devolved County Governments lacked dairy strategic plan, while Artificial Insemination services were constrained by lack of liquid nitrogen, semen bank and testing laboratory. Finally, assessment of dairy cooperatives showed they were still embedded in traditional functions and had not taken off on a business path.

It is concluded that key challenges affecting dairy development and farmer groups in particular are mainly institutional rather than technological. Creating an enabling policy, institutional and regulatory framework would be key to the sector’s growth in the region.

Introduction

Dairy development in East Africa in general and Kenya in particular has evolved through three eras. Before independence up to 1960s, dairy was dominated by colonial settlers and was characterised by large scale farms and formal milk marketing based on the industrialized Western model (Staal \textit{et al.}, 2008; Conelly, 1998). The 1960s to 1980s was characterized by state controlled, free or subsidized livestock services to enable smallholder farmers improve productivity while formal milk marketing was done through a giant farmer organization, the Kenya Cooperative creameries (KCC) (FAO, 2011). From early 1990s most sub-Saharan African (SSA) countries including Kenya were experiencing economic difficulties and budgetary constraints, leading to failure of state run enterprises to provide subsidized/free services. Pressure from Bretton Wood
Institutional issues affecting the dairy value chain in Western Kenya

Institutions (World Bank and International Monetary Fund) led to structural adjustments leading to economic liberalization of input and output markets in which the private sector was expected to take over hitherto state controlled functions (Karanja, 2003). Though these policy changes were well intentioned, private sector entry did not effectively improve delivery of some services, especially dairy inputs (Tambi et al., 2004). To date, institutional failure still continue to limit access to inputs and marketing resulting in low productivity and commercial orientation especially of smallholder farmers in rural areas (Omiti, 2002). Using the case of Western Kenya, a region with high raw milk prices but low productivity, the objective of this study was to assess the capacity and inefficiencies in key institutions involved in dairy development.

Methodology
The study was carried out in Butula and Butere Sub Counties in Busia and Kakamega counties of Western Kenya. The region has an estimated 99,000 smallholder dairy farmers keeping about 192,300 improved dairy cattle (FAO 2011). The study assessed capacity of institutions dealing with various services which were identified as important predictors of milk yield in the region in a recent study (Wanjala and Njehia, 2014). These included: thirty agro dealers (dairy meal), Kenya Agricultural Research Institute (fodder), Livestock department (source of breeding stock, Artificial insemination services, and disease control), County government (Policy), financial institutions (credit), ten cooperatives and dairy farmer groups (group membership).

Data was collected using checklists and interview guides administered to key institutions and farmer groups involved in dairy development in Butula and Butere Sub Counties. Analysis of data entailed use of descriptive statistics and thematic grouping.

Results and Discussion

Farmer groups
In depth focus group interviews with six farmer groups in Butula and Butere identified key challenges to dairy development as: lack of breeding stock, inadequate feeds and feeding, Unreliable AI services, tick borne diseases, inaccessible credit due to fear to take loans and lack of dairy cattle management skills. These findings suggest that dairy development in the region is mainly constrained by institutional rather than technological factors. Following liberalization era of 1990s, institutional support previously undertaken by state agencies was either withdrawn or reduced leading to near collapse of services at farmer level (FAO, 2011; Karanja, 2003, Tambi et al, 2004). Forging stronger farmer organizations as entry points for input supply, modern technology, credit, marketing, knowledge sharing, innovation and policy advocacy could partly fill this gap.

Access to improved feed technologies
A case study of the institute revealed that over the years KALRO has developed and validated dairy feed technologies consisting of pastures, legumes, fodder trees and crop residues. However, lack of agribusiness orientation and inadequate funding for livestock programmes has limited the scaling up and dissemination of these technologies to target
users. A recent study of 400 dairy farmers in the region showed that 56.2% were not aware of existence of improved research technologies while 35.6% said research technologies were not accessible (Wanjala and Njehia, 2014). Several studies in Kenya have shown that inadequate quantity and quality of feed is the major constraint affecting milk production (FAO, 2011; Omore et al., 1999), yet, productivity enhancing technologies in research stations remain largely inaccessible. The relevance of an institution depends squarely on its ability to be on the forefront of providing solutions to challenges, especially with regard to facilitating business and initiating reforms that can make the dairy industry competitive (Kurwijila and Bannet, 2011). Given that research is a public good funded by tax payers, there is urgent need to initiate effective partnerships to facilitate awareness, availability and utilization of research findings.

Commercial dairy meal
A survey of dairy meal supplied to agro-dealer stockists in the region by sixteen companies established that there were three types of dairy meal available in the market: ordinary, standard and high yield. However, the level of protein content or ingredients were not labelled on bags and therefore unknown to both agro dealers and farmers. A recent analysis of feeds bought from the market in Kenya by large scale farms and a study of small holder farms by Katiku et al (2014) showed that feeds from most companies had very low protein content for along time in Kenya, concerns on the low quality of commercial concentrate have been raised in various studies, reports and stakeholder workshops, but the problem still persist due to weak enforcement (Karanja, 2003; FAO, 2011).

County Livestock department
The major challenges affecting delivery of services by the department were: lack of dairy strategic plan (30%), low funding by national/county government (25%), inadequate facilitation (24%) and weak linkages with research institutions in technology dissemination and feed back (21%). An evaluation of seven NGOs showed that linkages to be strong since they are actively involved in implementing dairy development projects in the region. However, due to lack of strategic plan at the Sub County level to give direction means that activities by these NGOs were driven by own agenda. The results indicate none of the NGOs is addressing the low milk production problem in the area. The findings of this study reflect a general declining trend in funding for livestock services in Kenya.

Artificial Insemination Services
The ratio of inseminators to dairy animals in Butula and Butere was 1 to 1700 and 1 to 650 respectively, showing an acute shortage of providers. Problems associated with AI services as perceived by farmers were high frequency of bull calves (50%), repeated service (35%) and poor quality of calves (15%). Interviews with the inseminators revealed that lack of semen (39%), unavailability of liquid nitrogen (24%), repeat inseminations (22%) and low payment by farmers (15%) were the key challenges affecting delivery of AI services in the area. The findings of this study reveal that the inefficiency of AI service is an institutional problem not only in Western Kenya but in the whole country,
Status of dairy cooperatives
The majority of officials had school certificate (70%), above 50 years of age (85%), and without training in financial management. 70% of the cooperatives had a history of leadership wrangles, 75% were indebted and only 30% had a strategic plan. These findings are consistent with those of Wanyama (2009) in a study on cooperative movement in Africa. Regarding the extent of performing traditional roles, the study found that all the cooperatives surveyed had milk coolers and basic milk testing facilities. However, only 10% provided extension and input supply services. A high proportion of members (92.1%) were not delivering milk to the cooperative and hence free riders. The results reflected major weakness in the ability of cooperatives to attract and forge strong horizontal linkages. The free rider syndrome (Olson, 2009) stem from deficiencies in the cooperative Societies legislation which gives exclusive ownership and management, including voting rights to members (Cooperative Act, 2005). Assessment of whether cooperatives have embraced six modern functions (Logistics; quality assurance; processing; contract with buyers; service diversification and professional managers (Bijman et al 2007), revealed a non starter position. These findings have showed that dairy cooperatives in western Kenya have not taken off on a business path.

Conclusion and Recommendations
This study examined institutional issues affecting the dairy value chain in Western Kenya. The results showed that inaccessibility to improved fodder; credit, breeding stock, AI services, low quality commercial dairy meal; lack of dairy strategic plan and inefficient milk cooperatives hindered dairy development in the region. It is concluded that key challenges affecting dairy development and farmer groups in particular are mainly institutional rather than technological. Creating an enabling policy, institutional and regulatory framework would be key to the sector’s growth in the region.

Acknowledgement
The authors are grateful for the support given by the livestock department, dairy farmers and various institutions in Butula and Butere Sub Counties; in Western Kenya. The study was facilitated by Kenya Agricultural and Livestock Research Organization and funded by East African Agricultural Productivity Project.
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Adapting dryland livestock production to meet climate change challenges in Kenya

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Introduction

Kenya’s arid and semi-arid lands cover 82% of the country’s total land area, and host close to 70% of its livestock and 25% of its human population. In Ijara, a sub-county of Garissa, persistent drought and high temperatures repeatedly devastate livestock herds, which has lowered dependence on livestock as a source of livelihood by 21% over the last 10 years. This has left local pastoralists poorer and more vulnerable. Garissa county’s poverty index was recently calculated at 70%, compared with the national average of 48% (Government of Kenya, 2013).

The local economy of Garissa revolves around livestock productivity, which has been hampered by factors including poor management, breed choice, and a lack of strategies to conserve feed. Looking to the future, climate predictions in Garissa indicate that mean temperatures will increase 3–4°C by 2100, which will lead to even less water being available for livestock and pasture production.

In response, the Agricultural Productivity and Climate Change in Arid and Semi-Arid Kenya project sought to improve livestock productivity through capacity building, by supporting pastoralists to adopt more productive, climate resilient livestock species and breeds, and by promoting fodder production and storage for times of feed shortage.

What did we do?

In consultation with pastoralists, five project intervention areas were selected within Ijara. Intervention activities included livestock management, and pasture and honey production. Farmer groups completed training on climate-resilient livestock species and breeds, including Sahiwal and improved Boran cattle, Dorper and Red Masai sheep, and camels. Through theory and practical field sessions they learned how to manage selection and breeding, how to determine live weight and drug dosage, and other management practices. Participants used demonstration farms to learn about improved pasture production, specifically Sudan grass (Sorghum sudanense) and African fox tail grass (Cenchrus ciliaris). Study visits allowed farmers in the program to see how farmers in other areas had profited from improved livestock and pasture production technologies. Kenya Agricultural and Livestock Research Organization (KALRO) representatives monitored and evaluated the program and collected data about the impact of the training. In implementing the project activities, the project team worked closely with field extension personnel to ensure sustainability of the efforts beyond the project duration. Most importantly, the project team has shared results with the Garissa county government, to gather support and to inform county livestock development policies.
Farmers have begun to plant and store fodder grasses for use in times of shortage

Key messages

- In Ijara sub-county, dependence on livestock as a source of livelihood has declined by 21% in the last 10 years. Farmers’ vulnerability and poverty have consequently increased to over 70%, compared with the national average of 48%.

- With improved pasture production, farmers can produce enough feed for their home-based cows to maintain milk production throughout the year.

- Site visits strongly encourage pastoralists to adopt recommended agricultural technologies such as appropriate breed choice and feed conservation among others.

- County governments in arid and semi-arid areas can support enhanced livestock productivity by strengthening their extension work in pasture production, organized grazing, and controlled breeding management.

- Strategic county feed reserves should be established to buy fodder grass from farmers and redistribute it during periods of drought, thereby reducing livestock mortality.

What did we learn?

- With one acre of Sudan grass and improved pasture production, farmers can produce 3.6 tons of feed in a year. This can maintain milk production by three cattle (the average number kept at home) during the annual four-month feed deficit period, and the milk can sustain a family of four. Alternatively, if the feed is sold, the pasture can generate US$1,160 (KES. 100,000) in a year.

- With a strengthened extension service and support for farmers in acquiring adapted livestock breeds, specifically camels, Sahiwal and improved Boran cattle, livestock
productivity can be increased by 50% and herd sizes reduced, which decreases overgrazing and environmental degradation.

**Stories of change**
During a recent monitoring activity, farmers were enthusiastic about the new practices they had been adopting and were expecting those practices to have a positive impact on livestock productivity. Six percent (6%) of the trained farmers had already acquired camels within a year.

“I have separated all the male goats from females and they are now herded separately for breeding control. I do not mix different drugs anymore when treating my livestock and am happy the drugs are working. As a group, we have written a proposal to Constituency Development Fund seeking support to buy five improved Boran bulls for use by our group members and other Kotile farmers. Following the trip to Transmara where the Masaai land had been sub-divided, I mobilized Kotile farmers for a meeting to discuss the need to sub-divide land, especially around town centres, so that each farmer can use the plot to manage breeding and grazing of his livestock. People bought our idea, and we want to pursue the same with the county government of Garissa.”

Ismael Muhumed from the community of Kotile

The issue of individual land ownership has since been discussed by farmers with Garissa county government officials during a project feedback workshop.

In Kenya, sales of Sudan grass can generate over US$1000 per acre per year
Farmers from experimental groups, as well as some from non-experimental groups, have begun growing pasture and storing the grass for use in times of feed deficit. About 44% of group members and 6 other farmers had planted plots up to 1/8th acre, and they were clearing five more plots of up to one acre for new pasture. One farmer had saved 15 small ruminants and 3 cows from starvation using grass harvested from his plot. Group members had also started harvesting and selling grass to community members for $3.5 (KES 300) per donkey cart; one member bought a goat worth $29 (KES. 2,500) using his share of the proceeds.

High quality pasture grasses, such as African fox tail grass, have been introduced.

What are the policy implications?
The Garissa county government should consider the following priorities:

- Promoting pasture production by providing seeds, training farmers and buying the harvested grass from farmers for storage in strategic feed reserves.

- Reorganizing grazing management so that certain areas are preserved for use in times of extreme shortage. This will ensure enhanced availability and optimal use of pasture land, while controlling environmental degradation.

- Promoting improved breeding management, using breeds that match expected future climate scenarios. Strategies are also needed to ensure the availability of breeding bulls, bucks and rams for use by farmers.
What next?
During a site visit to Transmara, Ijara farmers were convinced that the individual land ownership they witnessed was facilitating improved livestock and pasture management practices. They have since started lobbying for the same to be introduced in their area. The research team would like to investigate the difference in productivity and income levels between farmers rearing livestock on communally owned land and on privately owned plots. The data can help the county and national governments make informed decisions regarding the farmers’ demand for individual land ownership.

References

One acre of improved grass can produce 3.6 tons of feed per year
Farmers were trained to use a single breeding male at any one time in order to assess their performance
Sub-theme: Alternative Feed Development
Effects of age on natural (auto) antibodies profiles and repertoire in calves

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Abstract

Masked auto-antibodies sometimes called natural auto antibodies (Na(a)bs) have been demonstrated in man, pigs, mice and now cattle. Several studies implicate na(a)bs in various physiological processes and pathophysiologies; inactivation of cytokines, masking of auto-antigens, clearance of obsolete or damaged cells and metabolic waste, compensating for immunosenesces and in vaccination potency. The detection of Na(a)bs can be achieved using several tissues like liver, kidneys, brain, muscles, nucleus (and other intracellular) antigens and endogenous tissues through Western blot, ELISA and antigen microarrays. The objective of the current study was three fold: a) to assess whether Na(a)b isotypes binding bovine liver lysate were present in calves, and b) to investigate whether the binding repertoires of Na(a)b was dependent of age.

A total of 20 calves from two age groups were used. Their sera were analyzed for IgM and IgG. Na(a)bs isotypes against auto-antigens present in bovine liver lysate (BLL) using quantitative Western blotting. The quantification of the immune blots were analyzed using the TotalLab v 2006 software. The bands and corresponding staining intensities derived were analyzed by one way ANOVA using age group as a factor using SAS 9.20. The correlation of bands showing tendency and significant differences were determined by Principal component analysis (PCA) using CANOCO for Windows program. We report for the first time the presence of IgM and IgG Na(a)bs isotypes in the calves sera binding BLL antigens. The binding patterns showed qualitative conservation but quantitative differences between age group for both IgM and IgG staining intensities among the shared bands. PCA revealed that age showed clear demarcation in band staining. This result implies that environmental effects are most likely to explain much of the variation in binding intensity and that Na(a)bs repertoire of cattle could be a parameter for breeding naturally resistant cattle.

Keywords: Natural (auto) antibodies, calves, age group, western blot, principal component analysis
1. Introduction

Innate immunity as the first line of defense plays an important role in preventing or combating infection (Ehrenstein and Notley, 2010). Amongst the components of innate immunity natural antibodies (Nab) of the humoral arm plays an important role (Vani et al., 2008). Natural antibodies are present in non-immunized cattle (van Knegsel et al., 2007), humans (Ehrenstein and Notley, 2010), rats, rabbits, python and poultry (Sun et al., 2011). The Nabs are mostly produced by CD5+ B cells in the peritoneal cavity and intestines but also CD5- B cells (Casali and Notkins, 1989) were described to produce Nab. Natural antibodies may arise independently of known antigenic stimulation. They are mostly poly-reactive, and poly-specific (Baccala et al., 1989) with low binding affinity, and are generally encoded by the unmutated V genes in germ line configuration (Hans, 2007). Evidence from various studies show they are genetically controlled (Sun et al., 2011). Most of Nab are of the IgM isotype class in lower vertebrates, fetus and neonates, but IgG and IgA Nab are also present as well in higher vertebrates (Marianne, 2000). There is growing evidence of na(a)bs presence in many animal species. Parmentier et al., (2004) reported auto-reactivity to various tissues in chicken plasma. Recently, it was revealed that chicken auto-reactivity was prone to in vivo and in vitro post translational polymorphism (Bergstra et al., 2010). Recently na(a)bs repertoires were typed in selected high or low chicken lines against sheep red blood cells. This papers reports in depth analysis of chicken Na(a)bs against chicken liver cell lysate (CLL) using principal component analysis (De Jong et al., in press). In our paper we report typing of Na(a)bs in Bos taurus and further delineate the principal bands of BLL responsible for observed variation in rumen score and weight using IgM and IgG repertoires. The specific objectives of the study were to determine; a. whether Na(a)b isotypes binding bovine liver lysate are present in calves, b. whether the binding repertoires of Na(a)b was dependent of age group and diet, and c. whether IgG or IgM specific band repertoires could explain rumen score and weight variation observed.

2. Materials and Method

2.1 Serum samples

Serum samples from 38 calves of two age groups fed were used. The sera were obtained by centrifugation at 10 minutes at 2900 x g, then aliquoted and frozen at -20°C until analysis. The experiment consisted of 20 calves sampled twice one month apart.

2.2 Natural antibody polymorphism

Quantitative Western blot analysis was used for the detection of polymorphism and binding patterns of bovine natural auto-antibodies against the Bovine liver cell lysate (BLL).

2.3 Identification of bands

For the number of bands and staining intensities, blots were scanned with a flatbed scanner and saved as a.tif file. The TotalLab v2006 software program (NonLinear Dynamics) with a minimum slope of 75 and linear log curve was used for identification of stained fragments, pixel intensities, calculations and graphs. KIM marker was chosen and the 250 kDa band was left out of consideration. Statistical analysis was performed using SAS 9.20 (SAS Institute Inc., Cary, NC) only on bands in the kDa 10 to 100. Region outside this range were left out in analysis.
2.4 Analyses of variance
Descriptive statistics was used to analyze the antibody repertoires of isotypes, on age group on a log10 transformed scale. A one-way ANOVA was performed for age effects.

2.5 Principles Components Analysis
Clustering of binding profiles of the antibodies that showed tendency and significant levels on age group from experiment was done by principal component analysis (PCA) on the log10 transformed extinction data using the CANOCO package for Windows (Leps and Smilauer, 2003).

3. Results
3.1 Western blot profiles
Quantitative Western blotting using BLL as the antigen was used for cryptic Nab detection of IgM and IgG isotypes. We report for first time the detection of Na(a)bs against BLL in calves’ serum (Figure 1 a and b). For IgM a total of 88 and 84 bands were present in the younger (6 months) and older (7 months) calves serum sample collections respectively. There were relatively more bands detected in young than old animals. For IgG a total of 85 and 79 BLL antigen bands were recognized in the young and old calves samples respectively. Consistently with IgM, higher number of bands were detected in the young animals. In comparison, IgM recognized a higher number of BLL antigens than IgG and was in time (figure 2). For all the isotypes there was a corresponding or similar band that are conserved in all the calves irrespective of age group. Notibly, there were individual animals with unique bands implying diversity (Figure 1). Although there were conserved banding patterns (figures1 a, b and c), the intensity of banding profiles varied quantitatively across these bands within, between and among the individuals. The quantitative variation was further analyzed as staining intensities of the profiles with one way ANOVA.

3.2 Analysis of staining intensities of the banding profiles
The Western blot profiles and staining intensities were generated using the Total Lab v2006. The profiles of individual animal was entered into excel files and imported to SAS 9.2 for analysis. Analysis to identify significant bands based on age was performed by one way ANOVA in cases with two classes of age group. The results are outlined in table 1

3.3 Correlations and clustering of bands in age group
The significant and tendency bands that were identified using one way ANOVA were used to perform principal component analysis. In a step by step analysis, for IgM we noticed clustering of samples, proximity of species (bands) and length of band to depend on age group. For IgM the correlation derived explained 14% and 19% for vertical and horizontal axis respectively. All bands in the extreme left depicts age group 1 while all bands in right hand side shows age group 2 (figure 3a and b). Upon introduction of diet, the landmark of clustering was noticed. In the four classes categorization, clear principal clustering was noticed with respect to animal fed on; (a). pseudo Diet A of age group 1
(b). pseudo diet A of age group 2 (c). pseudo Diet B of age group 1 and (d). pseudo Diet B of age group 2. In this grouping there was homogenous quantitative and qualitative correlations of antibodies binding BLL fragments and clear cut between the groups could be easily noticed. For instance calves number 8708, 2992, 5667 and 3140 falling within class (b) are clustered in a close proximity albeit with some outliers. The proximity of bands kDa 43, 31 and 11 shows they are related to the same age group 2 (figure 3 a). With respect to IgG, correlation explained was 17% and 28% for the vertical and horizontal axis respectively. However, there was similarity of the pattern of proximity and orientation of bands as in the case for IgM. Considering bands 91, 86, 58 and 56, 46, 42 and 67, 57, 41, 31, 15 etc were related to age group 2 and 1 respectively (figure 3 b). The longer bands depicts high significant variance (p value). In essence the calves in class b and d were the most dispersed, almost in all the four quadrats. Moreover, calves 1647 was totally in a different quadrant with calves 8708 and 9573 (Figure 3b). We recall that these animals were in the same age group and fed same diet and were clustered with IgM. However, there is clustering with respect to class (a) consisting of calves number 5146, 2052, 3655 etc. The same is noticed with class (c) as well. The similarity between these classes is the age group depicting the role that age plays in shaping the defined IgG repertoires. In all the cases figure 3 a and b, for IgM and IgG there was clustering into two; right and left halves depicting age group effect.

4. Discussion

4.1 Natural auto antibodies are present in calves

In the present study and under the conditions of the experiment, the results showed IgM and IgG isotype auto-antibodies present in calves. This is in line with other studies that identified these Na(a)bsisotypes besides IgA in human and other animals (Pozsonyi et al., 2009). The majority of the calves showed conserved banding and almost corresponding bands for both IgG and IgM except a few bands that were recognized by IgM but not IgG. This is contrary to previous results that found extra IgG autoantibodies bands detected in humans (Stahl et al., 2000) and chicken (De Jong et al. 201; Khobondo et al., 2014). Contrary to our expectation, is the observed qualitative conservation of IgG along time and among individual calves. This contradicts other literature that reported distinct banding pattern for IgG amongst individuals in chicken (de Jong et al., 2013) and in human (Madi et al., 2009). The pattern may be differently logical in cattle because no work has been reported before.

4.2 There exist quantitative differences in staining intensities

Although most of the bands were qualitatively the same, our study reveals the bands staining intensities were significantly affected by age group. First, it is worth noting that we observed differences in the height of specific peaks staining of isotypes (figure 2). In essence IgG had higher height of specific peaks staining as compared to IgM but the background staining was comparable between the two isotypes. In our opinion, the detection of higher heights of specific peaks with IgG suggest the implication of auto- IgG as the isotype most suitable for determining genetic variation and immune competency. The choice for IgG over IgM or verse versa for fingerprinting is debatable: some report prefer IgGisotype fingerprinting (Francoeur,
1988) while for others IgM is preferred (De Jong et al., 2013). We could not ascertain this in our case because of the ambiguity of our experimental design.

**4.3 PCA reveal clustering according to age group for both IgM and IgG.**

Indeed we confirmed that animals were profoundly and principally grouped according to age groups. The role played by age is principally noticed. As noted in figure 3 there were clear demarcations of clustering with virtually all old calves (age group 1) being on the left while the young ones (age group 2) are on the right on the horizontal first dimensional axis. The role played by aging is principally highlighted in PCA analysis for both IgM and IgG. In our case, the cause for such age related effect can be attributed to environmental factors. We cannot further speculate the exact environments because we do not know what the antigens are constituted of, neither do we know their sources. We could be biased to attribute that the calves IgG depict the maternal imprinting (Lemke et al., 2009). Although there are high chances that the dams were fed the same diet and reared in the same periphery resulting on the almost same maternally transferred IgG with idiotypic network to the next generation through epigenetic (Finke et al., 2008).

**5. Conclusions.**

We report the presence of IgM and IgG(Na(a))bsisotypes binding bovine liver lysate in calves. The IgG and IgM(Na(a))bs repertoires are affected by age. There is a confirmed clustering of animals and proximity of bands sharing same age group.

**6. Acknowledgement**

We acknowledge the Indigenous Chicken Productivity Programme for provision of facilities. The programme is funded by European Union through African Union.
Table 1. The tendency and significant levels for the IgM and IgG age group

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Y= bands staining intensities

List of Figures

Figure 1 a. Representative Western blots of the animals for IgM Isotype showing different animals of different age groups. There is qualitative similarities of the conserved banding pattern in animals but with quantitative differences.
Figure 1 b. Representative Western blots of the same animals (as for figure 1 a), for IgG Isotype showing different animals age groups. There is qualitative similarities of the conserved banding pattern in animals but with quantitative differences. Many bands are recognised at the lower molecular weight for IgG than IgM.

Figure 2 a. Graphical representations of western blot of an animal for IgM Isotype. The graph depicts background and height of the staining peak. The total number of recognised bands are 39 which are relatively higher as compared to IgG recognised bands.
Figure 2 b. Graphical representations of western blots of the same animal (figure 2 a) for IgG Isotype. IgG has relatively higher staining peak but the background are comparable. The number of bands recognised are lower (30) as compared to IgM.

Figure 3 a. PCA analysis of staining patterns of IgM auto antibodies to bovine liver lysate of the four Classes of 20 calves showing the tendency and significant bands (table 1). Eigenwaardes were 19% vertical and 14% horizontal axis.
Figure 3 b. PCA analysis of staining patterns IgG auto antibodies to bovine liver lysate of the four classes of calves showing the tendency and significant bands (table 1). Eigenwaardes were 28% vertical and 17% horizontal axis

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Dissemination of cassava products for livestock supplementation: are the cassava and goat farmers in coastal lowland Kenya ready?

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Abstract

Cassava production using high yielding, disease and pest tolerant varieties in coastal Kenya yield 9t DM/ha of unmarketable cassava root and 1.5t DM/ha of leaf which could be used to feed livestock. Research has shown that cassava chips can be used to improve milk production in dairy cows whereas cassava hay has been shown to be as good as a commercial anthelmintic in controlling worms in goats. However this information has to reach farmers to be applicable, and the most likely farmer to adopt these technologies is one who grows cassava and keeps livestock. Observations have shown that a cassava farmer is more likely to keep goats than cattle. Therefore a study was carried out with Amani Farmers Field School (FFS), Basi Mwangaza Farmers Group, Ruruma Farmers Association, Migumoini Dairy Farmers Group and Jaribuni Farmers Group of Kilifi County in coastal lowlands, Kenya, to find out if cassava cum goat farmers were ready to receive the information and their perceptions on supplementing goats with cassava chips and hay. The farmers were called to sensitization meetings where a checklist was used to probe on systems of goat rearing, housing, supplementation, dry season feeding, prevalent goat diseases and treatment of worms. They were also informed of the benefits of supplementing with cassava chips and hay and asked if they would adopt the technologies. Results showed that 70% of cassava farmers kept goats. The goats were kept for subsistence reasons. Except for Amani Farmers Field School and to a small extent Jaribuni Farmers Group where free range system of rearing was practiced, goats were tethered when browsing. Farmers in all groups tethered or housed their goats at night, except Migumoini Dairy Group farmer who housed their goats exclusively. Dry season feed scarcity was experienced and addressed by Basi Mwangaza and Migumoini Farmer groups whereas Amani FFS experienced it but did not address the problem. Basi Mwangaza group addressed the problem by destocking at the beginning of the dry season and feeding mango leaves whereas in Migumoini Dairy Group addressed it by feeding mango leaves, maize stover and wild twigs. Worms and/or diarrhoea were common health problem in all study sites where it was treated using commercial anthelmintics and medicinal plant products. Except Basi Mwangaza farmers group who would not
feed cassava hay because they believed cassava leaves are poisonous to goats, farmers in the other groups did not have any problem feeding cassava chips and hay to their goats. However, at all sites sampled, farmers felt preparation and feeding of the chips and hay was too laborious for subsistence goat rearing. Theory you results are discussed with a view to introducing cassava chips and hay in the goat rearing systems.

Introduction

One of the major limiting factors to livestock production in coastal Kenya is feed scarcity especially during the dry periods. Furthermore, smallholder livestock farmers in the region are poor therefore unable to purchase commercial supplements needed to feed their livestock during these times. The alternative is to use homegrown feed supplements. Research in coastal lowland Kenya has revealed that cassava chips is as good as maize bran in providing energy to milk producing cows (Kiura et al., 2007). Munga et al. (2014) demonstrated that cassava based Napier grass silage could sustain milk production in dairy cows during the dry period which lasts up to four months. It has been shown that daily supplementation of goats with cassava hay for eight weeks had a similar effect to a commercial anthelmintic on worm control. With proper information, farmers can produce the cassava products on their farms. This is possible through the release by the Ministry of Agriculture of high yielding (70 t/ha of roots) cassava varieties developed by KALRO (Gethi et al., 2011). Nine (9) t/ha of the harvested roots are unmarketable and can be used as livestock feed (Lewa et al., 2014). In addition, cassava yields up to 1.5 t DM/ha of leaf which is high in protein (22%) and contains tannins which are anthelmintic (Dung et al., 2005, Mwamachi et al, in press). This information should reach and be applied by livestock farmers in order to improve dairy productivity. It would be more beneficial to farmers who grow cassava and also keep livestock since they do not have to purchase the cassava roots and/or leaves. Earlier it was observed that cassava growers were more likely to keep goats than cattle, and therefore, a study was conducted to evaluate potential uptake of this technology by farmers. The objectives of the study were to determine the goat rearing systems practiced by cassava farmers, sensitize farmers on the benefits of supplementing goats with cassava products and get farmers’ perceptions on supplementing goats with cassava products.

Materials and methods

Site and farmer group selection

The groups involved in the study were: Amani Farmers Field School (FFS) in Gotani (Kaloleni sub-County); Basi Mwangaza Farmers Group (FG) in Tezo (Kilifi North sub-County); Ruruma Farmers Association (RUFA) in Ruruma (Kaloleni sub-County); Migumoini Dairy FG in Kikambala (Kilifi South sub-County) and Jaribuni FG in Jaribuni (Ganze sub-County). The farmers groups were invited to sensitization meetings through the area agricultural/ livestock officer or through their group leaders.

Information gathering

During the sensitization meetings, information was received or passed to farmers through a semi-structured questionnaire (checklist). The information gathered was: the proportion of cassava farmers who also kept goats; production objectives (commercial or subsistence); system of goat rearing and housing; ways of dealing with feed scarcity.
during dry seasons (supplementation and feed conservation); prevalent goat diseases and how they are treated (ethno-veterinary vs conventional medicine). Farmers were informed of how to prepare the cassava chips and the benefits of supplementing goats with the chips and hay using samples of the products and extension leaflets before they were asked about their perceptions on the technologies.

**Results**

**Attendance**

Group membership and meeting attendance are shown in Table 1. A total of 63 farmers (35 male and 28 females) attended the meetings. However, with Basi Mwangaza and Amani FFS, more females than males attended. Many members of the umbrella groups (Basi Mwangaza, Ruruma Farmers Association and Jaribuni) did not attend due to the long distances from their homes to the selected venues. For individual groups (Amani FFS and Migumoini Dairy Farmers Group) attendance was about 50% (19 out of 37); absentee farmers were reported to be involved in other commitments.

**Table 1. Group membership and attendance by gender at sensitization meetings**

<table>
<thead>
<tr>
<th>Group name</th>
<th>Membership</th>
<th>No. of members who attended meeting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amani Farmers Field School</td>
<td>22</td>
<td>11 (5M, 6F)</td>
</tr>
<tr>
<td>Basi Mwangaza Farmers Group</td>
<td>&gt;300 (Umbrella body of many groups)</td>
<td>27 (12M, 15F)</td>
</tr>
<tr>
<td>Ruruma Farmers Association</td>
<td>Many (6 Farmer Groups)</td>
<td>10 (6M, 4F)</td>
</tr>
<tr>
<td>Migumoni Dairy Farmers</td>
<td>15</td>
<td>8 (6M, 2F)</td>
</tr>
<tr>
<td>Jaribuni Farmers Group</td>
<td>Many (5 Farmer Groups)</td>
<td>8 (6M, 2F)</td>
</tr>
</tbody>
</table>

M = Male, F = Female

**Goat rearing**

The number of goats kept and systems of goat rearing used by the cassava farmers are shown in Table 2 below. Apart from Ruruma Farmers Association, most of the farmers who attended the meetings kept goats. The number of goats kept by one farmer ranged from 1 to 19 and consisted almost exclusively of Small East African breed except in Jaribuni where the Galla breed was also found. The goats were kept for subsistence; the animals were tethered on the farm during the day in all sites but some members of Amani FFS and Jaribuni FG practiced free range rearing. At all sites provision of water was not a problem.
Table 2. Number of goats kept and systems of rearing practiced by cassava farmers

<table>
<thead>
<tr>
<th>Group name</th>
<th>Proportion of farmers who kept goats</th>
<th>Number of goats kept by a farmer</th>
<th>System of rearing</th>
<th>How farmers secured goats at night</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amani Farmers Field School</td>
<td>10 out of 11</td>
<td>1-16</td>
<td>Free range mostly</td>
<td>Housing or tethering</td>
</tr>
<tr>
<td>Basi Mwangaza Farmers Group</td>
<td>16</td>
<td>2-11</td>
<td>Tethering</td>
<td>Mostly housing. Tethering to a small extent</td>
</tr>
<tr>
<td>Ruruma Farmers Association</td>
<td>4 out of 10</td>
<td>3-6</td>
<td>Tethering</td>
<td>Housing or tethering</td>
</tr>
<tr>
<td>Migumoni Dairy Farmers</td>
<td>7 out of 8</td>
<td>2-4</td>
<td>Tethering</td>
<td>Housing</td>
</tr>
<tr>
<td>Jaribuni Farmers Group</td>
<td>7 out of 8</td>
<td>2-19</td>
<td>Tethering or free range</td>
<td>Housing or tethering</td>
</tr>
</tbody>
</table>

Dry season feeding and supplementation

Table 3 shows handling of dry season feed scarcity and supplementation by various groups. Three groups (Amani FFS, Basi Mwangaza and Migumoini) had problems feeding their goats during dry seasons. In Basi Mwangaza, farmers destocked to manageable numbers and supplemented with maize bran. Amani FFS farmers did not take any action but released the animals to eat whatever they could find whereas Migumoini farmers provided mango leaves and maize stovers.

Table 3. Addressing dry season feed scarcity and supplementation of goats by cassava farmers

<table>
<thead>
<tr>
<th>Group name</th>
<th>Addressing dry season feed scarcity</th>
<th>Supplementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amani Farmers Field School</td>
<td>Ignored</td>
<td>None was given. Cassava peels were given during preparation of cassava for human food. Goats fed on cassava leaves accidentally</td>
</tr>
<tr>
<td>Basi Mwangaza Farmers Group</td>
<td>Addressed by destocking at the start of dry spell, and feeding the remaining goats on mango leaves</td>
<td>Maize bran was given</td>
</tr>
<tr>
<td>Ruruma Farmers Association</td>
<td>Was not necessary</td>
<td>Was not given</td>
</tr>
<tr>
<td>Migumoni Dairy Farmers</td>
<td>Addressed by offering mango leaves, maize stover, wild twigs</td>
<td>Was not given</td>
</tr>
<tr>
<td>Jaribuni Farmers Group</td>
<td>Was not necessary</td>
<td>Was not given</td>
</tr>
</tbody>
</table>
Disease control and farmer group perceptions

Table 4 shows the various goat health conditions that were prevalent in the various study sites and how cassava farmers managed them. Diarrhea and/or worms were prevalent at all study sites. It was treated by the use of commercial anthelmintics and ethno-veterinary products such as aloe vera, neem and moringa. The Table also shows the perceptions of the five farmer groups on supplementing goats with cassava chips and hay. Farmers in all groups did not have any problem supplementing goats with cassava chips and/or hay except those of Basi Mwangaza Farmer Group who believed that cassava leaves were poisonous to goats and therefore they would not supplement with cassava hay. All the groups were in agreement on one thing, that the preparation and feeding of cassava products was too laborious for subsistence goat keeping but would be appropriate when farmers in the coastal region adopt dairy goats for commercial milk production.

Discussion

The information gathered gives a picture of goat rearing systems practiced by cassava growing farmers in coastal lowland of Kenya as an opportunity to introduce cassava chips and hay as goat supplements. In general, males outnumbered females in the meetings due to the fact that goats are owned and managed by men in the study areas. About 70% of the farmers kept goats; the Small East African goat was kept for subsistence reasons.

The practice of tethering goats when browsing and tethering or housing the animals in the evening offers an opportunity for supplementation of animals individually thereby ensuring each goat receives the required quantity. Farmers at a majority of the study sites did not supplement their goats. This means that the concept of goat supplementation would have to be introduced to cassava farmers before they can adopt supplementation with cassava chips and hay.
Table 4. Prevalent health conditions, worm treatment and farmer groups’ perceptions on supplementing cassava products

<table>
<thead>
<tr>
<th>Group name</th>
<th>Prevalent goat diseases/parasites</th>
<th>Treatment of worms</th>
<th>Perceptions on feeding cassava products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amani Farmers Field School</td>
<td>Pneumonia, Worms, Skin diseases</td>
<td>Commercial drugs</td>
<td>Had no problem feeding cassava chips and leaves to a commercial flock.</td>
</tr>
<tr>
<td>Basi Mwangaza Farmers Group</td>
<td>Diarrhoea, Worms</td>
<td>Commercial drugs</td>
<td>Had no problem feeding cassava chips but not hay because they believed cassava leaves were poisonous to goats</td>
</tr>
<tr>
<td>Ruruma Farmers Association</td>
<td>Worms, Diarrhoea, Pneumonia</td>
<td>Commercial drugs</td>
<td>Would have no problem feeding cassava chips and hay to a commercial enterprise. However it was not necessary as the goats had enough browse.</td>
</tr>
<tr>
<td>Migumoni Dairy Farmers</td>
<td>Skin diseases, Foot rot, Worms</td>
<td>Commercial drugs</td>
<td>Would feed the products to a profitable enterprise like dairy cattle</td>
</tr>
<tr>
<td>Jaribuni Farmers Group</td>
<td>Worms, Foot rot, Diarrhoea</td>
<td>Commercial drugs</td>
<td>No necessary to feed cassava products to goats, only to dairy cattle.</td>
</tr>
</tbody>
</table>

In all the five sites, worms and or diarrhea were prevalent. This is in conformity with results by Kiura and Mwamachi (2006) who found that the major health condition limiting goat production in the coastal region is worms. Farmers in the study sites used Neem, aloe vera and moringa to treat the parasites in addition to the use of commercial anthelmintics. This means introduction of cassava hay for worm control would not be such a foreign idea to the farmers. However, the plants they use are deemed to be curative whereas cassava hay is preventative i.e. it has to be supplemented for at least four weeks for its effects on worms to be you. Thus this long period of supplementation may discourage farmers willing to adopt the technology.

**Conclusion**

Farmers were willing to adopt the technologies for commercial ventures such as dairy goat production. Adoption of cassava hay for worm control in goats by cassava farmers could be easy because the farmers use medicinal plants to treat worms. However, the
long period needed to manage worm load with cassava hay discouraged farmers from using the method.

**Recommendation**

The authors recommend that feeding of cassava products be targeted to dairy production since dairying is the most popular commercial enterprise in the coastal region. Meanwhile efforts should be made to introduce milk goats in the region; only then would cassava hay supplementation for worm control be applicable in coastal lowland Kenya.

**Acknowledgment**

The authors acknowledge the Director General, KALRO for permission to carry out the work, National Council for Science and Technology [renamed: National Commission for Science Technology and Innovation (NACOSTI)] for providing the funding through University of Nairobi Grant and Mr. J. K. Gogwe assisting in farmer interviews.

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Variation in chemical composition of *eragrostis superba* peyr and *cenchrus ciliaris* l.

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Abstract

A study was conducted in the southern rangelands of Kenya to establish the nutritive value of ecotypes of *Cenchrus ciliaris* and *Eragrostis superba*. A total of eleven ecotypes for *C. ciliaris* and nine for *E. superba* collected from various sites representative of agro-ecological zone III to VI were established at KALRO Kiboko research centre in a randomized complete block design. Collected plant samples were analysed for In-vitro dry matter digestibility (INVDMD), crude protein (CP), Crude fibre (CF), ash content and percent dry matter yield (%DM).

Significant variations were observed among the *C. ciliaris* ecotypes. KBK2 and KLF2 collections had significantly higher ash content. Only KBK2 had higher values ($p < 0.05$) than TVT1 in INVDMD with no variation between the rest of the ecotypes. INVDMD had positive correlation ($p < 0.05$) with stem thickness and leaf breadth while CP correlated positively with leaf length, plant height, heading time and stem thickness. Plant size could therefore be used to select for CP levels in *C. ciliaris*. However, further studies, especially across seasons are necessary to ascertain this observation. Kiboko (KBK2) and Kilifi (KLF1) collections had higher CF, CP and INVDMD among *E. superba* ecotypes. However, significant variations between ecotypes were recorded resulting in several groupings within individual variables. There was no significant relationship between the nutritive value components and herbage related traits such as plant height, leaf length and breadth and tiller numbers with *E. superba*. Mean ash content for *C. ciliaris* (13.6%) was higher than *E. superb* (8.6%). The two species had no difference in the other four nutritive value components. Significant variations exist among the collections that could potentially be exploited to meet different feed requirements.

Keywords: nutritive value, ecotype, grasses, in-vitro digestibility

Introduction

Feed inadequacy in terms of quality and quantity is the major constraint to livestock production in the Arid and Semi-arid Lands (ASALs) of Kenya (Gitunu et al., 2003; Kibet et al., 2006; Mnene, 2006). Reseeding with range grass species as an option to address the problem has been promoted with some success (Nyariki et al., 2008; Manyeki et al., 2011). *Eragrostis superb* and *Cenchrus ciliaris* grass species are drought tolerant and are among the species being used in the reseeding. They are among the most
Variation in chemical composition of eragrostis superba peyr and cenchrus ciliaris l. preferred grasses by farmers in the ASALs (Mnene, 2006) with preference shifting from *E. superba* to *C. ciliaris* with increase in aridity (Ndathi *et al.*, 2012).

Despite having been the most studied species in the genus *Cenchrus*, Goel *et al.* (2011) notes that *C. ciliaris* has not gone through the bottleneck of domestication and is still open for exploitation by using naturally occurring variation in the species. Variation in its natural collections has been observed in agro-morphological attributes and chemical composition (Pengelly *et al.*, 1992; Hacker and Waite, 2001; Guillermo, 2003; Mnif *et al.*, 2005; Jorge *et al.*, 2008, Ashraf, 2013). The species has been associated with loss of native plant species due to its invasive nature and has been declared as a noxious weed in some areas (Cook *et al.*, 2005; Franklin *et al.*, 2006). *Eragrostis superba* has high tolerance to drought, salinity and alkalinity and it is also used for erosion control. It is fairly palatable and readily grazed but it gets stemmy and unpalatable near maturity where its nutritive value drops (FAO, 2012).

Amount of nutrients in the forage determines the productivity of livestock. Knowledge of forage quality is necessary in planning and proper utilization of the pastures for optimum livestock performance (Amiri *et al.*, 2012). This study was therefore aimed at establishing the nutritional value of the ecotypes of the two grass species with the aim of exploiting the potential in their natural variation for development of better varieties.

**Materials and methods**

The study involved 11 ecotypes of *Cenchrus ciliaris* and 9 of *Eragrostis superba* that were collected from Kilifi, Taveta, Kiboko, and Magadi in the semi-arid lands of Kenya. They are represented by KLF, TVT, KBK and MGD, respectively. The collection sites are representative of agro-ecological zone 3, 4, 5 and 6, respectively. The ecotypes were planted at KALRO Kiboko research centre in October 2012 in single plant spaced plots of 4m × 4m with 1m and 0.5m between and within rows. The design was a randomized complete block design with 3 replicates. Full plot establishment was achieved in the long rains of April 2013. The data reported here was collected during the short rains of October – December 2013. All the plots were clipped to 5cm level above the ground at the beginning of the rains. At six weeks post clipping, twelve plants were randomly sampled from the 3 replicates of each ecotype and clipped to 5cm level. The samples were bulked into 1 sample per ecotype and dried in the oven for 24 hours at 60°C. The dried samples were used in the analysis of ash, crude protein (CP), Crude fibre (CF) content, percent dry matter yield (%DM) and in-vitro digestibility at the animal production laboratory, University of Nairobi.

The ash, CP, CF, and DM yield of individual grass ecotypes were analyzed using the standard procedures of AOAC (2005). Nitrogen content was determined by the Kjeldahl method, while percent crude protein (CP) was calculated by multiplying the nitrogen content in the sample with a factor of 6.25. The in-vitro digestibility of dry matter (IVDMD) was done by the Tilley and Terry procedure (Tilley and Terry, 1963). The data on herbage related traits, which was used in correlation, was collected at full plot heading or flowering during the same season.

The data was analysed using Statistical Package for Social Sciences (SPSS Version 20) for correlation, analysis of variance (ANOVA), and mean was nice using Lsd at 0.05 level of significiance.
Results and discussion

There was variation in crude fiber, In-vitro digestibility and percent dry matter between sites in ecotypes of *C. ciliaris* (Table 1). Kilifi ecotypes were significantly higher than Taveta in CF and also significantly higher than Kiboko and Kilifi in In-vitro digestibility. However, the Taveta collections were significantly lower than Kilifi in % dry matter. All the Kilifi collections were previously clustered as none robust ecotypes that were short with thin stems and thin, narrow leaves compared to the rest of the ecotypes. This could explain the high DM content in these collections. Taveta ecotypes had lower CF and high In-vitro digestibility which indicate better nutritive values. However, they were lower in percent dry matter yield.

<table>
<thead>
<tr>
<th>Site</th>
<th>N</th>
<th>CF</th>
<th>CP</th>
<th>IVDMD</th>
<th>Ash</th>
<th>%DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiboko</td>
<td>6</td>
<td>35.8</td>
<td>a</td>
<td>8.7</td>
<td>a</td>
<td>48.8</td>
</tr>
<tr>
<td>Kilifi</td>
<td>6</td>
<td>37.7</td>
<td>a</td>
<td>9.0</td>
<td>a</td>
<td>49.4</td>
</tr>
<tr>
<td>Magadi</td>
<td>4</td>
<td>36.2</td>
<td>b</td>
<td>8.6</td>
<td>a</td>
<td>49.3</td>
</tr>
<tr>
<td>Taveta</td>
<td>6</td>
<td>34.2</td>
<td>b</td>
<td>10.2</td>
<td>a</td>
<td>52.5</td>
</tr>
</tbody>
</table>

Figures with different letter superscript are significantly different at p<0.05.

There was variation in crude fiber, crude protein and ash between the sites in ecotypes of *E. superba* (Table 2). Kilifi ecotypes had significantly higher CF levels than Magadi and Taveta while Magadi collection had significantly higher CP level than those from Kiboko. The Magadi collection had significantly higher ash content than those from Taveta.

<table>
<thead>
<tr>
<th>Site</th>
<th>N</th>
<th>CF</th>
<th>CP</th>
<th>IVDMD</th>
<th>Ash</th>
<th>%DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiboko</td>
<td>4</td>
<td>39.1</td>
<td>b</td>
<td>8.4</td>
<td>a</td>
<td>51.8</td>
</tr>
<tr>
<td>Kilifi</td>
<td>6</td>
<td>40.5</td>
<td>a</td>
<td>9.6</td>
<td>b</td>
<td>51.3</td>
</tr>
<tr>
<td>Magadi</td>
<td>2</td>
<td>37.0</td>
<td>b</td>
<td>11.2</td>
<td>a</td>
<td>49.9</td>
</tr>
<tr>
<td>Taveta</td>
<td>6</td>
<td>39.0</td>
<td>a,b</td>
<td>10.0</td>
<td>a</td>
<td>48.9</td>
</tr>
</tbody>
</table>

Figures with different letter superscript are significantly different at p<0.05.

There was significant variation in all measured nutritive content attributes among ecotypes of *C. ciliaris* (Table 3). Significant variation was observed in Kiboko collections in percent DM yield where KBK1 was higher than KBK2 and KBK3. The mean DM yield was 91.5% for all the ecotypes which was lower than 92.1 reported by Ndathi *et al.* (2012) with *C. ciliaris* grass samples from farmers’ fields.
Table 3: Mean values for nutritive contents of *C. ciliaris* ecotypes

<table>
<thead>
<tr>
<th>Ecotype</th>
<th>% DM</th>
<th>Ash</th>
<th>IVDMD</th>
<th>CP</th>
<th>C F</th>
</tr>
</thead>
<tbody>
<tr>
<td>KBK1</td>
<td>93.1</td>
<td>a</td>
<td>14.0</td>
<td>48.0</td>
<td>3.8</td>
</tr>
<tr>
<td>KBK2</td>
<td>90.5</td>
<td>b</td>
<td>15.2</td>
<td>55.0</td>
<td>3.5</td>
</tr>
<tr>
<td>KBK3</td>
<td>90.4</td>
<td>b</td>
<td>13.9</td>
<td>51.7</td>
<td>3.2</td>
</tr>
<tr>
<td>KLF1</td>
<td>92.4</td>
<td>a</td>
<td>12.5</td>
<td>48.7</td>
<td>3.7</td>
</tr>
<tr>
<td>KLF2</td>
<td>91.7</td>
<td>a</td>
<td>15.3</td>
<td>50.0</td>
<td>3.4</td>
</tr>
<tr>
<td>KLF3</td>
<td>91.5</td>
<td>a</td>
<td>11.2</td>
<td>51.7</td>
<td>3.4</td>
</tr>
<tr>
<td>MGD1</td>
<td>91.7</td>
<td>a</td>
<td>13.2</td>
<td>50.8</td>
<td>3.7</td>
</tr>
<tr>
<td>MGD3</td>
<td>91.2</td>
<td>a</td>
<td>14.6</td>
<td>51.1</td>
<td>3.2</td>
</tr>
<tr>
<td>TVT1</td>
<td>90.6</td>
<td>a</td>
<td>14.2</td>
<td>45.5</td>
<td>3.7</td>
</tr>
<tr>
<td>TVT2</td>
<td>92.1</td>
<td>a</td>
<td>11.9</td>
<td>49.5</td>
<td>3.7</td>
</tr>
<tr>
<td>TVT3</td>
<td>91.8</td>
<td>a</td>
<td>14.2</td>
<td>50.9</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Figures with different letter superscript are significantly different at p<0.05.

There were significant variations between sites in ash content. KBK2 and KLF2 had significantly higher ash content than all the other ecotypes. Ash represents the total mineral content in the sample. However, this includes both endogenous and exogenous mineral content. The endogenous content includes calcium, magnesium, potassium and phosphorus, which is valuable to livestock and is about 6% in grasses. Therefore, the extra ash represents contamination with soil contents among others, which may not be valuable to the animal by reducing total digestible nutrients in the feed. The ash content results in this study were higher than Onyeonagu and Eze (2013) who recorded 6.21 and 5.77 for rainy and dry seasons with selected grass species. However, their grass species were robust grasses, mainly fodder, with higher stem content which could explain the difference. Higher stem content has been reported to result in low ash content in plants.

KBK2 had higher IVDMD value (p<0.05) than TVT1 but there was no variation between the rest of the ecotypes. This attribute had significant positive correlation with stem thickness and leaf breadth. This indicates that Ecotypes with thicker stems and wider leaves could have higher IVDMD. Although not significantly correlated with robustness, these two attributes are associated with the robust group.

The highest CP content among the ecotypes was in KBK3 at 10.9% and the lowest was KLF3 with 6.6%. This range was below the minimum reported by Ashraf (2013) at 13.1, which could be due to variation in the time of sampling, ecotypic variation or environmental factors. All the Kiboko collections (KBK1, 2 and 3) and MGD3 had significantly higher crude protein levels than KLF3. Variation in CP content among cultivars have previously been reported by Saini *et al.* (2006) and Ashraf (2013). There was significant positive correlation (p<0.05) between CP and six of the selected herbage related traits as well as ash content (Table 4). Tall, long leaved and thick stemmed ecotypes have higher CP. Also, robust and late flowering ecotypes have potentially higher CP than small and early flowering ecotypes at six weeks post harvesting. Probably the CP levels were already on the downfall in the small ecotypes since full plot heading had been achieved by end of the fourth week. Full plot heading among the robust group was achieved by end of fifth week. Thus heading/flowering time can be used to estimate the period for obtaining optimum CP for different ecotypes of this species. However, further
studies are necessary to ascertain the optimum levels for individual ecotypes.

Table 4: Pearson correlation results between nutritive content and selected herbage related traits

<table>
<thead>
<tr>
<th>Attribute</th>
<th>% DM</th>
<th>Ash</th>
<th>INVDMD</th>
<th>C P</th>
<th>C F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% DM</td>
<td>1</td>
<td>-</td>
<td>3 4 3</td>
<td>-</td>
<td>3 7 5</td>
</tr>
<tr>
<td>Ash</td>
<td>-</td>
<td>3 4 3 1</td>
<td>-</td>
<td>2 7 9</td>
<td>6 6 1 *</td>
</tr>
<tr>
<td>INVDMD</td>
<td>-</td>
<td>3 7 5</td>
<td>2 7 9 1</td>
<td>1 6 2</td>
<td>-</td>
</tr>
<tr>
<td>C P</td>
<td>-</td>
<td>2 3 2</td>
<td>6 6 1 *</td>
<td>1 6 2 1</td>
<td>-</td>
</tr>
<tr>
<td>C F</td>
<td>6 5 4 *</td>
<td>-</td>
<td>1 5 6</td>
<td>5 2 6</td>
<td>2 9 1 1</td>
</tr>
<tr>
<td>Robust group</td>
<td>-</td>
<td>1 3 1</td>
<td>4 7 3 5 5 0</td>
<td>6 5 2 *</td>
<td>-</td>
</tr>
<tr>
<td>Flowering group</td>
<td>-</td>
<td>1 6 7</td>
<td>5 3 8</td>
<td>4 9 2</td>
<td>7 7 0 **</td>
</tr>
<tr>
<td>Heading date</td>
<td>-</td>
<td>2 6 8</td>
<td>3 9 7</td>
<td>4 4 6</td>
<td>6 3 4 *</td>
</tr>
<tr>
<td>Plant height</td>
<td>-</td>
<td>4 8 0</td>
<td>5 0 9 5 5 1</td>
<td>7 1 9 *</td>
<td>-</td>
</tr>
<tr>
<td>No of nodes</td>
<td>-</td>
<td>0 8 3</td>
<td>2 4 2</td>
<td>3 4 0</td>
<td>2 2 6</td>
</tr>
<tr>
<td>Stem thickness</td>
<td>-</td>
<td>3 7 1</td>
<td>4 3 8</td>
<td>6 0 8 *</td>
<td>7 1 2 *</td>
</tr>
<tr>
<td>Leaf length</td>
<td>-</td>
<td>5 7 8</td>
<td>4 8 2 5 6 0</td>
<td>6 7 5 *</td>
<td>-</td>
</tr>
<tr>
<td>Leaf breadth</td>
<td>-</td>
<td>2 4 7</td>
<td>4 8 7</td>
<td>6 8 4 *</td>
<td>5 7 1</td>
</tr>
<tr>
<td>Tiller numbers</td>
<td>-</td>
<td>4 5 5</td>
<td>-</td>
<td>0 3 1</td>
<td>2 7 4</td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level and *Correlation is significant at the 0.05 level (2-tailed). 1small and 2 robust; 2 early and 2 late**

Crude fiber levels ranged from 38.4 to 32.4% for KBK1 and KBK3 or MGD3, respectively. The highest CF of compared well with Ashraf (2013) with 39.48g/100g. Four ecotypes, KBK1, KLF3, TVT1, TVT2 and MGD1 were significantly higher than KBK3 and MGD3. KBK1 had the highest level of CF probably because the ecotype has tough stems and rough leaves. This was corroborated during an evaluation of the farmer knowledge and perception on the ecotypes. Crude fibre was negatively correlated with all the traits and to significant levels with plant height and leaf length. This means tall and long leaved ecotypes had lower Crude fibre. These are KBK2, KBK3 and MGD3 that had significantly (p < 0.05) longer leaves than the rest. There was also positive and significant relationship between ash content and CP and %DM and CF.

Some of the ecotypes in the collection that have promising results include KBK2, KBK3 and MGD3 which had the highest CP and lowest CF. Ecotype KBK3 had significantly high IVDMD but was significantly low in dry matter yield. This is probably due to its long, broad, wide leaves and high moisture content. The ecotype was clustered in the robust group during characterization using morphological traits. Bulkiness is always misinterpreted to mean high yield in forage production (Boonman, 1993). Despite being bulky, Elephant grasses has the lowest %DM yield of all cultivated East African grasses such as Guineagrass and Rhodesgrass.

There was significant variation in all the measured attributes among ecotypes of E. superba resulting several groups within a component (Table 5). Unlike C. ciliaris, there was no significant relationship between the nutritive value components and herbage related traits such as plant height, leaf length and breadth and tiller numbers.
**Table 5: Mean nutritive contents of E. superba ecotypes**

<table>
<thead>
<tr>
<th>Ecotype</th>
<th>C</th>
<th>F</th>
<th>C</th>
<th>P</th>
<th>I</th>
<th>V</th>
<th>D</th>
<th>M</th>
<th>A</th>
<th>s</th>
<th>h</th>
<th>%</th>
<th>D</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>KBK1</td>
<td>3.9</td>
<td>8</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>0</td>
<td>c</td>
<td>d</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>a</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>KBK2</td>
<td>4.0</td>
<td>4</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>a</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>TVT1</td>
<td>3.9</td>
<td>2</td>
<td>c</td>
<td>d</td>
<td>8</td>
<td>4</td>
<td>c</td>
<td>d</td>
<td>4</td>
<td>8</td>
<td>9</td>
<td>b</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td>TVT2</td>
<td>3.8</td>
<td>5</td>
<td>d</td>
<td>e</td>
<td>7</td>
<td>7</td>
<td>d</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>c</td>
<td>d</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>TVT3</td>
<td>3.7</td>
<td>0</td>
<td>f</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>a</td>
<td>4</td>
<td>9</td>
<td>7</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>9</td>
</tr>
<tr>
<td>KLF1</td>
<td>4.1</td>
<td>6</td>
<td>a</td>
<td>1</td>
<td>0</td>
<td>8</td>
<td>a</td>
<td>b</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>a</td>
<td>b</td>
<td>8</td>
</tr>
<tr>
<td>KLF2</td>
<td>4.0</td>
<td>7</td>
<td>a</td>
<td>b</td>
<td>9</td>
<td>7</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>5</td>
<td>0</td>
<td>4</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>KLF3</td>
<td>3.7</td>
<td>7</td>
<td>e</td>
<td>f</td>
<td>9</td>
<td>3</td>
<td>c</td>
<td>d</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>d</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>G BK</td>
<td>3.8</td>
<td>8</td>
<td>d</td>
<td>e</td>
<td>9</td>
<td>4</td>
<td>b</td>
<td>c</td>
<td>4</td>
<td>9</td>
<td>2</td>
<td>b</td>
<td>c</td>
<td>8</td>
</tr>
</tbody>
</table>

Figures with different letter superscript are significantly different at p≤0.05

The Kilifi collection, KLF1, had the highest (p≤0.05) crude fiber (41.4%) than all other ecotypes. The lowest CF was recorded for TVT3 at 37%, which was significantly lower than all. TVT3 and KBK2 had the highest CP (p≤0.05). Despite recording the highest levels of CF, KLF1, KBK2 and KLF2 are also among the highest in CP. Positive correlation between CF and CP had previously been reported by Ashraf (2013) for different grass species.

The recorded INVDMD ranged from 45 - 56.1% while the CP was 4.8%. The range for INVDMD is higher but lower for CP than that reported by Ndathi et al. (2012) on E. superba grass growing in farmers’ fields. The variation could be attributed to the difference in the time of harvesting in the two studies. There was a significant positive correlation (p≤0.05) between INVDMD and CF with a coefficient of 0.7. Dugmore et al. (1986) also found a positive correlation between fibre components and digestible Organic matter (DOM) in Kikuyu grass. The ash content was different in all ecotypes except KBK1 and KLF2 that were similar. All the ecotypes had different % DM except KBK1 and KLF1 that had similar content.

The ecotypes KLF1 and KBK2 have high CP, CF, INVDMD and % DM. The KBK 1 and KBK2 ecotypes were taller (92.8 and 96.1 cm) than KLF1 (66.6 cm) compared to an overall mean of 80.8 cm.

Comparison between E. superba and C. ciliaris in nutritive value components indicated lack of significant variation in all attributes except ash content where C. ciliaris had 13.6 compared to E. superba’s 8.6%. Similar results were recorded by Rasool (2013) where Cenchrus ciliaris had significantly higher levels in ash content and crude fibre. However, Ndathi et al. (2012) found E. superba (44.9%) to have higher levels of INVDMD (44.9%) than C. ciliaris (36.9%). Among ecotypes, there was no difference in CP except TVT3 and KBK2 of E. superba being significantly higher than KLF3 of C. ciliaris. KBK1 and ErsuKLF1 recorded the highest %DM (93.1%) while ErsuKLF3 recorded the lowest (88.9%). This variation was significant at p≤0.05. ErsuKLF3 also recorded the lowest INVDMD (45.4%) and ErsuKBK1 recorded the highest (56.1%).
Conclusion

Significant variation in nutritive value components existed among the ecotypes of *C. ciliaris* and *E. superba*. This provides an opportunity for further of exploitation of the ecotypes to meet the different feed requirements including using their mixtures pasture production.

The positive correlations between some of the components such as CP or INVDMD and plant morphological traits (plant height, leaf length, stem thickness and time to flower) means that this traits could be used to select for higher CP or INVDMD levels in *C. ciliaris*.

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An analysis of fish farming value chain with emphasis to value addition and traceability: case of Kirinyaga County in Kenya

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Abstract
Fish is gaining importance in the diets of many countries in Africa. Fish supply in Kenya is mostly from wild capture fisheries, particularly fresh water lakes that contribute more than 90% of the total fish produced. Agri-food supply chains bring out flow of products and information, and activities from production through to processing to consumption. Through value addition, at each stage, the value is increased along the chain. Traceability enhances tracking and tracing of fish and fish products information in the supply chains. A situational assessment was conducted along the farmed fish value chain in Kirinyaga County in Kenya in June and July 2013. The objective of the study was to assess traceability along the farmed fish value chain. Data was collected using semi-structured questionnaires. Most farmers stocked mixed sex tilapia in monoculture, which led to over-breeding and harvesting of small sized fish, while the market demand was for table-sized fish. The high cost of inputs, especially feeds, increased the cost of production. Value addition was limited as most farmers didn’t have enough quantities of fish to facilitate value addition. Traceability was limited; only a few farmers kept operations records and most of them did not share production information with other stakeholders in the chain. The study recommends capacity building through training on value addition and traceability along the value chains.

Keywords: Farmed fish, Tilapia Value addition, Traceability, value chain

Introduction
Value addition of products can either be through innovation or coordination (Tilley, 1989). Innovations create value by improving on existing products and processes or by creating new ones. Coordination adds value by facilitating efficient arrangements among farmed produce and market farm products. Coordination can either be horizontal, which involves pooling/consolidation among stakeholders at the same level of the value chain, or vertical coordination, which involves making strategic alliances, contracting, agreements, licensing and single ownership of multiple market stages in different levels of the food chain (Peterson and Wysocki, 1997). Through coordination, production processes and product characteristics are linked to consumers’ preferences (Royer, 1995).

Food safety markets are characterized by high information asymmetry since food safety is a credence attribute. Only partial information flows along the supply chain since product flow is usually delinked from information flow (Heyder et al., 2012). Food safety and quality are credence attributes which create imperfections in the supply chains. Traceability has been shown to improve information management along a value chain (Souza-Monteiro and Caswell, 2010). Traceability systems enhance tracking and tracing.
of products and processing information along the value-chains. Linking traceability with the entire information flow and documentation effectively improves operational efficiencies and increases food safety and quality (Ruiz-Garcia et al., 2010).

In Kenya, fish farming has been popularized through the Fish Farming Enterprise and Productivity Program funded through the Economic Stimulus Programme in phase one, and the Economic Recovery, Poverty Alleviation and Regional Development Programme (ERPARDP) in the second phase. The aims of the project were to increase fish production, enhance food security, improve livelihoods of farmers, and provide employment for the youth (Uhuru, 2010). Previous Government initiatives in fish farming have not been sustained and there is need to evaluate challenges and opportunities that exist along the farmed fish value chain in order to formulate policies that enhance sustainability of the sector.

Tracking and networking information systems along food supply chains provide information that could be used in risk assessment (Li et al., 2006) and to improve on food safety (Pouliot and Sumner, 2008). In addition, traceability reduces transaction costs to downstream actors (retailers or processors) by monitoring upstream activities (primary production and raw material supply) (Hobbs, 2003). Electronic based traceability systems reduce labour costs when compared to paper based systems. The main challenge of traceability systems is that they create additional costs for actors in the sector. These costs depend on the type of identification technology (which can either be paper-based or electronic), and the labour costs (Buhr, 2003; Alfaro and Ra´bade, 2009).

The market potential based on demand of fish and fish products is high but the farming system is unable to meet the quality attributes demanded by the consumers. In addition, traceability strategies implemented are inadequate since there are improper records kept by stakeholders. There is limited empirical data on the strategies adopted by stakeholders along the aquaculture sector to ensure product information flow along the chains. The main objective of this study was to examine the strategic options for design and implementation of a traceability system along farmed fish value chains in Kenya. Such knowledge can be used by players in the aquaculture sector to improve logistics along products value chain and records keeping in developing countries.

**Study Methodology**

**Study design**

Situational analysis was conducted along the farmed fish value chain to identify current practices in value addition and traceability along the chain. This was done using a cross-sectional study design where information was collected at two levels. The first level was the primary production which was carried out in Ndia Sub-County in Kirinyaga County in Kenya. The next level was with the traders which were conducted in the entire Kirinyaga County.

**Sampling**

Data was collected from 109 households in Ndia Sub-County of Kirinyaga County, among farmers who owned at least one fish pond. Snowball technique was used to
identify fish farmers and traders in the entire County. Twelve traders were identified using this technique and they all took part in the study. Stratified random sampling was used in selection of farmers to ensure that all categories of farmers from all locations in the Sub-County were included in the study.

**Data collection**

A semi structured questionnaire with both closed and open ended questions was used as the survey instrument. Global positioning system (GPS) co-ordinates were taken for each homestead included in the study to facilitate researchers to make a follow-up. Secondary data were collected using documents from the Ministry of Fisheries Development headquarters in Nairobi and Fisheries reports from the Kirinyaga District Fisheries office.

Data was collected through interviews using two sets of semi-structured questionnaires specifically designed for the target respondent (farmers and traders). The questionnaires provided a guide to the interviewer, covering details of the post- harvest handlings, handling of waste and rejects and record keeping. The data was collected in July 2013.

All data were cleaned, edited, sorted and entered into the computer. Descriptive statistics consisting of frequencies, means and modes were computed for different data categories to facilitate comparisons. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 16.0.

### 2.1 Farmed Fish Value Chain Mapping in Kirinyaga County

The farmed fish value chain is made of several actors such as primary input providers, fish farmers, processors, traders and consumers.

**Input providers**

Most of the primary inputs are from social networks and the government. The government through the Fish Farming Enterprise and Productivity Program (FFEPP) provided feeds, extension services and start up capital (ponds, liners and fingerlings). Social networks such as neighbours provided animal manure for use in fertilization, advice and sharing information and a ready market for the harvested fish.

**Fish producers**

Most of the producers were small- scale farmers owning at least one fish pond measuring 300 m², and stocked with tilapia in monoculture or tilapia and catfish polyculture. Most are concerned with daily pond management practices such as feeding, water management, pond fertilization, hygiene and sales. Fish are mostly sold immediately after harvesting with minimal preservation; some techniques used in preservation include smoking, sun-drying and freezing.
Transformation

The most popular product transformation activities carried out were gutting (42 percent), descaling (37 percent) and sorting (14 percent). These were done by traders immediately after harvesting but farmers also assisted in these processes when it was necessary. Other transformation processes included packaging, salting, sun-drying, smoking, deep frying and stewing.

Marketing

Most of the fish were consumed at home usually on a weekly basis. Others were sold to neighbours at the farm-gate, which was usually done between major harvests. Traders from the main towns and trading centres also came to the fish farms during major harvests to purchase fish. Fish harvested in bulk from Ndia Sub-County were taken to Nairobi (Gikomba and Baba Ndogo markets).

2.3 Social demographic characteristics of fish farmers

More than two-thirds (71 percent) of the respondents were men. Most of them (51 percent) were more than 51 years old, 30 percent were 61 years or older. Only 9 percent were below 30 years. More than 60 percent of the respondents were household heads, who were the main decision makers in the household with only about 20 percent being spouses to the household heads.

Most respondents (43.7 %) had completed secondary education, while only 24 percent had tertiary education. From this group, 19 percent and 5 percent had attended colleges and university respectively. More than 30 percent of respondents had not attained secondary school education.

Approximately 13 percent of respondents owed less than one acre of land, 20 percent owed more than one acre but less than two acres, and about 17 percent owed more than 2 acres. Only one percent owned land greater than ten acres. This is an indication that fish farming was mainly done by small scale farmers. More than 75 percent of the farmers had liner ponds while 24 percent had earthen ponds. There were no farmers using concrete pond or tanks in the area.

Fish farming practices

Fish farming practices of farmers in Ndia sub-county in Kirinyaga County are summarized in Table 1. Experience in fish farming was assessed using the number of years the respondents had been in the practice. Fish farming was a relatively new venture in that area and more than 80% of respondents were funded through the Fish Farming Enterprise and Productivity project (FFEPP). This was a project funded by the Government to stimulate fish farming in the country. It started in the 2008/2009 financial years and was funded under the Economic Stimulus Programme in the first phase, and the Economic Recovery, Poverty Alleviation and Regional Development Programme (ERPARDP) in the second phase.

Under this programme, the government gave funds to farmers for construction of fish ponds and also supplied other inputs such as fingerlings and feeds.
Most of the respondents (90.9 percent) had been in fish farming for less than 3 years. This was because most of them (over 80 percent) were funded through the FFEPP. Only 11 percent of respondents used their own funds to start fish farming and most of them had started the venture before the start of the Fish farming Enterprise and Productivity Project. Nine percent of respondents were funded through the FFEPP, but also used their own funds to increase the number of fish ponds.

Most farmers (50%) kept mixed sex tilapia in mono-culture, while about 37.8 percent had both catfish and tilapia in polyculture. Very few respondents (less than 1 percent) kept ornamental fish. More than 86 percent of the farmers produced mature fish while less than five percent produced fingerlings only. The rest produced both fingerlings and mature fish.

Only 41 percent of the farmers were organized into active groups. When asked the reasons for forming groups, 48 percent of respondents said it was for easier access to inexpensive fish feeds, which were pelleted using a community pelleting machine. Another 24 percent formed groups to access fish markets, while 20 percent reported that it was for easier access to training. Eight percent (8%) of respondents formed groups to share ideas and inputs.

Most fish farmers in the region (about 84 percent) practiced mixed (crops and livestock) farming with only two percent who were strictly fish farmers only. About 51 percent of the households were arable farmers while around 26 percent were livestock farmers. Less than ten percent had other sources of income other than farming.

Approximately 54 percent of respondents kept fish as a source of extra income while 25 percent kept them primarily for home consumption. This latter group reported that they were aware of the health benefits of eating fish.

Approximately 44 percent of respondents said they would increase their production over the next 3 years, while 34 percent would maintain production at the current levels. Twenty two percent (22%) of respondents reported that they would reduce their tilapia and/ or catfish production in the next 3 years. On further probing, most respondents in the latter group wanted to change to ornamental fish farming which was considered to be more profitable than food fish farming.

**Post harvest handling of Farmed Fish**

The findings of this study indicated that during major harvests at end of year, most of the farmers (81.7 percent) sold harvested fish immediately. Thirty six percent (36%) preferred to sell their fish to traders who came to the farm on harvesting days, while 30 percent preferred selling to neighbors. The rest of the fish were sold in markets near the farms. Only five percent of the harvested fish were stored under reduced temperature conditions, four percent were sun dried, one percent smoked and approximately six percent preserved using other preservation techniques. During the minor harvests conducted between major harvests, most of the farmers (81 percent) did not sell the harvested fish. Only 17 percent of the farmers had a refrigerator at home although most farmers said they have never used it to store harvested fish waiting to be sold, it was used...
for domestic purposes. Most of the homesteads were not connected to electricity which explains why they did not have refrigerators.

The quality attributes demanded by most of the fish traders were the lengths and weights of harvested fish. Most traders (60 percent) only bought fish that exceeded 150 grams while 35 percent of the traders demanded fish exceeding 20 centimeters. Other quality factors demanded were color and age of fish. Most of the harvested fish did not attain the quality parameters demanded by traders; hence they were sold at reduced prices.

Farmers who delivered fish to markets usually used vehicles that had no cold storage facilities to transport fish and fish products, while others just walked to the marketing centers most of which were less than five kilometers from the homesteads. Only five percent of respondents used vehicles that had cold storage facilities while six percent used other preservation facilities such as cool boxes to transport the fish; these were used when large quantities of fish had been harvested and were to be taken to the market. About 35 percent of the fish was sold at the pond while 54 percent was delivered to the market places within two hours after harvesting. Only two percent of respondents delivered fish to the market 24 hours after harvest.

Value addition along the chain was limited, only simple technologies had been adopted with 41 percent reporting that they removed the gut contents, 37 percent removed scales, and 14 percent grading based on weight and size. Other preservation techniques used by farmers were sun drying, salting, smoking, deep frying and stewing. Filleting was not done at farm level although it had potential to add value and increase income for farmers since a good proportion of consumers preferred buying fish fillets rather than full fish.

**Record Keeping and Traceability along the Farmed Fish Value Chain**

Regarding information on record keeping practices by farmers this study reveals that 57 percent of fish farmers did not keep records on regular basis. Among those who did, the main types of records kept were on harvesting (eleven percent), sales (nine percent), fish stocking (seven percent), feeding (six percent), pond construction (five percent), and sampling (four percent). Other types of records kept were on pond fertilization/liming records, water pumping, water temperatures and pond draining records. Almost 47 percent of those who kept records used the records for planning, 27 percent used them to analyze the trends for input and production management, 13 percent for daily controls, seven percent for lending institutions both formal and informal. Five percent or respondents used records to calculate the enterprise’s profitability while two percent used them for comparing performance among seasons. Almost 57 percent of the fish farmers had undergone training on documentation. However, most of them said that training on record keeping in aquaculture was not a major emphasis of the training. Other farmers reported that although they had been trained on record keeping, there was no motivation for them to keep proper records, as they felt it didn’t improve their performance. On chain traceability, only 35 and 44 percent of the farmers shared production information with their immediate customers and immediate input providers respectively. This was an indicator of the inadequacy of current traceability systems.
Conclusions
Most of the farmers in the county were funded to do fish farming through the Government Economic Stimulus programme and had less than three years of experience in fish farming. There is need to educate these farmers on fish farming practices, post-harvest value addition, and record keeping and sharing information. Most farmers did mixed farming (crops and livestock) and fish farming was considered as a source of extra income. Since most farmers were funded through the ESP programme, they had ponds of similar sizes and with similar stocking capacities. The farmers had done little to repair the ponds and they said that they were waiting for support from the government to do that. Fish farming is not labour intensive, hence, there was minimal use of hired labour. More than 80 percent of the farmers were more than 40 years old and most had not achieved a secondary education. Their low education level and relatively young age was the main reason why most of them had not adopted record keeping and post-harvest value addition of the fish. Most actors in the chain were not adequately linked to one another; in particular, vertical linkages were weak. Post-harvest value addition was limited, with most farmers just descaling and gutting the harvested fish. Most of the fish were sold within 2 hours of harvesting. There was no standard way of using fish processing wastes and rejected fish with most farmers preferring to throw them away. Most of the harvested fish did not meet quality requirement demanded by consumers and traders in terms of weight and length. This can be attributed to the practice of keeping mixed sex tilapia in monoculture systems. In addition, the quantities entering the supply chain did not meet the demanded from consumers and traders, hence insufficient to encourage value addition. The challenges create opportunities for design and implementation of appropriate value addition programs and policies to support small scale farmers and traders, individually or in groups, to improve market participation. Traceability was limited as most farmers did not keep proper production records. Traceability along the value chain was non-existent with minimal sharing of information among actors. The study estimated the costs associated with implementing a record keeping system; most of the costs were on the initial system outlay, personnel training costs and system maintenance. These costs can be covered by the stakeholders who have been offering backstopping services to fish producers along the value chain they include the extension officers, non-governmental organizations, training institutions, financial institutions, among others identified during value chain mapping. The costs to run the record keeping systems are low and can be covered by benefits estimated to arise from the record keeping systems.

Acknowledgement
We wish to thank the National Commission for Science, Technology and Innovation (NACOSTI) and the USAID-PEER Science program for funding the project. We also thank the University of Nairobi (College of Agriculture and Veterinary Science) for their assistance and all farmers and traders who participated in the study.
References:


Exploring options for improved crop residues’ utilization and manure quality improvement in Central Kenya

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Introduction

Over 80% of rural farmers derive their livelihoods from dairy sector (GoK, 2004), while accounting for 14% of agricultural GDP (Dairy Mail, 2008). It contributes significantly to the national economy, and generates employment and income for many households (Rees et al 1998; Muriuki 2002; Kurwijila 2002). Hence, due to its strategic positioning in the economy, devising appropriate mechanisms for improving dairy production is fundamental.

For many small holder farmers, feeding dairy cattle over the dry period when forages are scarce is a major challenge. Lanyasunya et al (2006) indicates that seasonality has a strong influence on feed availability, quality and subsequent performance of ruminants in small holder farms. Hence, most small holder farmers mainly depend on crop residues that are usually too dry and hard, to meet the nutrient requirements of the animals.

Kiruiro et al (2006) indicated that the contribution of crop residues is underrated despite their abundance. They further state that farmers are endowed with adequate resources for enhanced accessibility of appropriate technologies for processing and storage to improve their utilization. Past studies have also showed that crop residues’ supplementation with forage legumes was also a sustainable way of improving quality (Getachew et al.; 1994 and Umunna et al.; 1995). Despite the foregoing improvements noted on crop residues utilization, overall dairy productivity remains low. Therefore, there is need to develop more innovative utilization and quality improvement strategies for small holder dairy farmers but it is imperative to first understand the existing crop residues utilization dynamics and existing improved utilization strategies, hence the reason why the current study was initiated.

Objectives

1. To identify the main crop residues produced and utilized in the area
2. To identify main constraints to increased crop residues utilization
3. To identify the main strategies and techniques used for increased utilization and quality improvement.
Methodology

In consultation with the extension staff at the County level, a representative district was selected on the basis of the size of the farming community engaged in both dairy and crop production. A specific representative site was then selected in the district and a sample frame of the households in the selected site developed. Sixty (60) households were randomly selected to constitute the sample size for questionnaire administration. The questionnaire was jointly developed and pre-tested in specific sites. It was further refined and administered by a team of trained enumerators, under the supervision of the implementing scientists. Data was entered into a spreadsheet, cleaned and descriptive statistics and frequencies were analyzed using SPSS Software. Matrix ranking of the main constraints and coping strategies for increased crop residues utilization was also done.

![Figure 1: Main livestock Forages Utilized](image)

Main Uses and Level of Utilization of Crop Residues

Main uses of crop residues in the study area are as summarized in figure two.
Figure 2: Main Uses of Crop residues in the Area

Constraints to Utilization of Crop Residues and Coping Strategies

The identified constraints were ranked in a participatory process and the results are as shown in table 1.

Table 1: Ranking of the main constraints to increased crop residues utilization

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate labour availability</td>
<td>5</td>
</tr>
<tr>
<td>Inadequate capital to access appropriate equipments and supplements</td>
<td>4</td>
</tr>
<tr>
<td>Low palatability</td>
<td>1</td>
</tr>
<tr>
<td>Inadequate capacity for quality improvement</td>
<td>3</td>
</tr>
<tr>
<td>Inadequate crop residues</td>
<td>2</td>
</tr>
<tr>
<td>Inadequate storage facilities</td>
<td>5</td>
</tr>
</tbody>
</table>

Main Crop Residues Quality Improvement Strategies

A summary of the main quality improvement strategies and level of awareness on the identified strategies as summarized in Figure 3.
Discussions

It is evident from the results that there is a range of animal feeds and crop residues are important for dairy production in the area. There is also low level of utilization of high quality forages and supplements for quality improvement. The results also show that there are competing uses of crop residues and hence a need to increase crop residues generation. It also clear that there are a wide range of constraints that hinder improved utilization of crop residues and manure quality, with low palatability, inadequate crop residues and inadequate capacity for quality improvement being the main ones. There is also a range of quality improvement strategies that the farmers in the area have adopted with chopping, supplementation with concentrates and legumes being the main ones, though the level of utilization and awareness of the latter two is pretty low. Most farmers appear complacent possibly due to limited capacities on how to utilize most of these techniques/methods or their inaccessibility, although lack of technical awareness is largely responsible. The same reasons could also explain the poor use of low-cost supplementary options from fodder trees.

Conclusions

It can be concluded that crop residues are an important and integral source of dairy feeds in Central Kenya, with low levels of utilization of innovative strategies like incorporating of improved herbaceous fodders/legumes in the farming system. This therefore compromises crop residues’ uptake and manure quality. It can also be concluded that though there are a number of constraints to improved utilization of the crop residues in the study area, the number of strategies adopted to mitigate against this is limited
mainly depending on conventional ones like chopping, which further compromises on utilization and manure quality. It can also be concluded that the level of awareness, capacity and accessibility of more innovative strategies like legume supplementation is limited and hence compromising on dairy productivity in the area. Limited availability of high quality feeds like herbaceous legumes and fodder trees implies that their use to supplement crop residues is also limited, further impending on dairy productivity.

**Recommendations**

Crop residues will continue to play an important role in dairy production in the study area given the low scale of use of alternative feed resources. However, the challenges of poor quality due to inadequate use of quality improvement practices and poor conservation, and low amounts resulting from competitive uses should be addressed to enhance contribution of crop residues to dairy productivity. Innovative strategies for improving efficient utilization from a farming systems perspective, that are recommended include promotion of appropriate supplementary forages, especially leguminous fodder trees that will have multiple uses, including soil and water conservation, and provision of fuel to households. The limitation on adoption of physical processing devises may be addressed by facilitating farmers’ access to micro-credit, although this should be tied to improved milk production. There is also need for capacity building and awareness creation so that the farmers can adopt more innovative strategies like high quality forages like herbaticous legumes and sustainable available of the same through establishment of community/group nurseries for improved access, crop residues utilization, manure quality improvement and improved dairy productivity.

**Acknowledgement**

We, the authors of this paper sincerely acknowledge the funding we got from East African Productivity Project (EAAPP) that enabled us to accomplish this study. We also highly thank KARI Director and Centre Director KARI-Embu for the facilitation and all the support that they extended to us while implementing this work. We can’t forget the commitment that the enumerators put while collecting the data to an extent of working to very late hours and over the weekend.

The extension staff, Ministry of Livestock Development, Othaya District, Nyeri County played a very crucial role of facilitating in identifying the specific study sites, development of sampling frames and recruitment of enumerators. Without their unreserved support, accomplishment of this work would have been a tall order. Last but not least is our special thanks to the entire community in the study sites for warm welcome that they gave us and the enthusiasm that they showed towards this project. We can’t forget to specifically thank part of the community that constituted the sample size for the precious time that they spared for us for the benefit of the entire region and the country at large, to collect this important information. We salute you all.
References


Evaluation of medicated *Prosopis* spp-based feed blocks for antihelmintic efficacy and performance of weaner lambs

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Abstract

The aim of this study was to determine effects of supplementing medicated *Prosopis juliflora*-based feed blocks on feed intake, daily weight gains and antihelmintic control potential in sheep. Twelve red maasai weaner lambs, 4 months old, with an average initial live weight of 10 kg (±2.3) were used in the study which lasted for 42 days. The sheep were blocked by weight and within each block, randomly allocated to 3 treatments with 4 animals each. Each animal block received one of the following treatments; (i). Cenchrus ciliaris grass hay (basal diet) *ad libitum*, without supplementation (control), (ii) C. ciliaris grass hay (basal diet) *ad libitum*, supplemented with Non-medicated *P. juliflora* feed blocks (iii) C. ciliaris grass hay (basal diet) *ad libitum*, supplemented with medicated *P. juliflora* blocks. Basal feeds and test supplements ( two blocks per day) were offered individually at 0800 h and 1430 h daily. Fresh drinking water was available *ad libitum*. The tested diets increased significantly total live weight gains for T₂ (18.1) and T₃ (20.5) as compared to control group (14.4). Significantly (P<0.001) higher daily average weight gains were reported in the treatment groups (431 and 488.1 g for non-medicated and medicated feed blocks respectively, than the control (342.9 g). Average dry matter intake (kg⁻¹ d⁻¹) varied among the treatment diets from 0.42, 0.67 to 0.89 for the control, non-medicated and medicated *P. juliflora* multi-nutrient blocks respectively. Higher feed conversion efficiency was reported in the animals on medicated prosopis blocks (1.82) than in the non-medicated treatment (1.56) and the control group (1.22). The mean EPG trends of control group progressively rose from day-zero to throughout the experimental period. Significantly higher (P<0.05) coccidial species egg output of the untreated controls had risen by 500% and 106% for strongyles spp respectively by end of the experiment. Non-medicated and medicated *Pjuliflora* feed-blocks achieved a maximum percentage mean EPG output reduction of 39% and 91% respectively for strongyles species by 42 days post treatment. 87% and 56% mean coccidial EPG output reduction was recorded for non-medicated and medicated feed blocks respectively. Therefore, according to the current results, *P. juliflora* based feed blocks fortified with a de-wormer such as Nilzan Plus at the rate of 5% per 100 kg of block ingredients would be a potential strategy to control gastro-intestinal parasites and improve livestock productivity in Kenya’s rangelands, and additionally, minimize *P. juliflora* invasions in affected regions of Kenya, and other areas of the world with massive colonization with this invasive plant species.
Keywords: gastrointestinal parasites, Livestock feed, invasive plant species, Value-addition.

Introduction
Pastoralism being the main-stay of most rural communities in Baringo county, current aggressive invasion of Prosopis species on the main grazing areas and elimination of grasslands is becoming a big threat to their livelihoods. The invasive potential of Prosopis spp. and the emerging trends of massive colonization of wetlands are already showing the indications of great disaster of national and international importance. The magnitude of the problem is easily understood in the contest that most infestations seen today are still relatively young stands and of moderate densities yet their negative impacts have already been felt by the pastoralists through elimination of treasured pasture lands. The full impact of their invasion is likely to be felt when the infestations will achieve high densities in the next 10-20 years if no intervention is introduced in good time. If unchecked, Prosopis spp has the potential to wipe out pastoralism in the near future (Aboud et al 2005). Watering points for both livestock and wild game is not accessible in some areas due to the impenetrable thickets of prosopis spp. Reports by Harding and Bate (1991) revealed that, with good rainfall, the colonization rate of Prosopis spp increases threefold. In such flooded conditions exacerbated by weather variability and climate change, the plant is able to form totally impenetrable thickets as seen in most dryland ecosystems of Kenya. Total eradication of P. Juliflora would not be a solution owing to high overhead costs. Therefore, small-scale prosopis-based feed industry would be an important avenue that can convert weedy invasions into productive and profitable model (Pasiecznik et al 2001). The seeds are passed undigested in the animal gut, and as a result, they are triggered to germinate even more readily under favourable conditions. By transforming Prosopis into a value-added livestock feed, crushing the seeds so they cannot re-germinate, value addition and processing technology has the potential to slow the invasion of Prosopis in crucial grazing lands and give animals a more balanced, nutritious diet. Efforts to address its control and management will therefore be a big relief to the affected communities. Seed harvesting coupled with value-addition and/or processing for animal feeding will reduce the rapid regeneration and colonization of P. Juliflora, while improving the household incomes of vulnerable groups in pastoral areas. There are much voices requesting for an external support to manage the spread or eliminate it altogether and replace it with better plant species. However, prosopis spp can provide many of the needs of populations living in drylands of the world, and have the potential to provide much more if knowledge on their utilization is expanded. For instance, feeding trial in India on livestock using rations containing up to 45% of prosopis spp components yielded a 1.5% of cattle body weight with acceptable live weight gains (Tewari et al 2000). Collection of prosopis pods is an important source of income, with earnings of up to US$ 50 per day with collection of about 150 kg per person per day. The purpose of the current study was to formulate, test and popularize prosopis-based feed supplements as management and control strategy of invasive prosopis plant species, while improving livestock productivity and livelihoods in dryland ecosystems. This will was achieved through establishment of a small-scale community-owned livestock...
feed industry, so that they can harvest prosopis pods, process and sell the value-added livestock feed products to the ready market within and outside the County of Baringo.

**Materials and Methods**

**Study area**

The study was conducted between July to August, 2014 at the Kenya Agricultural and Livestock Research Organization (KALRO), Perkerra Research Station in Baringo County, Kenya. Baringo County was purposively selected as a pilot study area due to its intense colonization by *Prosopis juliflora*, and where the invasive species problem has elicited mixed reactions by the community members. Baringo county is an arid area situated in the former Rift valley Province of Kenya, in Agro-ecological zone Zone IV and V (FAO 1996). Temperatures in this region ranges from a minimum of 10°C to a maximum of 35°C in different parts of the county. The average annual rainfall ranges from approximately 650 mm on the Njemps plains to over 1,300 mm at Kabarnet near the summit of Tugen hills. The rainfall is low, erratic and poorly distributed throughout the year.

**Animals and management**

Twelve red maasai weaner lambs, 4 months old, with an average initial live weight of 10 kg (+2.3) were used in a study comprising feed intake, growth and antihelminthic efficacy trials. The weaner lambs were purchased from pastoral farmers in the outskirts of Marigat sub-county of the greater Baringo county. During the 42 days long trial, animals were housed in individual metabolic cages indoors.

**Experimental design and treatment diets**

The sheep were blocked by weight and within each block, randomly allocated to 3 treatments with 4 animals each. Each animal block received one of the following treatments; (i). Cenchrus ciliaris grass hay (basal diet) *ad libitum*, without supplementation (control), (ii) C. ciliaris grass hay (basal diet) *ad libitum*, supplemented with Non-medicated *P. juliflora*-based feed blocks (iii) C. ciliaris grass hay (basal diet) *ad libitum*, supplemented with medicated *P. juliflora*-based feed blocks. Basal feeds and test supplements ( two blocks per day) were offered individually at 0800h and 1430h daily. Fresh drinking water was available *ad libitum*.

**Feed intake and Growth performance trial**

To calculate daily feed intake, amounts of basal feeds and supplements offered to and refused by each individual animal were recorded daily. Samples of feed offered and refused were collected three times per week for DM determination at 60°C for 48 h. Sub-samples of feed offered were ground to pass through a 1-mm sieve and stored for laboratory analysis. The sheep were weighed every Friday at the start, up to the end of the trial for calculation of growth rates. Feed and water were removed about 15 h before weighing for data accuracy.
Chemical analysis

The samples were analyzed for DM, CP, CF and ash contents. Nitrogen in samples was determined by the Kjeldahl N method (AOAC 2000).

Statistical analysis

The effects of treatments were compared by analysis of variance (ANOVA) using the Statistical Analysis System. 2000 (SAS) general linear models procedure for a completely randomized block design. Least Significant Difference was used to compare the mean effect of diet treatments.

Formulation of the test feed blocks

The chemical composition of the experimental diet is presented in Table 1. Least-cost feed formulation using feedsoft computer software program was used in the formulation of experimental prosopis feed blocks. Medicated and non-medicated prosopis blocks were prepared using two formulations as shown in Table 2.

Table 1: Dry matter (g/kg) and chemical composition (g kg\(^{-1}\) DM) of basal diet and test supplements

<table>
<thead>
<tr>
<th>Test feed</th>
<th>DM</th>
<th>CP</th>
<th>CF</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cenchrus ciliaris</td>
<td>900</td>
<td>73</td>
<td>350</td>
<td>40</td>
</tr>
<tr>
<td>Medicated Prosopis block</td>
<td>750</td>
<td>201</td>
<td>180</td>
<td>483</td>
</tr>
<tr>
<td>Non-medicated prosopis block</td>
<td>750</td>
<td>200</td>
<td>180</td>
<td>485</td>
</tr>
</tbody>
</table>

Moulding and drying

One-kilogram cooking oil containers were improvised, and used in casting the \(P. \) juliflora multi-nutrient blocks. During casting, the insides of the moulds were lined with cooking oil to prevent the blocks from sticking to the walls of the moulds, and to allow for easy removal of the blocks from the moulds (Mugambi et al 2008).
Moulding and storage of the blocks was done under a roofed building to allow proper curing of the blocks. The blocks were left to air-dry in the well-ventilated shed for a period of five days.

Table 2: Inclusion rates (% DM) and chemical composition of ingredients used for preparation of Prosopis feed blocks

<table>
<thead>
<tr>
<th>Feed ingredient</th>
<th>Formulations</th>
<th>Chemical composition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Prosopis pod meal</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Molasses</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>NaCl</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Mineral premixes</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cement</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Water</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Nilzan Plus (Dewormer)</td>
<td>5 L</td>
<td></td>
</tr>
</tbody>
</table>

In vivo anthelmintic activity trial

Prevailing common nematodes in the study area were characterized before experimentation by sampling the feces of all experimental animals, and cultured for larvae identification. The animals were ear-tagged for identification and de-wormed once before and after the experiment using Nilzan Plus at a rate of 25 to 50 ml per animal, depending on the live weight at the time. The active ingredient of this de-wamer (Nilzan) is 1.5% w/v levamisole hydrochloride B. P, 3.0% w/v Oxytocazide B. P and 0.38% w/v Colbalt Sulphate. After 14 days, the animals were re-infected again with the identified common parasites in that region at the rate of 10µ (3000 larvae). Faecal egg count (FEC) was performed twice viz once immediately after challenge, and then six weeks post-challenge.
Collection of fecal material and quantification of egg output

The freshly passed feces were collected directly from the rectum per animal using rubber glove at the start of the sixth week (Figure 2). Each collection was put in a container labeled with the number of the animal and the date of collection. Thereafter, the fresh samples were kept in a refrigerator to avoid hatching till the counting exercise. The fecal samples were collected at day-zero and 42 days post treatment. Fecal egg counts were performed on individual fecal samples and expressed as eggs per gram feces (EPG). Modified McMaster egg counting technique was used for quantification of nematode eggs (MAFF 1986, Bondarenko et al 2009) from individual fecal samples.

Figure 2: Screening for nematodes during experimentation at KALRO Perkerra

Figure 3: Medicated Prosopis feed blocks

Culture for larvae identification

At the end of the monitoring period, the fecal samples were collected to culture for isolation of larvae and later their identification. On each sampling day, composite fecal cultures were made for each treatment group. Cultures were incubated for 14 days at 27°C. Third stage larvae were recovered from the cultures by the Baerman technique and identified according to Thienpont et al 1979, MAFF 1986 and Hansen and Perry 1990.

Statistical analysis

The anthelmintic efficacy was determined by comparing the parasites egg population means in treated groups and the control groups of animals and zero day fecal egg collection record. Data was subjected to analysis of variance (ANOVA) using GenStat version 14th edition. Significant differences were detected at $P<0.05$. Significant differences among treatment means were separated using Least Significant Difference (LSD).
Results

Effect of *P. juliflora*-based feed block supplementation on dry matter intake and growth performance

The results of live weight gains and dry matter intake of experimental diets are presented in Table 3. Results showed a significant (P<0.001) difference in growth rates among the treatment groups. The tested diets increased significantly total live weight gains (kg) for T\(_{2}\) (18) and T\(_{3}\) (21) as compared to control group (14). Higher daily average weight gains were also observed in the treatment groups (431 and 488 g for non-medicated and medicated feed blocks respectively, than the control (343 g). Average dry matter intake (kg\(^{-1}\)d) varied among the treatment diets from 0.4, 0.7 and 0.9 for the control, non-medicated and medicated *P. juliflora* multi-nutrient blocks respectively (Table 3).Medicated prosopis blocks had higher recorded feed conversion efficiency (1.8) than in the non-medicated treatment (1.6) and the control group (1.2).

Table 3: DM intake and growth performance of red masai weaner lambs supplemented with prosopis feed blocks

<table>
<thead>
<tr>
<th>Parameters</th>
<th>C. ciliaris grass hay (Control)</th>
<th>Non-medicated PB</th>
<th>Medicated PB</th>
<th>LSD(_{(0.05)})</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Growth rates</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total average live weight gain (kg)</td>
<td>14(^{c})</td>
<td>18(^{b})</td>
<td>21(^{a})</td>
<td>2.41</td>
<td>0.002</td>
</tr>
<tr>
<td>Average daily wt. gain, (g(^{-1})d)</td>
<td>343</td>
<td>431</td>
<td>488</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DM intake</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average DMI (kg(^{-1})d)</td>
<td>0.4(^{c})</td>
<td>0.7(^{b})</td>
<td>0.9(^{a})</td>
<td>0.17</td>
<td>0.003</td>
</tr>
<tr>
<td>Feed conversion efficiency (kg DMI/kg gain)</td>
<td>1.2</td>
<td>1.6</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{a,b}\) Values bearing different superscripts in row differ significantly (P < 0.05)  
PB= Prosopis spp. blocks

Antihelmintic efficacy determination of medicated *P. juliflora* multi-nutrient blocks

The mean EPG output of weaner lambs supplemented with medicated and non medicated *P. juliflora*-based feed blocks, and un-supplemented C. ciliaris as control are presented in Table 4.
Table 4: Mean fecal egg counts and percent count reduction of gastrointestinal nematodes after supplementation with medicated and non-medicated *P. juliflora* multi-nutrient blocks

<table>
<thead>
<tr>
<th></th>
<th>Fecal egg output</th>
<th>% Fecal egg output</th>
<th>LSD (0.05)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strongyle</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 days</td>
<td>42 days</td>
<td>0 days</td>
<td>42 days</td>
<td></td>
</tr>
<tr>
<td>C. ciliaris</td>
<td>3000</td>
<td>3167</td>
<td>100</td>
<td>106</td>
</tr>
<tr>
<td>Non-medicated PB</td>
<td>3000</td>
<td>1833</td>
<td>100</td>
<td>61</td>
</tr>
<tr>
<td>Medicated PB</td>
<td>3000</td>
<td>283</td>
<td>100</td>
<td>9</td>
</tr>
<tr>
<td><strong>Coccidia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 days</td>
<td>42 days</td>
<td>0 days</td>
<td>42 days</td>
<td></td>
</tr>
<tr>
<td>C. ciliaris</td>
<td>3000</td>
<td>15000</td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>Non-medicated PB</td>
<td>3000</td>
<td>1333</td>
<td>100</td>
<td>44</td>
</tr>
<tr>
<td>Medicated PB</td>
<td>3000</td>
<td>400</td>
<td>100</td>
<td>13</td>
</tr>
</tbody>
</table>

*a, b Values bearing different superscripts in rows and columns differ significantly (P < 0.05)*

The mean EPG trends of control group rose from day-zero to throughout the experimental period (Table 4). Significantly higher coccidial and strongyles species egg output of the untreated controls had risen by 500% and 106% respectively by end of the experiment (Table 4). Notably, non-medicated and medicated *P. juliflora* feed blocks achieved a maximum percentage mean EPG output reduction of 39% and 91% respectively for strongyles species by 42 days post treatment. 87% and 56% mean coccidial EPG output reduction was recorded for medicated and non-medicated feed blocks respectively.

**Parasites isolated in the experimental animals**

The culture results revealed presence of two nematode species, namely; Haemonchus species and Trichostrongylus species (Table 4).

Table 5: Gastrointestinal nematode species prevalent in the red maasai sheep in farms surrounding Marigat sub-county

<table>
<thead>
<tr>
<th>Species of nematode</th>
<th>Prevalence of species</th>
<th>% Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemonchus</td>
<td>+++</td>
<td>331</td>
</tr>
<tr>
<td>Trichostrongylus</td>
<td>++</td>
<td>75</td>
</tr>
</tbody>
</table>

*(++) fairly prevalent, (+++) highly prevalent*
Discussion

*P. juliflora*-based feed block supplementation had a great effect on average daily weight gains, with or without medication in the block, as compared to the control groups on sole *C. ciliaris* as basal diet. The Relatively higher dry matter intake (DMI (kg⁻¹d⁻¹)) of the basal diet of the animals on Prosopis block supplementation could be attributed to improvement in rumen environment due to higher crude protein (CP) content (22%) in the prosopis (Kyuma 2013). Microorganisms in the rumen requires nitrogen for their cell synthesis and multiplication. They in turn improve the degradability of ingested feeds in the rumen, as they also form part of the microbial proteins, a high value protein which is digested and absorbed in the lower gut. However, there was a significantly higher DMI in the medicated prosopis feed blocks as compared to the non-medicated. The relative higher DMI in the medicated blocks could be due to the boosted antihelmintic drug (Nilzan Plus at a rate of 25 to 50 ml per animal depending on their weights at that time). Generally, prosopis plants have natural antihelmintic effects against certain worms due to anti-nutritional factors, mainly tannins present in the pods, leaves and the bark (Koech et al. 2011). Thus the variation between the two prosopis blocks (medicated and non-medicated) could be due to the boosted antihelmintic activity with Nilzan Plus.

Higher weight gains of weaner lambs due to supplementation of basal diets of *C. cialis* with prosopis feed blocks in the current work could be partly explained by high content of CP (22%) of prosopis pod meal, leading to high digestibility and high utilization efficiency in ruminants (Jones 1984). The prosopis pod has two main parts; the outer part, relatively with high sugar contents (13 MJ/kg) and the inner part, mainly the seed with high protein content of approximately 40% (Kyuma 2013). The animal only utilizes the outer part of the pod (with high sugars), and eliminates the high valued seed with high protein, which passes through the gut undigested. This passage through the gut undigested de-scalarizes the seed making it more aggressive and easy to grow after defaecation in the dung. The ingested sugars from the pods are responsible for decaying teeth in livestock (Kyoge et al. 2002) which causes the animal to starve and later dies of malnutrition. Therefore value addition of prosopis pods by crushing and/or grinding has an added advantage of improved CP availability and utilization, a factor that is attributed to the enhanced feed intake and average daily weight gains of weaner red maasai lambs on *C. ciliaris* as basal diet.

The study revealed that fortifying prosopis feed blocks with a dewormer inhibited substantially production of eggs by gastro-intestinal nematode parasites. However, it was also evident from the study that non-fortified prosopis blocks also had positive effects in controlling the gut nematodes as compared to the control groups. A recent survey study (Syomiti, Unpublished data) revealed that greater percentage of pastoral farmers around Baringo County were not de-worming their livestock as a routine management. Instead, the animals dependent on indigenous knowledge of phytotherapy, where certain tree species including prosopis plant were believed to have some anti-helmintic activity against some nematodes. This is evidenced by massive tree bark stripping of some tree species by livestock, in an attempt to de-worm themselves (Fig. 4).
This is confirmed in the current study where parasite egg output was substantially reduced by non-medicated prosopis feed blocks. In the current study, Nilzan Plus addition to feed blocks acted as a booster to the existing antihelmintic activity of prosopis pod meal, which is attributed to secondary plant metabolites such as tannins.

Conclusions

Results obtained in this study suggested that *P. juliflora* based feed blocks fortified with a de-wormer such as Nilzan Plus at the rate of 5% per 100 kg of block ingredients would be a potential strategy to control gastro-intestinal parasites and improve livestock productivity in Kenya’s rangelands, and additionally, minimize *P. juliflora* invasions in affected regions of Kenya, and other areas of the world with massive colonizations.

Recommendations

The current study recommends *P. juliflora* management by exploitation as value-added livestock feed and a vial option for controlling the spread of this invasive tree species. Commercialization of value-added *P. juliflora* feed blocks could improve livestock productivity and rural livelihoods where prosopis invasion is a menace. In view of these findings, a further *in vitro* and *in vivo* studies on antihelmintic potential of different locally available plant species and natural soil-salt lick for inclusion in the feed blocks targeting specific parasite species and for cost reduction in feeds and feeding in rangelands.

Acknowledgement

The authors are sencerely thankful to Feed the Future Innovation Lab for Livestock, Colorado State University who funded this study. An appreciation is also extended to Egerton University lecturers, Drs. Maranga and Obwoyere who provided technical support to this study. Gratitude to the centre director, KALRO Perkerra, who provided an humble environment in support of this study. More appreciation to the reviewers of this manuscript.
References


Evaluation of medicated Prosopis spp-based feed blocks for antihelmintic efficacy and performance of weaner lambs


Potential of green grams, cowpeas and lablab beans as broiler chicken feed

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Abstract
A 42 days study was carried out to determine the effect of replacing soybean meal (SBM) with varying levels (0, 10, 20, and 30%) of green grams (GG), cowpeas (CWP) and Lablab beans (LB) in pearl millet (PM) based diets on growth performance and carcass quality of broiler chicken. The ten experimental diets formulated to be isocaloric and isonitrogenous were: 0% LGM (Control), 10% GG, 20% GG, 30% GG, 10% CWP, 20% CWP, 30% CWP, 10% LB, 20% LB and 30% LB. Four hundred male sexed Arbor Acres broilers were randomly allocated to the ten treatments of four replicates each and ten birds per replica in a 3*4 factorial experiment in a completely randomized design. Data on feed intake, body weight gain, Feed Conversion Ratio (FCR) as well as dressed weight, weight of breast muscle, drumstick, abdominal fat pad, gizzard, liver and pancreas were collected and analyzed. Inclusion of GG in broiler chicken diets at levels of 10, 20 and 30% had no effect (P>0.05) on body weight gain, feed efficiency and all carcass parts studied. However, its inclusion at 30% level caused a significant reduction in feed intake. Inclusion of CWP at 10, 20 and 30% level had no effect (P>0.05) on feed intake, feed efficiency and all carcass parts studied. However, its inclusion at 20 and 30% level resulted in a reduction (P<0.05) in body weight gain. Use of LB at all levels resulted in a significant (P<0.05) reduction in feed intake, body weight gain, feed efficiency, dressed weight and breast weight but it had no effect (P>0.05) on the weights of the other carcass parts. Green gram fed broilers had a better performance in terms of body weight gain, live weight, dressed weight and drumstick weight followed by CWP while those on the LB diets had the least performance. Green gram can therefore be used in diets of broiler chicken at a 30% level and CWP at a 10% level without negatively affecting performance. However use of LB at all test levels resulted in a negative effect on growth performance and is hence not encouraged.

Keywords: Anti-nutritive factors, Green grams, Cowpeas, Lablab bean, Growth performance, Carcass quality, Broilers.

Introduction
Soybean meal, an important raw material in the broiler chicken diets due to its high protein level (44-48% CP) with a well balanced amino acid profile and high ME, NRC (1994) is unavailable in enough quantities to meet consumer demands in the Kenya (Tinsley, 2009). In order to satisfy the demand, the deficit is usually imported from countries such as Uganda, Tanzania and India making it expensive.
Kenya is largely arid and semi arid lands (ASALs) and legumes such as green gram (*Vigna radiata*), cowpeas (*Vigna unguiculata*) and lablab beans (*Lablab purpureus*) grow well in these areas. These grain legumes contain similar amino acid profile as SBM and can be used as substitutes in diets of broiler chicken (Wiryawan, 1997; Moawia, 2015). The utilization of the three legumes in monogastric animals is however limited by presence of various anti-nutritive factors that affect nutrient utilization (Téguia and Beynen, 2005; Khalil, 2006; Ramakrishna *et al.*, 2008). However, the amount and type of these anti nutritive factors differ hence the utilization potential of the three legumes by broiler chickens also differ. Studies on utilization of these legumes have been conducted elsewhere combined with either maize or sorghum (Murwani, 2008; Chakam *et al.*, 2010; Moawia, 2015). Research on the potential of the three legumes combined with PM would therefore be important. The nutritional value in the legumes also varies with cultivars and climatic conditions (Allen and Davis 2013). Therefore the available data may not be replicated for diet formulation under local conditions. The objective of the study was to determine the effect of replacing SBM with varying levels (0, 10, 20, and 30%) of GG, CWP or LB on growth performance and carcass quality of broiler chicken.

**Materials and methods**

*Experimental diets and management of experimental birds*

Raw materials used in formulation of the experimental diets were procured from Mbeere in Embu County and transported to Nairobi where the formulation was done. Consequently, the feed ingredients were taken to a commercial feed mill where the grinding and mixing was done. Ten experimental diets based on PM and SBM were formulated to contain 0, 10, 20, or 30% GG, CWP or LB respectively. The diets were isocaloric containing 3000kcal/ kg ME for both the starter and finisher periods and isonitrogenous with a CP content of 22 and 20% for the starter and finisher diets respectively. The starter and finisher diets are presented in Table 1 and 2.

The house was well ventilated and lit to ensure comfort of the experimental broilers. Each experimental unit (pen) measured 1.5 m by 1.5 m and a height of 1 m therefore providing a floor space of 0.225m$^2$ per chick. Prior to arrival of the chicks, the house and all the equipment were disinfected and the floor covered with wood shavings to about 10cm deep. Brooding was done during the starter period (first three weeks) and routine vaccination done against New Castle Disease on the 7th and 21st day and Infectious Bursal disease (Gumboro) on the 14th day.

Four hundred (400) day-old male sexed Arbor Acres chicks were bought from a commercial hatchery in Nairobi for the feeding trial. The chicks were fed on a commercial diet for the first three days during which they were acclimatized to the experimental conditions. On the fourth day they were weighed in groups of ten and randomly allocated to the experimental treatments.

*Experimental design and analyses*

The ten experimental treatments were divided into four replicates each that contained ten chicks per replica. The design of the experiment was a 3*4 factorial in a Completely Randomized Design (CRD).
Data on body weight and feed intake was determined weekly. From this data, body weight gain and FCR were computed. The overall body weight gain per bird (0-42 days) per replica was calculated as the difference in weight between the last and the initial weights of the chicks. The weight was then divided by number of broilers per replica to get the total weight gain per bird per replica. At the beginning of each week, feed was measured and was put into the feeding troughs for each replica. At the end of each week the feed remaining on the troughs was emptied into buckets of known weight and weighed.
### Table 1: Composition (%) of the starter diets

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Ingredients</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
<th>T8</th>
<th>T9</th>
<th>T10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearl millet</td>
<td>65.19</td>
<td>59.31</td>
<td>51.99</td>
<td>44.51</td>
<td>59.27</td>
<td>51.91</td>
<td>44.37</td>
<td>58.69</td>
<td>50.89</td>
<td>43.99</td>
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<td></td>
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<td>-</td>
<td>10.00</td>
<td>20.00</td>
<td>30.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Cowpea</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10.00</td>
<td>20.00</td>
<td>30.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Lablab bean</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10.00</td>
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<tr>
<td></td>
<td>Limestone</td>
<td>0.29</td>
<td>0.26</td>
<td>0.19</td>
<td>0.30</td>
<td>0.28</td>
<td>0.25</td>
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<td>-</td>
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</tr>
<tr>
<td></td>
<td>Berger fat</td>
<td>2.56</td>
<td>2.52</td>
<td>2.55</td>
<td>2.65</td>
<td>2.52</td>
<td>2.58</td>
<td>2.70</td>
<td>2.21</td>
<td>3.35</td>
<td>3.45</td>
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<td></td>
<td>Meat and bone meal</td>
<td>2.49</td>
<td>2.54</td>
<td>2.54</td>
<td>2.54</td>
<td>2.56</td>
<td>2.57</td>
<td>2.60</td>
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<td>0.72</td>
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<td>Vitamin mineral premix</td>
<td>1.00</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
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</tr>
<tr>
<td></td>
<td>Salt</td>
<td>0.20</td>
<td>0.40</td>
<td>0.33</td>
<td>0.36</td>
<td>0.49</td>
<td>0.42</td>
<td>0.42</td>
<td>0.50</td>
<td>0.32</td>
<td>0.71</td>
</tr>
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<td></td>
<td>Lysine HCL</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
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<td>0.01</td>
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</tr>
<tr>
<td></td>
<td>DL methionine</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Dicalcium phosphate</td>
<td>0.22</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.06</td>
<td>1.07</td>
<td>1.92</td>
<td></td>
</tr>
</tbody>
</table>

T1 = 0% LGM - Diet with 0% of the selected legumes; T2 = 10% LGM; T3 = 20% LGM; T4 = 30% LGM; T5 = 10% Cowpea; T6 = 20% Cowpea; T7 = 30% Cowpea; T8 = 10% Lablab bean; T9 = 20% Lablab bean; T10 = 30% Lablab bean.

The composition of the premix was: vitamin A, 10,000,000 IU; vitamin D3, 2,000,000 IU; vitamin E, 24,000 IU; vitamin K3, 3,200 mg; choline chloride, 350,000 mg; folic acid, 960 mg; thiamine, 1,600 mg; riboflavin, 5,600 mg; vitamin B6, 4,000 mg; vitamin B12, 24 mg; copper, 2.000 mg; iron, 4.000 mg; manganese, 15.000 mg; zinc, 4.5.000 mg; cobalt, 200 mg; iodine, 1.400 mg; and selenium, 122 μg.
Table 2: Composition (%) of the finisher diets

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearl millet</td>
</tr>
<tr>
<td>T1 (0% LGM)</td>
<td>75.02</td>
</tr>
<tr>
<td>T2 (10% G. gram)</td>
<td>67.92</td>
</tr>
<tr>
<td>T3 (20% G. gram)</td>
<td>60.55</td>
</tr>
<tr>
<td>T4 (30% G. gram)</td>
<td>54.08</td>
</tr>
<tr>
<td>T5 (10% C. pea)</td>
<td>67.87</td>
</tr>
<tr>
<td>T6 (20% C. pea)</td>
<td>60.46</td>
</tr>
<tr>
<td>T7 (30% C. pea)</td>
<td>52.94</td>
</tr>
<tr>
<td>T8 (10% L. bean)</td>
<td>67.53</td>
</tr>
<tr>
<td>T9 (20% L. bean)</td>
<td>59.57</td>
</tr>
<tr>
<td>T10 (30% L. bean)</td>
<td>52.07</td>
</tr>
</tbody>
</table>

**Note:** Table 2 presents the composition (%) of the finisher diets across different treatments. For treatment T1, the diet contains 0% of the selected legumes. For T2, T3, T4, T5, and T6, the legumes' percentages are 10%, 20%, and 30%. The vitamin-mineral premix includes: vitamin A, 10,000,000 IU; vitamin D₂, 2,000,000 IU; vitamin E, 24,000 IU; vitamin K₃, 3,200 mg; choline chloride, 350,000 mg; folic acid, 960 mg; thiamine, 1,600 mg; riboflavin, 5,600 mg; niacin, 32,000; pantothenic acid, 8,000 mg; pyridoxine, 4,000 mg; biotin, 100 mg; vitamin B₁₂, 24 mg; copper, 5,000 mg; iron, 960 mg; zinc, 4,500 mg; and selenium, 120 mg.
Feed intake was then determined by subtracting the amount of feed left over from the quantity given at the beginning of the week. Feed Conversion Ratio was determined as the ratio between total feed intake during the 42 days and the final total body weight gain per bird per replica.

At the end of week six (42 days), four broilers were taken at random from each treatment and fasted overnight. Their live weight was measured and the broilers bled by severing the jugular vein, scalded in hot water and de-feathered. The dressed weight was measured after the head, neck, viscera and shanks were removed. The weight of the breast muscle, drumstick, abdominal fat, liver, gizzard and pancreas were also recorded as a percentage of the live weight as indicated below.

\[
\text{Organ weight } \% = \frac{\text{Organ weight (g)}}{\text{Live weight (g)}} \times 100
\]

**Chemical analysis**
Duplicate samples of experimental diets were sampled from different sections of the bag containing them and taken to the laboratory where they were analyzed for Dry Matter (DM), Crude Protein (CP), Crude Fiber (CF), Ether Extracts (EE) and ash according to procedures of the Association of Official Analytical Chemists (AOAC, 2002). Dry Matter (DM) was estimated by oven drying the samples at 105°C for 12 hours. The ash content was determined by burning the samples in a muffle furnace at 600°C for 3 hours. Crude lipid was quantified as the loss in weight after its extraction from the sample using diethyl ether. Crude fiber was quantified as that portion of carbohydrates that resists digestion by 2.04 N H\text{\textsubscript{2}}SO\text{\textsubscript{4}} and 1.78N KOH solutions. Crude protein was estimated by the Kjeldahl nitrogen method in which the nitrogen measured was multiplied by a factor of 6.25. Nitrogen-free Extracts (NfE) was calculated by subtracting the percent of the above determinations from 100%.

**Statistical analysis**
All data obtained on feed intake, body weight gain, FCR and the carcass parts (as a percentage of live weight) were subjected to a one way Analysis of Variance (ANOVA) using Genstat Discovery 14\textsuperscript{th} edition. The significant difference between treatment means was tested at statistical significance level of P ≤ 0.05 and when found to be significant they were separated using Tukey’s multiple comparison procedure.

**Results**
Proximate composition of the experimental diets is presented in Table 3. The CP of the starter and the finisher diets was 22 and 20 % respectively. The results of feed intake, body weight gain and FCR of broiler chicken at 42 days of age are presented in Figure 1-3 and Table 4 below. A significant interaction (P<0.05) was observed between legumes and dietary levels for all growth parameters.

Generally, feed intake and body weight gain of broilers on GG and CWP based diets increased at an inclusion level of 10% but reduced at 20 and 30 % levels when compared...
to the control based diet. Lablab fed broilers had decreasing feed intake and body weight gain with increase in its level in the diet. Feed conversion ratio of the birds on GG and CWP was comparable to the ones on the control diet while the FCR of broilers fed on LB increased (became poorer) with increased levels of LB in the diet.

Table 3: Proximate composition (%) of the starter and finisher diets (DM basis)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Component</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
<th>T8</th>
<th>T9</th>
<th>T10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starter diets</td>
<td>Dry matter (%)</td>
<td>88.59</td>
<td>88.41</td>
<td>88.56</td>
<td>88.64</td>
<td>88.28</td>
<td>87.70</td>
<td>88.53</td>
<td>88.04</td>
<td>88.31</td>
<td>87.10</td>
</tr>
<tr>
<td></td>
<td>Crude Protein (%)</td>
<td>22.34</td>
<td>22.63</td>
<td>22.07</td>
<td>22.73</td>
<td>22.09</td>
<td>23.30</td>
<td>22.56</td>
<td>22.52</td>
<td>23.45</td>
<td>22.76</td>
</tr>
<tr>
<td></td>
<td>Crude Fiber (%)</td>
<td>3.71</td>
<td>5.20</td>
<td>4.11</td>
<td>4.59</td>
<td>3.70</td>
<td>4.36</td>
<td>4.57</td>
<td>4.45</td>
<td>4.22</td>
<td>6.29</td>
</tr>
<tr>
<td></td>
<td>Ether Extracts (%)</td>
<td>7.14</td>
<td>5.24</td>
<td>4.86</td>
<td>5.54</td>
<td>5.10</td>
<td>5.09</td>
<td>4.84</td>
<td>5.81</td>
<td>5.62</td>
<td>6.07</td>
</tr>
<tr>
<td></td>
<td>Ash (%)</td>
<td>6.29</td>
<td>6.17</td>
<td>6.41</td>
<td>6.78</td>
<td>6.46</td>
<td>6.35</td>
<td>6.61</td>
<td>6.19</td>
<td>5.95</td>
<td>7.45</td>
</tr>
<tr>
<td>Finisher diets</td>
<td>Dry matter (%)</td>
<td>88.55</td>
<td>88.32</td>
<td>86.64</td>
<td>87.20</td>
<td>84.62</td>
<td>87.73</td>
<td>88.10</td>
<td>87.86</td>
<td>88.76</td>
<td>87.07</td>
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<tr>
<td></td>
<td>Crude fiber (%)</td>
<td>5.54</td>
<td>4.61</td>
<td>5.01</td>
<td>4.82</td>
<td>4.54</td>
<td>4.65</td>
<td>4.28</td>
<td>5.09</td>
<td>5.65</td>
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<td></td>
<td>Ether extracts (%)</td>
<td>6.29</td>
<td>6.17</td>
<td>6.41</td>
<td>6.78</td>
<td>6.46</td>
<td>6.35</td>
<td>6.61</td>
<td>6.19</td>
<td>5.95</td>
<td>7.45</td>
</tr>
<tr>
<td></td>
<td>Ash (%)</td>
<td>3.22</td>
<td>4.20</td>
<td>4.15</td>
<td>3.55</td>
<td>3.25</td>
<td>3.85</td>
<td>3.50</td>
<td>4.45</td>
<td>4.05</td>
<td>3.90</td>
</tr>
</tbody>
</table>

T1= 0%LGM - Diet with 0% of the selected legumes; T2 = 10% Green gram; T3 = 20% Green gram; T4= 30% Green gram; T5 = 10% Cowpea; T6 = 20% Cowpea; T7 = 30% Cowpea; T8 = 10% Lablab bean; T9= 20% Lablab bean; T10 = 30% Lablab bean.

Figure 1: Effects of different legumes and levels on feed intake of broiler chicken at 42 days of age.

——— 125 ————
Figure 2: Effects of different legumes and levels on body weight gain of broiler chicken at 42 days of age.

Figure 3: Effects of different legumes and levels on FCR of broiler chicken at 42 days of age
Table 4: Effects of legume type and inclusion levels on broiler performance after 42 days

<table>
<thead>
<tr>
<th>Parameter</th>
<th>0%LGM</th>
<th>10%GG</th>
<th>20%GG</th>
<th>30%GG</th>
<th>10%CWP</th>
<th>20%CWP</th>
<th>30%CWP</th>
<th>10%LB</th>
<th>20%LB</th>
<th>30%LB</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed intake (g)</td>
<td>3172</td>
<td>3357</td>
<td>3051</td>
<td>2818</td>
<td>3337</td>
<td>3152</td>
<td>2952</td>
<td>3099</td>
<td>2796</td>
<td>2354</td>
<td>59.5</td>
</tr>
<tr>
<td>Body wt gain (g)</td>
<td>1668</td>
<td>1699</td>
<td>1527</td>
<td>1475</td>
<td>1698</td>
<td>1445</td>
<td>1401</td>
<td>1380</td>
<td>974</td>
<td>648</td>
<td>39.1</td>
</tr>
<tr>
<td>Feed Conversion Ratio</td>
<td>1.91</td>
<td>2.10</td>
<td>2.01</td>
<td>1.91</td>
<td>1.97</td>
<td>2.19</td>
<td>2.11</td>
<td>2.25</td>
<td>2.88</td>
<td>3.65</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Means within a row with different superscripts differ significantly (P<0.05).

0%LGM - Diet with 0% of the selected legumes; GG - Green gram; CWP - Cowpea; LB - Lablab bean; SEM - Standard error of mean; FCR - Feed Conversion Ratio.
Results of carcass yield are presented in Table 5. Birds fed on GG based diets had numerically higher weights of various parameters while those on the LB based diets had the least. The ranges of various carcass weights were; mean dressed weight (g), 904 –1248, dressed (%), 72.32 - 77.97; breast (%), 13.74 – 22. 20; drumstick, 4.12 – 4.96 (%); gizzard(%), 2.06 – 2.80; abdominal fat(%), 1.21 – 1.64 and liver (%) 2.51 – 2.72. The pancreas weights (%) ranged from 0.33 – 0.35 with birds on LB based diets having highest values. There was no significant (P>0.05) interaction between the legumes and levels for all the carcass parameters investigated.

Discussion
The analyzed CP and the CF values in all the treatments were within the recommended values by KEBS (2009) (20 and 18% for CP in the starter and finisher diets respectively) and 7.5 % for CF.

Effects of green grams on growth performance of broiler chicken
Broilers that were fed on the 0%LGM diet had a higher (P<0.05) feed intake (3172g/bird) when compared to those fed on 20 and 30% GG (3051 and 2818g/bird respectively) but they had a lower intake (P<0.05) when compared to those fed on 10% GG (3557g/bird). The reduced feed intake could be as a result of increased amounts of tannins with higher dietary levels of GG in the diet. Murwani (2008) also reported reduced feed intake for broilers fed diets containing 50% GG in maize based diets compared to those fed on maize-soybean based diets.

Broilers fed on GG had higher (P>0.05) weight gain at 10% level of inclusion (1699g/ bird) when compared to those on 0% LGM (1668g/bird). Those on 20% GG level (1527g/bird) and 30% GG (1475g/bird) however, had a similar (P>0.05) weight gain to those on the 0% LGM (1668g/bird).

Table 5: Effect of legume type on carcass quality of broiler chicken

<table>
<thead>
<tr>
<th>Type of legume</th>
<th>0%1LGM</th>
<th>2GG</th>
<th>3CWP</th>
<th>4LB</th>
<th>5SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean dressed weight (g/bird)</td>
<td>1226.00a</td>
<td>1248.00a</td>
<td>1208.00a</td>
<td>904.00b</td>
<td>100.30</td>
</tr>
<tr>
<td>Dressed weight (%)</td>
<td>74.20</td>
<td>77.97</td>
<td>77.50</td>
<td>72.32</td>
<td>2.93</td>
</tr>
<tr>
<td>Breast weight (%)</td>
<td>22.20b</td>
<td>18.22ab</td>
<td>18.96ab</td>
<td>13.74</td>
<td>2.38</td>
</tr>
<tr>
<td>Drumstick (%)</td>
<td>4.89</td>
<td>4.96</td>
<td>4.78</td>
<td>4.12</td>
<td>0.31</td>
</tr>
<tr>
<td>Abdominal fat (%)</td>
<td>1.53</td>
<td>1.64</td>
<td>1.60</td>
<td>1.21</td>
<td>0.24</td>
</tr>
<tr>
<td>Gizzard (%)</td>
<td>1.80</td>
<td>2.06</td>
<td>1.86</td>
<td>2.11</td>
<td>0.24</td>
</tr>
<tr>
<td>Liver (%)</td>
<td>2.72</td>
<td>2.51</td>
<td>2.64</td>
<td>2.70</td>
<td>0.20</td>
</tr>
<tr>
<td>Pancreas (%)</td>
<td>0.30</td>
<td>0.33</td>
<td>0.31</td>
<td>0.35</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Means within a row without superscripts/with similar superscripts do not differ significantly (P>0.05)
10%LGM - Diet with 0% of the selected legumes; 2GG - Green gram; 3CWP – Cowpea; 4LB - Lablab bean; 5SEM - Standard error of mean
These results are in agreement with those reported by Miller and Holmes (1992) who observed a reduction (P<0.05) in body weight gain when GG was included in broiler chicken diets at a level of 30%. Wiryawan et al. (1997) and Murwani (2008) however, found no significant effect (P>0.05) on average daily gain and body weight when GG was added up to 30 and 50% level in diets of finishing pigs and broiler chicken respectively. Broilers fed on different levels of GG and the control diet had a similar (P>0.05) FCR Robinson and Singh (2001) reported similar results where no significant (P>0.05) difference on FCR was reported when layer chickens were fed GG based diets at an inclusion level of 30%.

Effects of cowpeas on growth performance of broiler chicken
Broilers that were fed on diets containing CWP followed a similar trend as those fed on GG in terms of highest and lowest feed consumption. Broilers fed on 30% CWP had the least (P<0.05) feed intake (2952g/bird) compared to those fed 10% CWP (3337 g/bird) but was similar (P>0.05) to those on 20% CWP and 0% LGM (3152 and 3172 g/bird respectively). The reduced feed intake in the broilers on the 30% CWP could have been due to presence of higher amounts of tannins which reduce feed palatability and affect feed intake. Akanji (2012) and Abdelgani et al. (2013) reported reduced feed intake when levels of cowpeas were increased in diets of broiler chicken. Kur et al. (2014) reported no significant difference (P>0.05) when broilers were fed on diets based on either 15% of cooked (1223.7g/bird) or roasted (1200.5g/bird) CWP compared to those that did not contain any CWP (1263.3g/bird).

Similarly, body weight gain of the broilers fed on CWP decreased with increase in the level of CWP in the diet; 1668, 1698, 1445 and 1401g/bird for 0% LGM 10, 20 and 30% CWP respectively. Those on 10% CWP had higher (P<0.05) body weight gain when compared to those on 20% CWP and 30% CWP but similar to those on the 0% LGM. The lowered weight gain for the broilers on the 20% and 30% CWP may have caused the reduced feed intake. Chakam et al. (2010) and Abdelgani et al. (2013) also reported decreased body weight when levels of cowpeas were increased in broiler chicken diets. FCR values for 0% LGM, 10, 20 and 30% CWP were not significantly different (P>0.05). In a study conducted by Kur et al. (2014) there was no significant difference (P>0.05) when 15% of either cooked (2.90) or roasted cowpeas (2.50) were used in broiler diets to replace SBM (2.70). Similarly Abdelgani et al. (2013) did not report significant differences (P>0.05) in FCR for broilers fed on 5, 10 and 15% levels of CWP diets. However Chakam et al. (2010) reported poorer FCR values when cooked CWP were added in broiler finisher diets at 25 and 30% levels but similar FCR when the same was added at 10 and 20% level.

Effects of lablab beans on growth performance of broiler chicken
The feed intake of the broilers fed on diets based on LB declined (P<0.05) with increase in the levels of the bean in the diet (3172, 3099, 2796 and 2354g/bird) for 0%LGM, 10, 20 and 30%LB respectively. The decline in feed intake with increased levels of LB in the diet may have been due to increase in the amount of tannins in the diet. Tannins are bitter in taste and have been associated with reduced palatability of legume seeds by
animals (Aletor, 1993). Abeke et al. (2008) also reported a reduction in feed intake with increased levels of cooked LB in the diets of broiler chicken.

Broilers fed on Lablab beans (LB) based diets had a decreasing (P<0.05) body weight gain with increase in the dietary level (Figure 2). This decline followed the trend of feed intake. A significant reduction of body weight gain with increase in the levels of LB in the diet was also reported by Moawia (2015) and Abeke et al. (2008) for broiler chicken fed decorticated LB and LB cooked for 30 minutes respectively.

Poor FCR was also reported with increased level of LB in legume in the diet (Figure 3). Broilers fed on diets containing 0% LGM had better (P<0.05) FCR (1.91) when compared to those fed on 10% LB (2.25), 20% LB (2.88) and 30% LB (3.65). This is an indication that those diets were poorly converted into meat probably due to inhibitory effects of various anti-nutritive factors present in the LB beans. The poorer FCR with increased dietary level of LB was also reported by Abeke et al. (2008) when broiler chicken were fed on diets containing decorticated lablab bean at 10, 20 and 30% level.

**Comparison of broiler growth performance among the three legumes**

In general, feed intake for the broilers fed on the three legumes decreased with increasing levels the diet (Figure 1). This may have been due to an increase in the amounts of anti-nutritive factors in the feed particularly tannins. Broilers on GG and CWP based diets had a higher (P<0.05) feed intake compared to those on LB based diets. Published values of total tannins have been reported to be 2.16 - 2.73, 3.6 and 3.5 - 4.7 tannins in mg/g sample in GG, CWP and LB respectively (Sharma et al., 1991; Iyayi et al., 2008; Soetan, 2012). The higher amounts of tannins in the LB grains compared to those in the GG and CWP grains may have caused the lower feed intake observed in LB fed broilers.

The body weight gain of the broilers fed different legumes also decreased with increased level of legume in the diet (Figure 2). The reduced body weight gain with increase in the levels of legumes in the diet may have been due to various anti-nutritive factors among them protease inhibitors, phytic acid, haemagluttinins and tannins contained in legumes. These anti-nutritive factors bind dietary protein and digestive enzymes forming complexes that are not readily digestible thereby interfering with the digestion and absorption of nutrients in the gastrointestinal tract resulting in depressed growth (Islam et al., 2002). Therefore increase in the levels of the legumes in the diet resulted to increased amounts of anti-nutritive factors thereby affecting growth negatively. It could also have been due to the feed intake that also decreased with increased levels of the legumes in the diet. Body weight gain in poultry has been shown to be directly related to the amount of feed intake and the efficiency of utilization of the feed (Dada et al., 2000). Dousa et al. (2011) also reported a reduction (P<0.05) in live weight as the level of plant concentrate was increased in broiler chicken diets.

Broilers fed on GG and CWP based diets had a higher (P<0.05) weight gain compared to those fed on LB based diets. This observation is similar to what was reported by Robinson and Singh (2001) who reported the least performance for the broilers fed on
LB diets compared to those fed diets containing cowpeas, chickpeas and mungbean (green gram). The trends observed in the current experiment could have been due to presence of higher amounts of anti-nutritive factors in LB compared to the other two legumes. Anti-nutritive factors interfere with feed intake and nutrient utilization hence affecting weight gain. Robinson and Singh, (2001) observed a higher amount of Trypsin Inhibitors Activity (TIA) in lablab beans (3.8 - 5.5mg/g) compared to 1.9 - 2.9mg/g and 3.1mg/g in GG and CWP respectively. Trypsin inhibitors cause increased secretion of the enzyme trypsin by inducing hypertrophy and hyperplasia of the pancreas. This in turn causes growth depression through endogenous loss of amino acids in the form of enzymes secreted by the hyperactive pancreas (Liener, 1994).

Effect of legume type on carcass quality of broiler chicken

Broilers fed on diets based on the three legumes and the 0% LGM had similar (P>0.05) weights of various carcass parts apart from the mean dressed weight and the breast weight (%). Feeding broilers on LB based diets resulted to lower (P<0.05) dressed weight (904g) when compared to those on GG(1248g), CWP (1208g) and the control (1226g) and lower (P<0.05) breast weight (13.7%) when compared to those on the control diet (22.2%). However, there was no (P>0.05) significant effect of feeding the three legumes on the percentage yield of the following; dressed weight, drum stick weight, abdominal fat, gizzard, liver and the pancreas.

The low dressed weights (g) and breast weights (%) of broilers on LB based diets may have been due to the low feed intake and body weight reported for the same broilers. Anti-nutritive factors have been reported to reduce feed intake thereby lowering weight gain of broiler chicken (Islam et al., 2002). Contrary to the present study, Eljack et al. (2009) reported no significant differences (P>0.05) on the breast weight when raw CWP were included up to 20% in broiler diets. However Abeke et al. (2008) reported significantly lower (P<0.05) breast weight of broiler finisher fed on 50% LB compared to the control diet.

Authors such as Wiryawan et al. (1997), Abeke et al. (2008), Eljack et al. (2009), Chakam et al. (2010), Kana et al. (2012) and Moawia, (2015) have also reported no significant differences (P>0.05) on percentage yield of: dressed weight, drumstick, abdominal fat, gizzard, liver and pancreas when GG, CWP or LB were included in broiler chicken diets at varying levels.

Conclusions and recommendations

Green grams and cowpeas are satisfactory feed ingredients and can be included in pearl millet based broiler chicken diets at 30 and 10% level without affecting growth performance and carcass quality. However, use of lablab beans at 10% level results in reduced body weight gain, dressed and breast weight and is therefore discouraged. It is recommended that further studies using cowpeas and lablab beans to treat the beans in order to reduce the amounts of anti-nutritive factors that negatively affects growth.
Acknowledgement
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References


Potential of green grams, cowpeas and lablab beans as broiler chicken feed


Aflatoxin contamination in maize and maize based feeds

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Abstract

Mycotoxin contamination of major food crops presents a serious problem in Kenya. Contamination can occur in the field stage, during harvesting and drying, or in storage. Several outbreaks of aflatoxin poisoning after consuming maize have been reported in Eastern Kenya since 1978. In the year 2010 popular press reported that 2.3 million bags of maize were contaminated with aflatoxin and declared unfit for human and livestock consumption. A survey on fungal and aflatoxin contamination in maize and maize products was conducted during the 2010 and 2011 growing seasons in Trans Nzoia, Uasin Gishu and, Nandi counties. Maize and partially processed feed samples were taken from farms. Aflatoxin content was determined by the competitive ELISA method. All maize samples were contaminated with aflatoxin B$_1$ with the highest concentration at 15.5 ppb. In all the counties the least concentration of aflatoxins reported was 0.01 ppb but the mode was 0.05 ppb. The means for aflatoxin concentration in Trans Nzoia, Uasin Gishu and Nandi counties was 1.738±0.966, 0.834±0.177 and 1.060±0.213 ppb respectively. On average, the aflatoxin content in the samples was below the national tolerance level of 10 ppb. However, there is need to sensitize farmers about the potential danger of aflatoxins. There is also need to establish the presence of other mycotoxins.

Keywords: aflatoxin B1, maize

Introduction

Concerns regarding humans and livestock affected by aflatoxin have been on the increase since the realization that strains of *Aspergillus* species may produce the mycotoxin in hot humid weather (Murphy, 2007). Aflatoxin is a carcinogen and its metabolite, M1 passes into milk of cattle ingesting aflatoxin containing feed. Specifically grain containing more that 20 ppb must not be fed to cattle because it will be transferred to the milk and eventually to the human beings. Pre harvest aflatoxin contamination of corn is associated with drought and high temperature during grain fill. Post-harvest aflatoxin contamination can develop when grain is improperly managed though the drying and storage process (Vince et al 1984). Sound production, harvest and storage practices can reduce the risk of aflatoxin contamination even further.

Work done in the North Rift has revealed that common grain moulds in that area include the genera Aspergillus, Fusarium and Penicillium. Toxin-producing species identified were *A. flavus, A. parasiticus* and *A. niger. Aspergillus flavus* and *A. parasiticus* produce aflatoxins. The four major aflatoxins are known as aflatoxins B1, B2, G1 and G2. When aflatoxin B1 and B2 are ingested by lactating cows, a proportion (ca 1.5%) is hydroxylated and excreted in the milk as aflatoxins M1 and M2,0 (Frobish et al.,1986) These compounds have a lower toxicity than the parent molecules, but are significant
because of the widespread consumption of cows’ milk by infants (Pitt, 1989; Cassel, et al., 2001). Aflatoxins are both acutely and chronically toxic to animals, including man. They produce four distinct effects: acute liver damage; liver cirrhosis; induction of tumours; and teratogenic effects (Stoloff, 1977). Aflatoxin poisoning is characterised by jaundice, rapidly developing ascites and portal hypertension, with the implication of a food-borne toxin involving the liver (Reference?) However, the ingestion of aflatoxins at the low levels necessary to induce liver cancer is totally asymptomatic and has a very long induction period as well (Eaon and Groopmen, 1994).

The principal toxins produced by *F. graminearum* which was isolated at a very high frequency (30.5%) are deoxynivalenol (DON; also known as vomitoxin), nivalenol and zearalenone (Maracas et al., 1984). DON causes vomiting and feed refusal in pigs at levels near 5 mg/kg of feed. Its toxicity to species other than pigs remains to be defined, and appears unlikely to be high.

The oestrogenic effect of zearalenone in animals are genital problems in domestic animals, especially pigs. Symptoms include hyperemia and edematous swelling of the vulva in prepubertal gilts, or in more severe cases prolapse of the vagina and rectum. Reproductive disorders in sows include infertility, foetal resorption or mummification, abortions, reduced litter size and small piglets. Male pigs are also affected: atrophy of testes, decreased libido and hypertrophy of the mammary glands are all well documented (Maracas et al., 1984).

Most regulating government agencies worldwide have regulations regarding the amount of aflatoxins allowed in human and animal foodstuffs. Limits for the presence of aflatoxin M1 in milk and milk products have also been declared. In the European Union (EU), this limit has been set at 0.05 mg/L or 50 parts per trillion (50 ppt) (Food Standards Agency). This has implications on milk marketing.

The presence of toxigenic moulds on maize does not imply an obvious occurrence of mycotoxins in maize. Circumstances that favour mould growth may also favour mycotoxin production but moulds may occur with little or no mycotoxin production. The level of toxin formation in the field is aggravated by host plant stress in the field, during harvesting, storage conditions and finished feeds and forages. The objective of this study was therefore to find out if mycotoxins existed in the grain and partially processed feed samples that had the toxigenic strains of moulds.

**Materials and methods**

A minimum of 200 gm of whole maize grain, semi-processed grain, maize flour and animal feeds were taken from randomly selected households in different agro-ecological zones of Trans Nzoia, Uasin Gishu, Nandi West Pokot and Bungoma Counties. Other information collected during household interviews using a structured questionnaire included: respondent and site identification, household composition and characteristics, maize agronomic and post-harvest information for 2011 seasons, farmer attitudes, and perceptions on mycotoxins and marketing aspects that were perceived to influence occurrence of the mycotoxins.
The samples were stored at 4°C until they were analyzed. Global Positioning System (GPS) co-ordinates were taken to be used to map out the extent of mycotoxin contamination in the study areas.

**Analysis for aflatoxins**

The enzyme linked immunosorbent assay (ELISA) was used to analyse for aflatoxin B1 in the samples. Whole grain and the semi-processed animal feeds samples were ground to pass through a 1 mm screen. Two grams of the ground samples was weighed into a screw cap glass vials and 10ml of methanol/distilled water (70/30 v/v) was added and mixed for 10 minutes at room temperature using a shaker. The extract was then filtered then 100 µl of the filtrate was diluted with 600 µl of distilled water and 50 µl of the diluted samples was used per well for quantitative analysis.

All reagents were brought to room temperature before use. Three micro-titre plate wells were inserted into the micro-well holder for all standards and samples to run in duplicates. Standard and sample positions were recorded. To each microwell 50 µl of the standard solution or prepared samples, then 50 µl of the enzyme conjugate and 50 micro-litres of the antibody solution added. The mixture was shaken gently and incubated at room temperature for 30 minutes in the dark. The liquid was then poured out of the micro-wells and any excess liquid dapped off using absorbent paper. The wells were washed three times with PBS washing buffer then 100 µl of substrate/chromogen was added to each well, mixed gently by shaking the plate manually. After incubating the wells at room temperature in the dark for 15 minutes, 100 µl of stop solution was added to each well, mixed gently by manual shaking and the absorbance measured at 450nm.

**Results and discussion**

The means of aflatoxin B1 in the samples collected was 3.71±0.29 ppb, 0.903±0.14 ppb and 0.129±0.065 ppb for Trans Nzoia, Uasin Gishu and Nandi counties respectively as indicated in Table 1. The highest levels were registered in Trans Nzoia (AEZ (UM) and the least was in Nandi county (AEZ LH). There was great variability in Trans Nzoia samples as seen from SD and CV compared to other counties.

<table>
<thead>
<tr>
<th>County</th>
<th>Level (ppt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional mean</td>
<td>1.33 ± 0.29</td>
</tr>
<tr>
<td>Trans Nzoia</td>
<td>3.71 ± 0.782</td>
</tr>
<tr>
<td>Keiyo Marakwet</td>
<td>1.63 ± 0.429</td>
</tr>
<tr>
<td>Uasin Gishu</td>
<td>0.903 ± 0.14</td>
</tr>
<tr>
<td>West Pokot</td>
<td>0.274 ± 0.061</td>
</tr>
<tr>
<td>Nandi</td>
<td>0.129 ± 0.065</td>
</tr>
</tbody>
</table>

All the maize samples collected from farmers were contaminated with aflatoxin B1. This confirms the presence of aflatoxin in this region. Neyole and Matyo, 2009) found out that up to 30% of grain loss was due to moulding. Similarly, Bii (2013) showed that 100%
of maize and oil cake samples used for feeding livestock in the neighbouring South Rift
were contaminated with aflatoxin B1.

The highest level of aflatoxin B1 was reported in Trans Nzoia County at 15.5 ppb which
above the maximum set limit of 10 ppb. This probably was due to difference in agro-
ecological zones and other economic activities besides dairy farming. In Nandi County
majority of farmers practice tea farming while in Trans Nzoia and Uasin Gishu Counties
farming of cereals is predominant hence the population of *Aspergillus spp.* fungi are
lower in Nandi County. Kang’ethe and Lang’a, (2009) reported that 67% of dairy
concentrates had Aflatoxin B1 levels above 20 ppb. All feed samples tested positive for
Aflatoxin B1. Only 6.25 % of the samples exceeded the maximum limit set by European
Union at 3 ppb for human consumption. Bii (2013) found 100% of oil seedcakes were
contaminated and using second grade maize and oil seed cakes would easily result in
a feed with a concentration above maximum set by Kenya Bureau of Standards of 20
ppb. The finding of this research are consistent with International Food Policy Research
Institute (IFPRI) (2011) which revealed that maize from Western Kenya had aflatoxin B1
ranging from 0 ppb to 1.4 ppb.

In the materials and methods the following was investigated “farmer attitudes, and
perceptions on mycotoxins and marketing aspects that were perceived to influence
occurrence of the mycotoxins” yet there are no results or discussions for the same.

Conclusions and recommendations
The aflatoxin levels were below the national stipulated limit of 10 ppb. However the
current practices in maize handling after harvest, the change in weather patterns which
has resulted in heavy rains around harvest time in recent years, and the practice of using
mouldy grain as a livestock feed in many parts in the region are all potentially hazardous
situations that call for immediate action.

Additional studies on other mycotoxins than aflatoxin should be done. This will enable
the drawing of a map showing the hot spots for each toxin, and area-targeted awareness
campaigns.

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Sub-theme: Pastoral systems: Options for tomorrow
Improving indigenous chicken productivity for enhanced livelihood and food security in Sub-Saharan Africa

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Abstract

Indigenous chicken (IC) play vital roles to the resource-poor rural households in Africa. Over the years, the IC population has seen tremendous growth, however, this has not been accompanied by increase in their production output due to various constraints along the IC value chain. To contribute solution to these challenges, the Smallholder Indigenous Chicken Improvement Programme (INCIP) was initiated with an aim to harness multi-disciplinary scientific research and development to increase productivity, promote, utilize and conserve IC in the face of climate change through the development and packaging of performance improvement technologies along the IC product value chain and promotion of partnership in service delivery and agribusiness development, and hence, contribute to poverty alleviation, income generation and food security of smallholders and disadvantaged actors in the IC sub-sector.

Introduction

Indigenous Chicken (IC) (Gallus domesticus) is a poultry species of importance for nutrition and income security among the poor rural households in Africa. The popularity of IC among the resource poor rural households is attributed to their low cost of production, adaptability to harsh scavenging conditions and poor nutrition and tolerance to parasite and diseases. The demand for IC products is ever-increasing due to urbanization, increasing human population, decreasing agricultural land and consumer preference however, the current status of IC production output is low. This has majorly been attributed to the low input system in which the birds are reared, poor IC genetic profile due to lack of purposeful selection strategies, and disconnection among actors and lack of proper marketing channels along the IC value chain. Having identified the value of IC and constraints facing the IC sub-sector, the Smallholder Indigenous Chicken Improvement Project (INCIP) was initiated in 2006, a collaboration between Egerton University, Kenya Agriculture Research Institute (KARI) and the Ministry of Livestock and Development (MoLD), funded by the World Bank. This was a research and development action intended to comprehensively analyse the IC value chain to provide insight into the existing situations of the IC sub-sector to help in formulation of solutions. The results were promising hence led to the development of the second phase of the INCIP programme in 2012, a collaborative between Egerton University, Kenya, Lilongwe University of Agriculture and Natural Resources, Malawi and Wageningen University, Netherlands, funded by the European Union through the African Union. This is also a research and development action intended to enable smallholder, and other
disadvantaged stakeholders to be involved in a coordinated IC sub-sector thus contribute to enhanced livelihood and food security in Sub-Saharan Africa.

Methodology

The InCIP programme has achieved its objectives through development and packaging of performance improvement and environmental friendly production technologies along the IC product value chain, promotion of partnership in service delivery and agribusiness development, and visibility and multiplication of the programme’s activities.

Results and outputs

Characterisation of IC genetic resources in Kenya

The Smallholder Indigenous Chicken Improvement Programme focused its research on specific counties in Kenya based on IC population, agro-ecological zones and lack of or minimal if any introduction of the exotic chicken breeds for crossbreeding. The counties were within the Western, North and South Rift, Eastern and Coastal regions. Therefore, IC genetic resources were identified as ecotypes depending on county of origin. Morphological characterisation of IC ecotypes indicate that heterogeneity exists within IC population with huge variability in features without standard phenotypic characteristics (Ngeno, unpublished). The choice of body plumage colours by IC keepers have been attributed to various traits, depending on the region. However, no scientific information has been able to back this perception. Whole genome sequencing of IC indicate that these birds significantly vary from the commercial layers and they pose a high genome variability that may be important for addressing present and future challenges associated with adaptability to the environment and to cope with farmers breeding goal (Ngeno et al., 2015). Further molecular studies have been used to explain the current geographic distribution of the IC ecotypes by investigating their genetic diversity and population structuring revealed that three clusters exist within the IC population in Kenya: Cluster one is composed of birds from the Western, North-Rift and South-Rift, cluster two is composed of birds from the Eastern region, and cluster three is composed of birds from the coastal region (Ngeno et al., 2015).

Strategies for developing sustainable improvement programmes for indigenous chicken

Characterisation of IC and their production systems help to understand how the whole system operates for the purpose of identifying threats and opportunities for holistic improvement. Free-range system is the most common among IC keepers, mainly identified as low input-output system with low mean flock and effective population size per household, translating to high inbreeding levels (Okeno et al., 2012a). Economic evaluation of production systems indicate that utilization of IC in their current genetic merit is more profitable under free-range and semi-intensive systems, but not economically viable under intensive system (Okeno et al., 2012c). Indigenous chicken form integral part of the rural households in terms of nutrition and income, however, high mortality due to diseases, poor nutrition, housing and marketing channels have been identified as major constraints faced by farmers (Okeno et al., 2012a). The IC Farmers select their breeding stock at household level based on growth rate, body size, egg number, disease resistance and fertility traits which are in line with those preferred by farmers, marketers and consumers as traits of economic importance (Okeno
Economic evaluation of these traits under the three production systems suggest that genetic improvement targeting these traits would have a positive impact on profitability of IC production (Okeno et al., 2011; 2012b). These results indicate possibilities of improving IC either as dual purpose to represent the producers’ breeding goal or as specialised lines. Okeno et al. (2013) reported pure line selection of IC for meat production was the most attractive breeding objective in terms of genetic gain and profitability followed by egg production and dual-purpose objectives, in that order. As such pure lines selection could be adopted in breeding programmes targeting meat and egg production while the crossbreeding scheme could be used to develop a dual-purpose breed and hybrids with moderate production potentials for egg production and growth rate. These programmes would be more beneficial to farmers who already practice SIS or IS, or who are willing to shift from FRS to SIS or IS.

In characterisation of growth performance in IC, Ngeno et al. (2011) observed within cluster variation focusing on cluster one on IC ecotypes from Kakamega and Bondo in Western region, West Pokot and Turkana in North Rift region and Bomet and Narok in South Rift region of the country. Bondo ecotype had the highest growth rate and body weight at maturity while Bomet and Narok ecotypes reached maturity earlier with lighter weights hence may be considered for egg production. This concurred with results on the negative correlation between mature weight and maturation rate (Ngeno, 2015). A similar study on growth revealed that genes with major effect on feather morphology have significant influence on performance (Magothe et al., 2010). The normal feathered genotype showed superiority in growth at different ages from 8 weeks of age while birds with the crested gene had the lowest growth rate, implying that the crested head genotype may be suitable for egg production. The feather reducing gene, on the other hand was identified as not being suitable in moderate to low environmental temperatures as indicated by the low growth performance observed in the Naked neck and frizzle-feathered genotypes. Genetic evaluation of growth patterns in IC suggest that selection for body weight at week 12 was the most favourable as indicated by the moderate heritability estimate, and high genetic correlation with both juvenile and mature weights (Magothe et al., 2011).

Description of growth patterns in IC provide insight on designing appropriate feeding interventions for the different growth phases for improved productivity. This has been explored by Gakige et al. (2015) where the study recommends that IC reared in free-range system should be supplemented during the final growth phase (15-23 weeks) to achieve high body weights while minimising the cost of supplementation. This indicates that IC reared for meat production can be free ranged but require fattening two months before sale. Further, IC clusters have been evaluated for feed efficiency in which cluster one was the most feed efficient, however, the presence of sexual dimorphism between clusters for feed efficiency indicated that males from cluster three and females from cluster one could be considered as suitable lines for improving growth and feed efficiency in indigenous chicken (Miyumo et al., 2015).

Vulnerability of IC to climate change and variability under their scavenging environment indicate that disease epidemic, feed shortage and heat stress are likely to have the highest impacts on IC performance while water scarcity, parasitic challenge and flooding have the least impact (Ngeno, unpublished). Indigenous chicken farmers have adopted various coping mechanisms which vary depending on regions but generally they use vaccination to control diseases, provide feed supplementation, and prefer certain IC genotypes and
provide shades to mitigate heat stress. Environmental friendly animal production has been demonstrated by use of an energy renewable system that utilizes poultry manure to produce bio-gas for artificial brooding, hence assist in curbing waste disposal. Poultry production under greenhouse technology was tested and has proved beneficial in assisting farmers to combat chilling challenges in cold highland areas.

**Strategies for improving the IC marketing systems**

In order to link the IC value chains with IC genetic resources, farmer participation in the market has been considered because of its importance as a source of inputs and revenue to the resource poor farmer households. Bett et al., (2012) identified a clear and significant relationship between actors in the IC value chain indicating that all stakeholders are required to participate and draft the way forward to sustainably utilise while conserving the indigenous chicken genetic resources. Based on the attributes of IC products consumers are willing to pay more for these products, and through value addition of IC products this would lead to expansion of their market both locally and internationally (Bett et al., 2013). Functional traits form basis of non-market traits according to farmer preference based on perception, indigenous knowledge and experience with IC (Bett et al., 2011). Price determination of IC products heavily depend on buyers’ assessment at local, secondary and terminal levels at market creating variation in prices hence pose risks especially to farmers (Bett et al., 2011). In addition, traders often do not provide adequate and reliable information to the farmers about the market conditions especially regarding prices and the preferences of the consumers. Therefore, to avoid exploitation from the intermediaries, farmers should be encouraged to form marketing groups for better access to market information sources, improvement of their bargaining power to negotiate higher prices for their IC and consequently concentrate on raising chicken based in the preferred for the market (Gicheha, unpublished). Demand elasticity estimates for meat suggest that different interrelationship among meat products exist in which IC meat and beef are considered substitutes while goat and exotic chicken are complements (Bett et al., 2012).

**Validation of the IC technologies**

The programme has developed various communication platforms to facilitate dissemination of developed technologies to target beneficiaries from different communities. These include outreach programmes, short courses on poultry production, an active programme website (www.incip.org), and an SMS-based marketing and information system has been developed under the name “M-FUGO” to serve as a means of instant information dissemination platform (The system is on the second phase of testing before its release for the general public to use).

**Promotion of partnerships and enterprise development**

The programme is currently creating an environment for the growth of business and innovative ideas in the IC sub sector by identification of problems affecting agribusiness in the IC product value chain and thereafter provide relevant information, links with relevant organizations and networks in the public and private domain and at the same time attract funding and investment. An agribusiness incubation centre has been developed that also pilots a farmer friendly package of credit access and a revolving fund in close collaboration with financial institutions.
Future prospects

The Smallholder Indigenous Chicken Improvement programme has by far taken shape by covering basic yet crucial aspects of the IC value chain which provide valuable information for making informed decisions regarding the improvement of IC product value chain through various strategies. The research findings on marketing systems provide necessary information for making policies and strategies targeting the IC sub-sector to improve the production output of IC products, thereby satisfying the local consumption and obtaining surplus for exports. In its next phase, the programme intends to focus on egg production, IC product quality, and genomic evaluation of resistance to priority diseases and efficiency of feed utilization. Sustainable breeding programmes focusing on pure line breeding for meat and egg production, and crossbreeding to develop dual-purpose IC will be developed and implemented. Thereafter, the improved IC will be multiplied and supplied as initial breeding stock to enhance efficient flow of products and services. In addition, an incubator using renewable energy (biogas) using poultry manure will be designed and tested. In the case of marketing systems, the roles social networks play in the exchange of genetic materials and adoption of technologies by IC farmers will be identified and channels through which farm level efficiency of IC production can be improved will be determined.

References


Genetic improvement of indigenous chicken in Kenya: the past, current and future efforts

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Abstract

The need to improve and conserve indigenous chicken (IC) genetic resources has been recognized. Previous attempts to genetically improve IC involved a cross-breeding scheme that utilized exotic cockerels and pullets. This scheme was complimented with farmer training on husbandry practices and vaccination for disease control. The scheme improved egg weight but not egg yield and growth rates. The failures of the programme to meet farmers’ expectations were identified as lack of a breeding goal and adoption of inappropriate strategies. The current attempt to improve and conserve IC has employed a systematic, holistic and comprehensive approach. Characteristics of the IC value chain have been documented, breeding goals defined, breeding strategies formulated and pilot on-station and community based breeding programmes initiated. Opportunities for the future include more studies to determine more traits for inclusion in breeding goals, expansion, coordination of pilot programmes and continuous capacity building. Active participation of all the stakeholders, private-public partnership and public financial support are needed to ensure sustainability of IC improvement programme.

Introduction

The importance of indigenous chicken (IC) in wealth creation and animal protein supply at national and household levels in Kenya has been well recognized (Khobondo et al., 2014). For instance, they contribute over 40 and 60% of chicken eggs and meat produced in the country, respectively. In addition, they serve as a means of capital accumulation and are valued in religious and socio-cultural lives of most communities (Magothe et al., 2012a). Despite the increasing demand for IC products, their low productivity limits their contribution to rural development. The constraints leading to low productivity are well understood and may be broadly categorized into non-genetic and genetic factors. The non-genetic constraints include inadequate nutrition and high disease and parasite incidences, while low genetic ability for growth and egg production constitute the genetic constraints.

Abilities of livestock to produce desired products have been increased tremendously through genetic improvement processes (FAO, 2010). Genetic improvement
systematically exploits genetic variation of individuals within or between populations, resulting to changes in the performance of important traits. These changes can only be realized when their overall effects results to short and long term benefits to stakeholders (FAO, 2007). Therefore, a successful genetic improvement strategy must consider not only the traits of economic importance but also the current and future social, economic and environmental conditions. A genetic improvement strategy aimed at increasing growth and egg production of IC through breed replacement was attempted in the past. However, the attempt resulted in creation of new challenges such as increased production costs, erosion of genetic diversity and threats of new diseases (Magothe et al., 2012b).

Indigenous chicken are a valuable genetic resource due to their adaptability to local climatic and environmental conditions. They could therefore form the basis for genetic improvement and diversification to produce adapted and high yielding breeds (Besbes, 2009). However, due to continued use of commercial exotic breeds and strains for upgrading, the diversity of these valuable IC genetic resources are at risk of erosion and possible extinction. To arrest this trend, there is need to develop genetic improvement programs that would improve IC productivity without losing their diversity and adaptability. Currently, more efforts are underway not only to improve productivity but also to conserve these valuable genetic resources. This paper reviews the past and current genetic improvement attempts and suggests future opportunities for long-term increased productivity and conservation of IC.

**Past improvement efforts**

Documented evidence indicates that the first IC genetic improvement attempt began in 1974 when the National Poultry Development Programme (NPDP) was initiated (Magothe et al., 2012b). The programme goal was to increase subsistence smallholder farmer’s protein intake and income through commercialization of rural chicken production. Replacement of IC with commercial broilers and layers was emphasized due to the perceived need to organize, promote and develop small-scale commercial chicken production in the country (Anonymous, 1981). Production of eggs and meat using commercial hybrid broilers and layers was started on a pilot basis in a few rural areas adjacent to major urban centers. This approach, however, was found to be uneconomical and was quickly abandoned; citing poor meat and egg marketing channels, inadequate husbandry practices and high costs of inputs, as the major constraints (Anonymous, 1985).

In 1976, the programme was re-organized and the focus turned to IC. Their genetic potential for egg and meat production was, however, considered to be too low to meet the programme goal (Wainaina, 1994). Upgrading of IC was considered as the quickest means of achieving genetic improvement and as such, a strategy involving the use of exotic pure breeds to improve IC meat and egg productivity was devised. The aim was to gradually replace the low yielding IC with exotic pure breeds instead of the commercial broilers and layers. Due to its dual purpose nature, the Rhode Island Red (RIR) was chosen as the best exotic pure breed for use in the programme. Consequently, cockerel and pullet exchange programmes were started in 1978 on a pilot basis.
Although the strategy was not clearly documented, it comprised of primary breeders, multipliers, growers and producers as summarized as in Figure 1. Initially, a parental stock of RIR was sourced and imported from a primary breeding company in Europe. The stock was raised at the National Animal Husbandry Research Centre (NAHRC) of the Kenya Agricultural and Livestock Research Organization (KALRO), Naivasha, and used to produce both cockerels and pullets. Cockerels produced were transferred to government farms and stations for rearing, while the pullets were retained at the centre and used as replacement stock. The day old male chicks were reared to sexual maturity and exchanged with farmers’ indigenous cocks (Nyange, 1995). To facilitate the exchange, farmers were trained on the advantages of crossbreeding and encouraged to get rid of all indigenous cocks within the homestead and exchange one of the cocks with a RIR cockerel.

After the first few exchanges, the cockerel exchange programme (CEP) became popular and from 1985 onwards was rolled out to all high potential areas of the country except the Arid and Semi-Arid Lands (ASALs). The popularity was due to higher performance of first generation (F1) crossbreds in addition to their ability to cope with the sub-optimal management conditions. The higher performance of F1 may be attributed to heterosis and breed complementarities (Okeno et al., 2013). Despite scarcity of reports on performance of subsequent generations of crossbreds, their reduced adaptability was in no doubt as indicated by introduction of mass vaccinations against Newcastle disease in 1988. The vaccinations were also to facilitate farm level survival of the poorly adapted pure bred RIR offsprings occasioned by the pullet exchange programme (PEP).

By the end of 1984, the supply of day-old chicks by NAHRC became irregular, unsustainable and eventually collapsed. From 1985 to the end of the programme in 1995, terminal hybrid cockerels from the local commercial broiler and layer hatcheries were used. To date, the hybrid cockerels have continued to be used for genetic improvement of IC in the country.
Achievements

Although comparative egg and meat production performances of IC before the programme are limited, studies conducted during and after the programme indicate some level of genetic improvement in egg weight. However, there was lack of improvement in egg number and body weight.

Egg weight

A study conducted before the start of the programme reported egg weight (EW) of free-ranging IC as averaging between 25–27 g (Stoltz, 1983). A study conducted during the programme implementation reported an average EW of 42.5 g for indigenous birds sampled from non-programme areas and 52.3 g for their crosses with RIR under intensive production system (Ndegwa and Kimani, 1996). Recent studies conducted more than 10 years after the end of the programme reported an average EW of 46.8 and 48.0 g for free-ranging and 47.2 g for intensively reared indigenous chicken (Magothe et al., 2006; Olwande et al., 2010). This shows an EW improvement of between 73% and 87% under free-range and about 11% under intensive production. This major achievement can be attributed to the genetic improvement programme.

Egg number

Whereas the study by Stoltz (1983) reported an average egg production of 40–60 eggs per hen per year under free-range conditions, other studies conducted after the end of the programme reported an average yield of 30–66 eggs per hen per year (Okitoi et al., 2000; Juma and Ondwasy, 2002). This indicates no improvement in egg number.

Body weight

Under free-range conditions, Stoltz (1983) reported an average body weight of 1750 g for both male and female IC at 24 weeks of age. Although comparative body weights after the programme are scarce, an average of 1482 g and 1600 g for pullets under free-range have been reported (Upton, 2000; Olwande et al., 2010). Under intensive system, Ndegwa and Kimani (1996) reported a mean body weight of 1630 g at 24 weeks of age while Magothe et al. (2010a) reported an average of 1525.7 g at the same age. It can therefore be concluded that no improvement on body weight was realized.

Challenges

Several factors contributed to the failure in achieving genetic improvement. Nyange (1995) pointed the main factors as high cockerel and pullet mortalities, lack of awareness of the genetic value of the cockerels and pullets, lack of a continuous supply of exotic breeding stock and the inability to select IC at farm level. The main drawback from genetic perspective could be summarized as inappropriate application of genetic improvement principles such as breeding goals and strategies.

Lack of breeding goals

One of the main guiding principles of genetic improvement is the derivation of breeding goals that specify the current and anticipates future value chain environments, traits to
be genetically improved and the direction of improvement (Okeno, et al., 2012b). The choice of traits should generally be in line with the agricultural development objectives and specifically be appropriate for future production systems, environmental, economic and socio-cultural conditions (Philipsson et al., 2011). The IC improvement programme had no defined breeding goal. The programme’s goal was more of a developmental than a breeding goal as the exact traits to be improved were not defined.

In addition, the production systems and circumstances had neither been documented nor understood. Furthermore, importation of parental stock implied reliance on the breeding goals of the parent breeder companies. Such breeding goals are inappropriate for free-range production environments (Philipsson et al., 2011). Consequently, due to unfavorable genotype by environment interactions, the poorly adapted cockerels, pullets and their offsprings could not survive the harsh environmental conditions, leading to high mortalities.

**Use of inappropriate breeding strategy**

Crossbreeding aims at utilizing different breed characteristics and heterosis. Except in synthetic breed’s development, all crossbreeding strategies require a constant supply of purebred individuals for sustainability. In addition, performance of the breeds, their crosses and the suitable combination levels must be known. The NPDP had no reliable source of purebred RIR thus resulting to use of terminal hybrids. Terminal hybrids are not used for reproduction due to expression of undesirable characteristics resulting from intense selection (Hocking, 2014). The use of hybrids by the programme was therefore inappropriate and may have contributed to lack of improvement.

Furthermore, the optimal upgrading levels suitable for the prevailing production systems were unknown. It is known fact that as the level of upgrading increases, adaptability of the crossbreds reduces (Philipsson et al., 2011). Such crossbreds require increased levels of inputs leading to increased costs of production. The increased costs of production could not be sustainable within the production system. The producers’ expectations were therefore unmet and the programme had to be terminated (Khobondo et al., 2014).

**Current improvement efforts**

The second IC genetic improvement effort began in 2006 when a collaborative smallholder indigenous chicken improvement programme (InCIP) was initiated (Khobondo et al., 2014). To avert past failures, the programme follows a holistic, comprehensive and systematic approach to IC genetic improvement. The objective of the programme is to genetically improve IC productivity while conserving their biodiversity.

Genetic improvement involves logical decision making and the application of genetics and animal breeding principles in order to obtain future generations that produce desired products more efficiently under prevailing economic and social circumstances than the present generation (Philipsson, 2011). In doing so, the following fundamental questions are answered; “where are we?”, “where do we want to go?” and “how do we reach there?” To answer these questions, InCIP has employed a systematic methodology as detailed by Khobondo et al., (2014).
Characterization of IC value chain

Characterization of the IC value chain is the first step to that answers the question of where we are. Production systems, phenotypic, market and consumer characterization helps in understanding the production and management practices, levels of productivity, marketing channels and consumer preferences and the associated factors that are essential in developing improvement strategies (Okeno et al., 2012a). The IC value chain (Bett et al., 2012), including production systems (Olwande et al., 2010; Okeno et al., 2012a), levels of productivity (Magothe et al., 2012a; Ngeno et al., 2013), genetic variability (Ngeno et al., 2014), marketing (Bett et al., 2012) and consumer preferences (Bett et al., 2011) have been described. The question of where we are has therefore been adequately answered. In addition, promising IC among and between populations have been identified (Khobondo et al., 2014; Ngeno et al., 2014).

Definition of breeding goals

Definition of breeding goals answers the question of where we want to go. A breeding goal is a combination of economic and breeding values of traits a producer would like to improve because of their influence on profitability in the production system (Okeno et al., 2013). Traits of interest to the producers, marketers and consumers have been identified, their economic values estimated and those to be included in IC breeding objectives established (Bett et al., 2011; Okeno et al., 2011 and 2012c). In addition, genetic parameters for some of the traits have been estimated (Ngeno et al., 2013). It has been recommended that improvement targeting egg number, average daily gain, live weight, fertility, hatchability and survival rate would have a positive impact on profitability of IC production in Kenya.

Furthermore, Okeno et al. (2013) developed and tested three breeding goals namely, dual-purpose IC (ICD), IC layers (ICL) and IC broilers (ICB). The breeding goals traits considered in ICD were egg number (EN) from 24 to 50 weeks, egg weight (EW), average daily gain (ADG), live weight at 16 weeks (LW), age at first egg (AFE), fertility (FER), hatchability (HA), fecal worm egg count (FEC), immune antibody response (Ab) and feed intake (FI). The traits in ICL were similar to those in ICD, but ADG and LW were not included in the breeding goal. In ICB the traits in the breeding goal were as in ICD, but selection emphasis was put on growth traits (ADG and LW).

Generally, all the three breeding goals had positive genetic and economic gains, but with different marginal benefits, implying that adoption of any of these breeding goals in IC breeding programmes would result in genetic improvement of IC and increased profitability. ICB was recommended as the most profitable breeding goal, followed by ICD and ICL.

Selection of genetic improvement strategies

Selecting a genetic improvement strategy answers the question of how do we reach there. Genetic improvement is achieved by selecting the best individuals of the current generation and using them as parents of the next generation. The main genetic improvement strategies include within breed selection, cross-breeding and between
breed selections (Philipsson et al., 2011). The definition, advantage and disadvantage of each are summarized in Table 1.

Table 1. Conventional genetic improvement strategies: their advantages and disadvantages.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Definition</th>
<th>Advantage</th>
<th>Disadvantage</th>
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<tbody>
<tr>
<td>1.  Between breed/strain selection</td>
<td>Replacement of current inferior breeds/stains with superior ones</td>
<td>Fast long-term improvement</td>
<td>Expensive</td>
</tr>
<tr>
<td>2.  Cross-breeding</td>
<td>Combination of two or more breeds/stains</td>
<td>Fast short-term improvement</td>
<td>Regular supply of pure breeds/stains</td>
</tr>
<tr>
<td>3.  Within breed/strain selection</td>
<td>Use of superior individuals within breed/strain</td>
<td>Cumulative and long-term improvement</td>
<td>Slow improvement</td>
</tr>
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</table>

Okeno et al., (2013) found within breed selection of IC to be superior in genetic gains and profitability and recommended the strategy for use in programmes targeting ICL and ICB. In addition, a three line cross breeding strategy was recommended for production of hybrids that not only exhibit improved egg production and growth rate, but also for development of dual-purpose synthetic breeds for use in feed scarce and disease prone production conditions.

**Pilot genetic improvement programmes**

After the initiation of InCIP in 2006, IC eggs and live birds were collected from various Agro-ecological regions and multiplied at the poultry research unit (PRU) of the NAHRC of KALRO, Naivasha, and at Egerton University poultry research and breeding (PRB) facility. This population of IC was used for on-station studies that generated information regarding best performing genotypes and ecotypes, levels of productivity and genetic parameters of various traits as described by Khobondo et al. (2014). Following Magothe et al. (2010b) suggestion of selection based on body weight at 12 weeks of age, an experimental divergent selection programme was started. The programme at PRU, however, stopped after three generations of selection due to financial constraints and internal conflicts. Nevertheless, two populations (heavy and light) had already been created (personal observation). At the PRB, the programme is still on-going with selection based on body weight at 16 weeks as recommended by Okeno et al. (2013).

The community based IC improvement model has been developed based on the recommendations of Okeno et al. (2012a) and the guidelines by FAO (2010) and Philipsson et al. (2011). This model was developed by InCIP in conjunction with farmers and stakeholders. The model’s breeding objective was to improve body weight (BW), egg number (EN) and survival (SV) traits of free-ranging IC. A within breed selection strategy in a two tier structure comprising of open nucleus and production flocks was adopted (Okore, personal communication). Selection traits were body weight at 6 months and age at first egg for males and females, respectively. The open nucleus was established from clusters of farmers whose chickens run together as suggested by Okeno et al. (2012a). Each cluster had an average of five households with at least 30
hens and 6 cocks. About 10 such clusters in two localities formed the nucleus (personal observations). The nucleus flock farmers elected cluster and nucleus leaders to coordinate the programme. A successful programme with a similar approach has been reported in Uganda (Roothaert et al., 2011). The programme is being piloted in Teso South sub-county, Busia County.

**Major challenges**

The major challenges experienced while implementing the pilot programmes include unreliable financing, lack of coordination between institutions and shortage of skilled human resource. The pilot programmes are financed by donors such as the International Fund for Science (IFS), World Bank (WB), European Union (EU) and Food and Agriculture Organization (FAO). Whereas breeding programmes take time for results to be realized, external funds are short term (Mueller et al., 2015). Reliance on donor funding may not be sustainable because they not only come with pre-conditions, but are also short time bound.

Additionally, initiation of the pilot programmes were mainly driven by individual links and initiatives that resulted in donor funded projects or research programmes implemented by various institutions. For instance, the on-station improvement programme funded by EU is being implemented by Egerton University, a parallel project is under KALRO implementation and the community based programme funded by FAO is being implemented by the State Department of Livestock. The uncoordinated projects have resulted in institutional rivalry instead of cooperation and duplication of activities. Furthermore, the institutions, except Egerton University, have a shortage of animal breeding technical experts that are necessary for any breeding programme to succeed (Zonabend et al., 2013). To overcome these challenges, there is need for policy to streamline genetic improvement and conservation of animal genetic resources. The government funding is also essential for research, capacity development and sustainability of breeding programmes.

**Future improvement opportunities**

It has been demonstrated that there are opportunities for improving IC either for dual-purpose or specialized lines for egg and meat production. The effects and economic benefits of genetic improvement accumulate over time and should therefore be seen as investments to produce food and conserve biodiversity (Philipsson et al., 2011). Khobondo et al. (2014) outlined the future research areas and suggested improvement opportunities including pure line selection and crossbreeding. Future breeding programmes should be implemented on-station or at community level.

**On-station programmes**

A three tier genetic improvement model comprising of the closed nucleus, multiplier and farmers flocks has been proposed for on-station implementation (Okeno, 2013). In this model the nucleus should be setup within research institutions such as the NAHRC of KALRO and universities that already have the necessary infrastructure like poultry housing, incubators and human expertise in place. The multipliers should be run by governments, farmers’ organizations, cooperatives or private hatcheries to encourage...
public-private participation in the breeding programme. The nucleus should be responsible for screening and recruiting the initial breeding stock from farmers, carrying out performance and pedigree recording, maintaining different purebred lines and carry out selection and mating with a focus on breeding objective. In addition, the nucleus should be responsible for development of synthetic breeds. The multiplier should be tasked with multiplication of purebred or synthetic parent stocks purchased from the nucleus either as fertilized eggs or day old chicks and sell them to farmers for improvement of the entire IC population. They would also be responsible for production of crossbreds from the purebred parent stock which could be sold to farmers for commercialization of IC production.

**Community based programmes**

Community based breeding programmes (CBBP) typically relate to low input systems where farmers within limited geographical boundaries have a common interest to work together for improvement of their genetic resources (Mueller et al., 2015). For the IC, CBBP provide opportunities for implementation of breeding strategies that could successfully improve IC productivity with limited available resources. In addition, the CBBP also provide a sustainable option for conservation of IC genetic resources. The two tier model should be replicated, with the necessary modifications, in all counties. However, as summarized by Mueller et al. (2015), it should be noted that success of the model is highly dependent on organizational, technical and reliable financial support.

**Conclusion**

To avoid the failure of past improvement efforts, IC studies have been undertaken and pilot genetic improvement programmes based on sound breeding principles initiated. These programmes should be expanded and formalized to realize sustainable improvement and conservation of IC resources. This require participation of all stakeholders and funding from exchequer. Reliance on donor funding has been unsuccessful because they not only come with pre-conditions, but are also short time bound. Continuous capacity building of framers, researchers and policy makers is needed to create awareness on the need and possible impact factors of improving and conserving IC for present and future generations.
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Effect of long-term grazing on soil carbon accumulation in pastoral areas of Northern Kenya

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Abstract

Under article 3.4 of Kyoto protocol, the need for enhanced carbon storage in the rangelands is emphasized for climate change mitigation and local livelihoods diversification through carbon credits. Carbon markets however require additional carbon storage to what is existing under normal-land use practices to qualify for carbon credits. Grazing exclusion is often thought to improve rangeland primarily productivity and provide extra carbon storage that warrant carbon credits. This study assessed soil carbon accumulation in semi-arid pastoral ecosystems of northern Kenya under 82 years of grazing exclusion and compared with soil carbon storage in the adjacent areas of continuous grazing. It was found that yearly soil carbon accumulation at the rate 0.769 tonnes ha⁻¹, providing economic value of 16.65 $ and 9.59 $ based on voluntary and compliance carbon markets respectively. Considering the opportunity costs and uncertainty in the carbon values, then such long-term exclusion did not provide adequate soil carbon accumulation for carbon credits.

Keywords: carbon credits, grazing exclusion, northern Kenya, pastoralists, soil carbon

Introduction

The importance of pastoral rangelands in the mitigation of global climate change through carbon storage in soils and vegetation has been emphasized (e.g Lal 2004). Evidence is emerging that significant proportion of the carbon is stored in soils as opposed to vegetation (Dabasso et al. 2014, Fynn et al. 2009, Hungate et al. 1997). Soils store the largest amount of terrestrial carbon as plant residues and litters (Chapin et al., 2009). Consequently, there is increasing need to link soil carbon storage in pastoral rangelands to local livelihoods through promotion of carbon-credits. This is because carbon credits will not only mitigate climate change through reduction of carbon dioxide emissions but will also diversify local livelihood and reduce vulnerability associated with climate variability and change (Stringer et al., 2012). However, under the Kyoto carbon trading platform, adoption of carbon sequestration practices should ensure additional reduction of carbon dioxide to what is existing under the normal-land use practices (IPCC 2014). Grazing exclusion is a commonly recommended practice to improve rangeland primarily
productivity and provide extra carbon storage for carbon credits. Nonetheless, both positive and negative implication on rangeland carbon storage have been reported. Grazing is suggested reduce primarily productivity or change plant species composition and therefore lead to less carbon sequestration in the rangelands (Pineiro et al. 2010, Golluscio et al. 2009). On the contrary, grazing is thought to enhance litter decomposition, remove dead materials for enhanced photosynthesis and therefore provide additional carbon storage (Conant and Panstian 2002, Reeder and Schuman 2002). These divergent opinions make it difficult decide whether grazing exclusion actually provide significant carbon accumulation that warrant carbon credits. This study assessed soil carbon accumulation in semi-arid pastoral ecosystems of northern Kenya under 82 years of grazing exclusion and compared with soil carbon storage in the adjacent areas of continuous grazing. It further evaluated the economic value of soil carbon difference between the two grazing management for carbon credits. It was hypothesized that long term grazing exclusion do not significantly sequester extra carbon in the soils and any extra soil carbon associated with long-term grazing exclusion has no substantial economic value for carbon credits.

Materials and Methods

Study areas

The study was conducted in three locations of Marsabit Forest Reserve (MFR) and its adjacent communal grazing areas such as Kituruni, Karare and Hula hula. MFR is a government protected forest over 8 decades and host large number of indigenous trees and wildlife species (Witsenburg and Roba, 2004). The common trees include Olea African, Croton megalocarpus, Juniperous procera and Cordia abyssinica. The forest has sub-humid ecological climate and is known for its dense morning mists and fog cover especially in the morning. Along the edges of the forest are settled communities who predominately practice pastoralism. The communities practice semi-sedentary pastoralism where small herd of animals are kept around homesteads for milking while other herds move strategically between forest peripheries and arid plains located far from the forest (Roba and Oba, 2008).

Collection of soil samples

MFR was taken as an area of long-term grazing exclusions while adjacent communal grazing areas were taken as areas of continuously grazing. A public road that run around at the edge of MFR formed the borderlines between the MFR and communal grazing areas. A transect walk of 2-km from the road into national park was constructed and soil sampling done at every 100 m. Soil sampling was done using soil-auger at 30 cm depth. Soil samples were collected in Khaki paper bags and labelled based on name of study area, type of site, sampling point and date of collection. All the sampling points marked with Geographical Positioning System for the next season repeat. Another transect of the same length is constructed from the road into the communal grazing site and soil sampling done following the same sampling procedure. A total of 240 soil samples were collected for the three study areas across dry and wet seasons. All soil samples were
oven-dried at 80°C for 48 hours. The oven-dried samples were sieved using 2mm-sieve and their bulk densities determined using the following formula; $BD_{sample} = \frac{ODW_{sample}}{VAD}$, Where: $BD_{sample}$ is the bulk density of soil sample (g cm$^{-3}$), $ODW_{sample}$ is the weight of oven dried sample (g), VAD is the volume of soil auger head (cm$^3$). The volume of soil auger head was determined using; $V = \pi r^2h$, Where: $V = \text{Volume head}$, $\pi =3.14$ cm, $r = \text{head radius (cm)}$, $h = \text{head height (cm)}$.

**Analysis of soil samples**

The samples were again grounded to enhance homogeneity and passed through 0.5-mm sieve. They were then analyzed using oxidation-reduction process developed by Walkley-Black (1934) where 10 ml of potassium dichromate was carefully measured and added to soil samples of 0.5g each. 20 ml of concentrated sulphuric acid was then added to the samples and allowed to stand for 20 minutes. A few drops (1-10) phenanthroline indicator were added to the samples. The excess dichromate that was not used in the oxidation process was then determine by titrating samples with ferrous sulphate until the colour change into dark-red.

**Calculations for organic soil carbon**

\[
\% \text{ oxidizable organic carbon} = \frac{V_{\text{blank}} - V_{\text{sample}}}{Wt} \times 0.3
\]

Where:

$V_{\text{blank}}$ = Volume of ferrous ammonium sulphate solution required to titrate the blank (mL)

$V_{\text{sample}}$ = Volume of ferrous ammonium sulphate solution required to titrate the sample (mL)

$Wt$ = Weight of oven-dried soil (g)

0.3 = where 3 is the equivalent weight of C

Since the method only covers for 77% of oxidizable carbon, \% total organic carbon = 100/77 x \% oxidizable organic carbon

**Data analysis**

Means for soil carbon storage for both controlled grazing site and uncontrolled grazing site were analyze and Least Square Difference (LSD) used to separate the means. Analysis of variance (ANOVA) done to test for variation in soil carbon storage between controlled grazing and uncontrolled grazing sites using GenStart release 12.1 (VSN International 2009) and significant difference accepted at 5%. Economic values for any variation of soil carbon storage between controlled and uncontrolled grazing sites were calculated based on existing carbon markets.
Results and Discussion

Contribution of long-term grazing exclusions to soil carbon accumulation

Soil carbon storage in the areas under long-term grazing exclusion were assessed and compared with soil carbon storage in the adjacent rangelands under communal grazing. The variation in the soil carbon storage for the three study areas is presented in Table 1. On average the areas under long-term grazing exclusion had soil carbon storage of 161.9 ± 38.87 tonnes ha\(^{-1}\) whilst areas under communal grazing had 98.8 ± 28.43 tonnes ha\(^{-1}\). The difference of soil carbon storage between the two management regimes is significant (P < 0.001). Areas under long-term grazing exclusion had additional soil carbon storage of 63.1 tonnes ha\(^{-1}\). The observed extra soil carbon storage was built up from 1932 when Kenya government gazette the area as protected land. This means that the soil carbon build up was at rate of 0.769 tonnes ha\(^{-1}\) per year. The carbon build up possibly result from accumulation of un-grazed plant residues and litters in the soils. Although, this ascertain negative implication of continuously grazing in soil carbon accumulation as earlier observed by other studies (e.g Pineiro et al. 2010, Golluscio et al. 2009, Su et al. 2005), its economic returns is minimal (see the section on economic values).

Table 1. Variation in the soil carbon storage between areas under long-term grazing exclusion and continuous grazing

<table>
<thead>
<tr>
<th>Study area</th>
<th>Areas under long-term grazing exclusion (tonnes ha(^{-1}))</th>
<th>Areas under continuous grazing (tonnes ha(^{-1}))</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kituruni</td>
<td>102.76 ± 26.88</td>
<td>165.02 ± 48.49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Karare</td>
<td>95.82 ± 30.71</td>
<td>150.51 ± 35.56</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hula Hula</td>
<td>97.79 ± 27.82</td>
<td>170.31 ± 27.87</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Economic value of additional soil carbon associated with grazing exclusion for carbon credits

The yearly soil carbon accumulation were converted into the carbon-dioxide equivalent and its economic values for carbon credits established based on the existing voluntary and compliance markets\(^3\). The average soil build up and its economic values for carbon credits is presented in Table 2. The overall soil carbon accumulation under long-term grazing exclusion had potential of sequestering 2.822 tonnes ha\(^{-1}\) of carbon dioxide equivalent which has economic value of 16.65 $ and 9.59 $ based on voluntary and compliance carbon markets respectively. Considering uncertainty in the value of carbon credits and opportunity costs of long-term grazing exclusion, it is unlikely that the additional soil carbon storage is economically viable for carbon credits. In addition, costs associated with project design and implementation will be lower than observed economic values for carbon credits (Galgani, 2012).
Table 2. Value of additional soil carbon stored associated with grazing exclusion based voluntary and compliance carbon markets

<table>
<thead>
<tr>
<th>Study area</th>
<th>Additional soil carbon associated with grazing exclusion (C tons ha⁻¹)</th>
<th>Carbon-dioxide equivalent (Tons of CO₂e ha⁻¹)</th>
<th>Value based on carbon market ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Voluntary market</td>
</tr>
<tr>
<td>Kituruni</td>
<td>0.759</td>
<td>2.785</td>
<td>16.43</td>
</tr>
<tr>
<td>Karare</td>
<td>0.669</td>
<td>2.455</td>
<td>14.48</td>
</tr>
<tr>
<td>Hula hula</td>
<td>0.884</td>
<td>3.244</td>
<td>19.13</td>
</tr>
</tbody>
</table>

**Conclusion**

This study provides empirical data on whether long-term grazing exclusion provide adequate soil carbon accumulation for carbon credits in pastoral areas of northern Kenya. Results show that soil carbon accumulate at the rate 0.769 tonnes ha⁻¹ per year, providing economic value of 16.65 $ and 9.59 $ based on voluntary and compliance carbon markets respectively. Considering the opportunity costs and uncertainty in the carbon values, long-term exclusion did not provide adequate soil carbon build up for carbon credits.

**Endnotes**

Pastoralists have traditional institutions that govern grazing management to up hold environmental conservation. The word “continuously grazing” is only used to differentiate it from grazing exclusion applied in this study.

One tonne of carbon is equivalent to 3.67 of carbon dioxide equivalent (Tennigkeit and Wilkes, 2008). Voluntary carbon markets average of $ 5.9 per tonne of carbon dioxide as carbon credits (Molly and Daphne, 2013), while carbon credit in Clean Development Mechanism (CDM) is 3.4 $ per tonne of carbon dioxide equivalent (Galgani, changeling 2012).

**Acknowledgement**

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Effect of long-term grazing on soil carbon accumulation in pastoral areas of Northern Kenya

Reference


Climate change and adaptative capacity of farmers to modern bee keeping in Kajiado county, Kenya

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Abstract

The impact of climate change is expected to heighten the vulnerability of livestock systems. Livelihood diversification empowers households, giving them a range of options to draw on, making them more food and income secure. The objective of the current study was to assess the current status of bee keeping, constraints and opportunities among pastoral farmers in kajiado county of Kenya, which could contribute to the knowledge-base in development of community based adaptation projects and policies. Multi-stage sampling procedure was used to select smallholder beekeepers for interview, using semi-structured questionnaire. A sample size of 120 respondents was selected for the study using simple random sampling. The findings from the study revealed that majority of the respondents (37.9%) were aged between 56-65 years, 31% between 46-55 and 5.2% between 18-35 years old. Higher percent of the respondents indicated 19.1% of men and 16.5% of women practice beekeeping. Men owned greater percent of the livestock in the study area (34%) than women (22%). Local chicken was mainly women’s’ business (90%). Absconding of bees (80%), lack of credit facilities (76%) and lack of marketing information (75%) were cited as the major constraint in beekeeping as an enterprise. Other high scoring constraints included lack of training (62%), low productivity (58%) and lack of better beekeeping technologies (52%). Training and demonstrations, and creating awareness about the existence of funding institutions to these farmers will help them acquire capital which will enable them take up modern bee hive technologies. A further study to establish factors associated with absconding of bees is required in this study area.

Keywords: Apiculture, constraints, gender, opportunities

Introduction

Evidence from the Intergovernmental Panel on Climate Change is now overwhelmingly convincing that climate change is real, that it will become worse, and that the poorest and most vulnerable people will be the worst affected. Climate change will have far-reaching consequences for dairy, meat and wool production, mainly arising from its impact on grassland and rangeland productivity. Heat distress suffered by animals will reduce the
rate of animal feed intake and result in poor growth performance (Rowlinson 2008). In pastoral and agro-pastoral systems, livestock is a key asset for poor people, fulfilling multiple economic, social and risk management functions. The impact of climate change is expected to heighten the vulnerability of livestock systems and reinforce existing factors that are affecting livestock production systems, such as rapid population and economic growth, rising demand for food (including livestock) and products, conflict over scarce resources.

Climate change and variability are already evident in Kajiado county (GoK 2004). Pastoralism is the primary source of income and food in this particular area. The recurrent droughts and unpredictable rainfall are increasingly affecting livestock and food security in this area and the local community have no option but to diversify their economic activities. Bee keeping has been identified as a livelihood diversification option for this particular community who in many years have wholly depended on pastoralism as their main source of livelihood.

Bee keeping is the art of managing bees in order to obtain honey, bee wax among many other products. It provides food of great nutritional value, enhances seed production through pollination and conserves natural environment (Klein et al 2007). In addition, bee keeping requires little capital, less space and does not require good soil, thus can be practised beside other farm activities. Bee keeping can be carried out by men and women and is a suitable activity for women groups, youth groups etc. Due to the numerous economic benefits, bee keeping is emerging as a very successful agricultural practice for rural areas in developing countries (Kukonza 2009). The government of Kenya in its strategy for development of apiculture and emerging livestock, has identified honey production and development of apiculture as one of the few means by which people in the Arid and semi-arid (ASALs) areas can earn an income and make them better adapt to climate change without damaging the environment they depend on to survive.

Kenya’s potential for apiculture development is estimated at over 100,000 tonnes of honey and 10,000 tonnes of beeswax per annum. At the moment only about one fifth of this potential is being exploited. Eighty percent of Kenya consists of arid and semi-arid lands (ASALs) which have high potential in production of honey and apicultural activity is a major occupation in these areas due to the abundance of bee flora. Non ASAL regions also practice beekeeping. Eighty percent of the honey comes from the traditional log hive which compromises on quality and quantity. Many communities in the country still use traditional production systems in form of log hives which are labour intensive and dangerous (Cramb 2003).These attributes of the log hives have made the management and utilization of honey and other bee products less viable. These log hives constitute the single largest number of hive in the country estimated at 1,273,000 with 73% of the hives concentrated in the eastern part of the country (Mwabu et al., 2002). Traditional bee keeping in Kenya has mainly been a male occupation. This is because traditional hives require physical strength and is necessary to climb trees to harvest honey and is not suitable for women due to modest reasons. Harvesting of honey is mainly done at night and sometimes involves stripping naked before climbing trees. Harvesting honey
from traditional beehives also required long absences from home, which conflicts with women’s domestic chores.

A study report by (GoK 2004) revealed that limited value addition was being realised due to minimal investment in technological and market development initiatives. In addition to this, the low priority given to the sector had also affected the scale of production and productivity of beekeeping. It was therefore necessary to explore ways to encourage technological innovation in the honey sector as a means of alleviating rural poverty. It is within this context that an opportunity for women to participate in the honey value chain was recommended. Therefore there is need to popularise modern bee keeping technologies amongst pastoral group especially women farmers as the hives require less physical activity and can be installed closer to their homes. The objective of the current study was to assess the current status of bee keeping, constraints and opportunities among pastoral farmers in kajiado county of Kenya. This could contribute to the knowledge-base in development of community based adaptation projects and policies.

Methodology

Study site

This study was carried out in Kajiado County, Kenya. Kajiado County is a semi-arid area (zone V) that is characterised by rough terrain with an annual rainfall of 300-600 mm. To the north, the escarpments of the Great Rift Valley rise to form the Ngong hills. The escarpments then stretch southwards to the Eastern side. On the floor are several hills and valleys forming a hilly and rough terrain with some areas having long stretches of grassland plains. Most of the land is covered by grass and shrubs forming shrub vegetation with acacia species being the most prevalent trees. This kind of vegetation is favourable for beekeeping. The main ethnic community found in Kajiado County is the Maasai. Population growth rate is 4.6 per cent; Household size is 4.2; Geographical area is 21,903 Km²; average annual income is US $400 in paid income; with infant mortality of 45/1000 (RELMA 2005). The main economic activity among the Maasai in Kajiado County is pastoralism, the main livestock kept being cattle, goats, sheep and donkeys.

Sampling Technique

Multi-stage sampling procedure was used to select smallholder beekeepers for interview. Kajiado County was selected purposively based on the honeybee production potential, availability of bee flora and improved box hive promotion. Kajiado County was sub divided into 4 sub counties which were further sub divided into villages. A total of 120 respondents were selected for the study using simple random sampling.

Data collection and analysis

Both primary and secondary data sources and qualitative and quantitative data types were utilized for this study. Primary data were obtained from sample respondents during June to September 2014 by using semi-structured questionnaire through interview method. Secondary data were gathered from various sources such as reports of Ministry
The age of the farmers in the study area ranged from 18 to 66 years (Fig 1). The findings from the study revealed that majority of the respondents (37.9%) were aged between 56-65 years, 31% between 46-55 and 5.2% between 18-35 years old. Figure 2 reveals that majority of the respondents did not attend school (37.9%), with 22.4%, 19.0%, 12.1%, 6.9% and 1.7% having attended lower primary, upper primary, secondary, technical college and university respectively (Fig 2).
Higher percentage of respondents indicated that women in this area are not formally employed (1.9%) but do business (25.2%) (Table 1). Only 13.2% of men do business.

From the Table 1 below, 19.1% of men and 16.5% of women practice beekeeping.

<table>
<thead>
<tr>
<th>Economic activity</th>
<th>Women (%)</th>
<th>Men (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal employment</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Business</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>Livestock farming</td>
<td>22</td>
<td>34</td>
</tr>
<tr>
<td>Crop farming</td>
<td>34</td>
<td>21</td>
</tr>
<tr>
<td>Bee keeping</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Social worker</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Hired labourer</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Gender dimensions in family resources ownership**

From the findings (Table 2) it is clear that men in this particular farming system own more valued livestock like cattle unlike their female counterparts who own less valued livestock like chicken and bees. Ninety three percent of men own cattle while own only 7% of the women of cattle.

<table>
<thead>
<tr>
<th>Livestock</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Man</th>
<th>Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local cattle</td>
<td>79</td>
<td>12</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>93</td>
<td>7</td>
</tr>
<tr>
<td>Exotic cattle</td>
<td>50</td>
<td>17</td>
<td>0</td>
<td>17</td>
<td>17</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Sheep</td>
<td>71</td>
<td>18</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>93</td>
<td>7</td>
</tr>
<tr>
<td>Local goats</td>
<td>67</td>
<td>18</td>
<td>12</td>
<td>2</td>
<td>0</td>
<td>96</td>
<td>4</td>
</tr>
<tr>
<td>Dairy goats</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Local chicken</td>
<td>24</td>
<td>3</td>
<td>26</td>
<td>26</td>
<td>21</td>
<td>8</td>
<td>92</td>
</tr>
<tr>
<td>Exotic chicken</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Bee</td>
<td>17</td>
<td>12</td>
<td>25</td>
<td>22</td>
<td>25</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Rabbits</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Rank (1-very important,5-least important).**

<table>
<thead>
<tr>
<th>Economic activity</th>
<th>Men (%)</th>
<th>Women (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bee hive preparation</td>
<td>36</td>
<td>2</td>
</tr>
<tr>
<td>Honey harvesting</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Honey extraction</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>Packaging/sales</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>
With respect to beekeeping activities, women in this area mainly are involved in honey extraction (18%). From the study, men are mostly involved in the honey harvesting activities and sales (25.3% and 9% respectively).

### Major constraints affecting beekeeping in the study area

Table 4 highlights the major constraints faced by respondents in the beekeeping activity. Absconding of bees (80%), lack of credit facilities (76%) and lack of marketing information (75%) were cited as the major constraint in beekeeping as an enterprise. Other high scoring constraints included lack of training (62%), low productivity (58%) and lack of better beekeeping technologies 52%.

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Mean score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absconding of bees</td>
<td>80</td>
</tr>
<tr>
<td>Lack of credit</td>
<td>76</td>
</tr>
<tr>
<td>Lack of marketing information</td>
<td>75</td>
</tr>
<tr>
<td>Lack of training</td>
<td>62</td>
</tr>
<tr>
<td>Low productivity</td>
<td>58</td>
</tr>
<tr>
<td>Lack of better technologies</td>
<td>52</td>
</tr>
<tr>
<td>Time constraint</td>
<td>46</td>
</tr>
<tr>
<td>Pests and diseases</td>
<td>43</td>
</tr>
<tr>
<td>Low household income</td>
<td>42</td>
</tr>
<tr>
<td>Lack of infrastructure</td>
<td>30</td>
</tr>
</tbody>
</table>

Figure 3 shows the farmers major sources of agricultural information. A large percentage stated extension services (46.6%) as their most important source, followed by radio (31%), chief (6.9%), television (5.2%); newspaper (3.4%), NGOs (1.7%) and elders was the least selected (1.7%) in that order.
**Discussion**

The analysis indicated that the young generation was yet to fully engaged in bee keeping. According to reports by New Agriculturalist (2011), the world is home to more than 1 billion young people aged between 15-24 years. Many are unable to fulfil their potential because of poverty, hunger and lack of education. As a result, they lack the skills needed to gain employment, with rural youth typically, but often fruitlessly, migrating in search of economic opportunities. However, given support and the opportunity of employment, young people have the potential to play a significant role in rural development. They deserve support to take advantage of the opportunities opening up such as beekeeping.

From the study, higher percentage of respondents indicated that women in this area are not formally employed, but do business. There was no strong cultural taboo that prohibits women from undertaking beekeeping activities. However, according to some beekeepers, women are not allowed to visit the apiary due to modest reasons. Generally, provision of practical training, protective cloth, beekeeping accessories and introducing affordable and appropriate beekeeping technology in the form of langstroth hive may be one step towards promoting the role of women in beekeeping development. In addition, placing of hives at suitable location for women has to be developed and tested with users at local condition.

From the findings (Table 2), it is clear that men in this particular farming system own more valued livestock like cattle unlike their female counterparts who own less valued livestock like chicken and bees. Equipping women with more skills on this less valued livestock will enable them earn income hence improve their living standards. Constraints to beekeeping as an enterprise such as lack of credit would be solved if these pastoral women farmers can be linked to micro leasing agents. Likewise, low household income among many villagers was known to limit villagers’ capacity to purchase modern beekeeping equipments such as modern hives, harvesting gears and processing equipments. Greater number of the respondents showed that they are still using traditional hives made from logs because they are relatively cheaper. Marketing was not a major problem in the area since Kajiado county, with production of good quality honey will be able to market the good quality honey at good prices. Bee rearing is a time consuming activity and not possible for female to give proper care and maintenance in the social setup. It was suggested that introducing modern bee keeping technologies will make people in this area successfully practice bee keeping.

**Conclusions and Recommendations**

The results presented here show that lack of credit was the main reason why farmers in this particular area did not practice modern bee keeping technologies. Farmers lack money to purchase the modern hives and have opted to stick to traditional hives because according to them they do not need any cash to purchase these hives. Creating awareness about the existence of funding institutions to these farmers will help them acquire capital which will enable them take up modern bee hive technologies.
Acknowledgements

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Abstract

This study was done to assess the effects of climate variability on Indigenous coping strategies of the Borana community of Isiolo County. The overall objective of the study was to assess the effects of climate variability on the indigenous coping strategies of the Borana community of Isiolo County. The specific objectives were to describe the effects of climate variability on the community’s coping strategies; and to identify possible adaptive strategies that have been used to minimize the adverse effects of climate variability on the livelihoods of the community. The study was guided by the cultural ecological and resilient theories, data were collected through secondary sources, semi-structured interviews, focus group discussions, key informant interviews and direct observation.

The findings indicate that pastoral coping strategies have been weakened by recurrent droughts and floods. The study further shows that some adaptive strategies have been put in place by government departments, NGOs and faith-based organizations to mitigate the effects of climate variability in the study area. The study concludes that climate variability has, in general, negatively affected the coping strategies of the Borana of Isiolo County. The study recommends that the government and other actors involved in the area should assist the community with more sustainable and effective intervention measures. Finally, there is a need for development agents to ensure full participation of the local communities in the conception, design and implementation of sustainable interventions to reverse the effects of climate variability in the County.

Keywords: Climate variability, indigenous, copings, strategies

Introduction

Climate variability refers to variations in the mean state and other statistics (such as standard deviations and the occurrence of extremes) of the climate on all temporal and spatial scales beyond that of individual weather events. IPCC (2007) gives indicators of climate variability as extended droughts, floods, and conditions that result from periodic El Niño and La Niña events. In Kenya there are various indicators of climate variability which include erratic rainfall patterns, persistent droughts, and vanishing glaciers on Mt. Kenya (Kanywithia, 2010:5). The areas in Kenya most affected by climate variability...
are the arid and semi-arid. Omosa (2005:7) states that the arid and semi-arid areas constitute 80% of Kenya’s land mass and support 70% and 25% of the nation’s livestock and human populations, respectively. Livestock is the major economic activity of these ASALs. As climate change looms globally, extreme weather events have already impacted on the livelihoods of pastoralist in significant and uncertain ways. According to Sergine and Verchot (2006:9) pastoral communities living in the predominant arid and semi-arid Counties of Kenya are bearing the brunt of adverse consequences particularly food insecurity due to droughts, floods and livestock diseases.

Traditionally, pastoralists have used indigenous coping strategies to address these disasters. Indigenous coping strategies included livestock mobility to areas with pasture, herd diversification, herd maximization, use of emergency feeding strategies such as cut and carry and reliance on wild fruits and vegetables. However, droughts have become more frequent, prolonged and severe than they used to be in the past, but to what extent they have affected the indigenous coping strategies of the Borana community was not known. Therefore, this study aimed at investigating the extent to which the pastoral indigenous coping strategies have been affected by climate variability. In order to achieve this, the study sought to answer the following questions:

1. How has climate variability affected Borana communities’ indigenous coping strategies?
2. Are there any adaptive strategies which might be more suitable for the community than others?

1.5. Objectives of the study

Overall Objective
To asses the effects of climate variability on the indigenous coping strategies of the Borana of Isiolo County.

Specific objectives

1. To describe the effect of climate variability on the community’s coping strategies.
2. To identify possible adaptive strategies that could minimize adverse effects of climate variability on the livelihoods of the community.

Materials and methods.

Study sites
This work was conducted in three villages in Isiolo County namely Kambi Odha, Kambi Bule and Kambi Garba. These areas are occupied by pastoral and agro pastoralists including the Borana, Somali, Turkana, Samburu, Rendille, and Ameru. This study focused on the Borana community not to suggest that the others are not important but because it is the largest community in Isiolo County.
Sampling size and data collection

A total of 400 respondents were interviewed and the unit of study was household heads. Systematic sampling technique was applied to select the respondents for the interview, while purposive sampling was applied to select focus group participants and key informants. Secondary data was collected through literature search, while primary data was gathered using questionnaires, focus group discussions and Key informants interviews.

Data processing and analysis

This study collected both qualitative and quantitative data. Qualitative data derived from focus group discussions and key informant interviews were presented in discussions. Quantitative data derived from the household interviews were edited, coded and entered into a computer and the Statistical Package for Social Science (SPSS) software version 20 spread sheets was used for the analysis. Descriptive statistics were run to give frequencies and percentages.

Results and Discussions

Effects of climate variability on livestock mobility

The findings of this study indicate that livestock mobility has been affected by climate variability in various ways. More than a third (36.6%) of the respondents said that droughts had caused water pans to dry up. Other respondents (23.5%) indicated that climate variability had contributed to livestock and human deaths, 18.8% stated that there was a shortage of pasture in areas which used to be referred to as fall back (fora) areas by pastoral communities, while 15.3% said that it had resulted in competition with other communities leading to conflicts. Lastly, 5.8% of the respondents indicated that some of the grazing lands have been converted into agricultural lands and settlements by the pastoral community. This was as a result of climate variability which has forced the communities to diversify their livelihoods.

Distance travelled and destinations

The study findings indicate that climate variability has affected the distance travelled and destinations moved to by the Borana of Isiolo. According to the responses given, the longest distance travelled during the drought period was 550–600 kilometres, while the shortest was between 50 and 100 kilometres. This information was also reflected in the key informant interviews and focus group discussions, as they indicated that frequent droughts made the Borana pastoralists to move to areas where they never used to go in search of forage for their livestock. They added that before, they used to take their livestock to graze and browse near Isiolo town, along the river valleys in Isiolo, Ewaso Nyiro and Kinna. However, with the intensification of climate variability they have changed their migration destinations to places such as Merti, Garbatulla, Sericho and Marsabit. They stated that sometimes they moved with their livestock across the Kenya-
 Ethiopian border although this was not very common. At other times, they moved up to Meru and to Mt. Kenya forest in search of pastures for their livestock.

**Sharing of resources with other communities**

This study revealed that the communities used to share resources with their neighbouring communities in the last 20 years. Almost all the respondents (98.5%) said that they shared resources with the Turkana, Samburu, Somali, Gabra and Ameru communities, while 1.5% stated that they have never shared. The resources shared include pasture, water and salt. Pasture and water are shared during herd mobility throughout the year. However, frequent and prolonged droughts have led to competition over similar resources and this has, in turn, led to conflicts between the pastoral communities. Insecurity forced livestock herds to concentrate in small secure grazing zones, while leaving large tracts of land unused in most parts of Isiolo County. Focus group discussants stated that some areas were considered to be no-go-zones or hot spots which included the mountains surrounding Isiolo, Sharp, Nyagachuru and Ewaso Nyiro valley.

**Effects of climate variability on herd diversification**

On whether the households had stopped rearing some livestock due to climate variability, more than half (58.5%) of the respondents said no while 41.5% said yes. Thirty-four per cent of those who stated that they had stopped rearing some livestock added that they had stopped keeping cattle since these could not survive for many days without water. On the other hand, 5% of the respondents said that they had stopped rearing sheep because they could also not survive for many days without water. Finally, 2.5% said that they had stopped rearing chicken as they died in great numbers due to diseases such as Newcastle.

Herd diversification as a coping strategy has been affected by the deaths of some livestock such as cattle in great numbers. The other factor that has affected herd diversification are high prices of livestock after droughts. According to the focus group discussions, the prices of livestock are usually very low during the time of droughts. For example, a mature cow would fetch as little as KES 5000 while a mature goat would go for KES 500. However, the prices of livestock would shoot up making it impossible for most of the pastoralists to restock. The other factor which was said to have affected herd diversification is limited labour as the strategy used to be combined with herd splitting. This involved dividing livestock into small herds and grazing them separately. However, this has changed due to decreased labour force as children who used to assist in herding go to school while young men have migrated to urban areas to look for alternative income-generating activities.

**Effects of climate variability on herd maximization**

It is quite evident from the study findings that the herd maximization strategy has been affected by climate variability. This is because 43% of the respondents said that frequent droughts had contributed to livestock deaths. On the other hand, 30% of the respondents indicated that shortage of forage had affected herd maximization. This was supported by focus group discussants and key informants who stated that recurrent droughts led
to range degradation and as a result of this, the area could not support large sizes of livestock. Furthermore, 20.3% of the respondents claimed that recurrent droughts have contributed to surface water scarcity because most parts of these water sources were fed by rainfall. Key informants and focus group discussants stated that livestock diseases such as Rift Valley Fever, foot and mouth disease, and Trypanosomiasis, led to livestock deaths, thus, affecting herd maximization as a coping strategy. They also attributed reduced herds of livestock in the Borana community to livestock raiding which has been accelerated by the effects of climate variability.

**Effects of climate variability on cut–and-carry strategy**

The study findings revealed that the Borana used to cut and collect leaves, plants and pods for their livestock. They used to do this for all livestock species and of all ages. They collected grass, leaves from trees, acacia pods, crop residues, *Anno* (*Euphorbia tiriculli*), hay and relief feeds for their livestock to sustain them during difficult times. The findings of this study revealed that climate variability has affected the availability of forages gathered for livestock during the dry periods. This is evidenced by 88.3% of the respondents who indicated that climate variability has led to depletion of some important plants, while 11.8% said that there were no effects. According to those in the affirmative, the rangelands used to contain quality forage and grass species that were used by all the different livestock species. They gave examples of valued perennial forages which have disappeared such as *geddi* (*Echinochloa haploclada*), *kumude* (*Lannea alata*), *sigriso* (*Acacia reficiens*), *hido* (*Cynodon sp*), and *urbu* (*Acacia tortilis*).

**Effects of climate variability on traditional wild edible fruits, vegetables, roots and seeds**

Wild edible plants refer to species that are neither cultivated nor domesticated but are available in their wild natural habitat. In answering a question on whether there were traditional fruits, vegetables and roots which used to be eaten by the Borana pastoral communities of Isiolo County, 85.8% of the respondents indicated that there were while 14.3% said that there were none. The types of fruits given included *deka* (*Grewia tembensis*), *mader* (*Cordia gharat*), *qurqura* (*Zizyphus mauritiana*), *jaj jab* (*Berchemia*), *ogomdi* (*Grewia Villosa*) and *kumude* (*Lannea alata*). Others, such as *mader* (*Cordia gharat*) produced edible fruits and also their gums were chewed during drought periods. Conversely *urbu* (*Acacia tortilis*) pods were boiled and eaten during droughts. Some of the plants, such as *iddi hiddi* (*Solanum scabrum*) also produced vegetables and fruits eaten during droughts. Other wild vegetables eaten as revealed during focus group discussions include *sumalele* (*Mormodica trifoliolata*) which is boiled in water, and mixed with salt to form porridge. The *ng’orondo* (*Cyphostemma nierrense*) plant also contributed to survival during drought. One of the elders made this statement, “when herding, herders ate these plants and they got satisfied such that when they got home they did not eat anything more.” *(Elder, Kambi Odha, Isiolo).*
Edible fruits, vegetables and seeds which have disappeared

On whether wild plants have disappeared, a majority (88.5%) of the respondents affirmed that many of the plants had disappeared while 11.5% were of the opinion that they had not disappeared. It also came out clearly from the study that the distance travelled while going to collect wild fruits and vegetables had changed as a result of climate variability. For example a majority (81.3%) of the respondents said that the distance travelled is longer than it used to be 20 years ago, while 18.8% said that the distance had not changed. Focus group discussions revealed that the distance covered had increased and they also indicated that some of the plant species had disappeared.

External adaptive strategies and organizations that give assistance

The findings of this study indicate that 99.5% of the respondents stated that there were organizations that assisted the community during times of calamities. Table 1 gives details of government departments and organizations which were involved in giving assistance, the type of assistance given and the period during which it was given.

Table 1: Organizations and type of assistance given to the respondents

<table>
<thead>
<tr>
<th>Organization</th>
<th>Type of assistance</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government ministries/ provincial administration, Ministry of Livestock</td>
<td>• Relief food, livestock relief feeds • Vaccination of livestock • Destocking • Resettlement</td>
<td>During droughts/ floods</td>
</tr>
<tr>
<td>Ministry of Arid-lands Ewaso Nyiro Development Authority Kenya Forest Service Kenya Red Cross World Vision International Food for the Hungry Kenya Muslim Council Catholic Mission Friends of Nomads</td>
<td>Restocking Digging of dams/ Restocking Offering of plant seedlings Resettlement Relief food Relief food / Medicine Resettlement/ relief food Resettlement/relief food Promotion of peace</td>
<td>During droughts/floods During dry period During rainy seasons During droughts/floods/times of insecurity During droughts/ floods During drought/floods/times of insecurity During drought/floods/times of insecurity In times of insecurity</td>
</tr>
</tbody>
</table>

A majority (70%) of the respondents said that government departments were highly involved in offering assistance to the respondents whenever they were faced with the negative effects of climate variability. They were followed by 25.8% who ranked NGOs
as the second. Faith-based organizations had 3.3%, while 1% of the respondents said that there were no agents to assist them. The study findings revealed that the government, NGOs and faith-based organizations had made efforts to assist the Borana pastoralists whenever they were faced with the negative effects of climate variability. However, a majority (61%) of the respondents stated that the type of assistance they got was not enough. For instance, the relief food given was very little, it was never available on time and sometimes it was given after three months. The other problem was that the assistance given sometimes never reached the intended beneficiaries. Relief food was usually intended for the very poor but in many cases the largest share ended up in the hands of the rich. Those respondents who said that the type of assistance given was not enough added that they needed a more and equitable distribution of the relief food.

**Conclusion and recommendations**

The results of this study suggest that climate variability has weakened the coping capacity of the Borana community. This coping strategy has been affected in various ways, for example, through competition by other pastoral communities leading to resource conflicts. This has forced the Borana community to change its destinations and the distances travelled. Conflicts make it impossible for the pastoralists to have access to some areas and they are forced to graze their livestock in areas which are perceived to be safe causing over-grazing and degradation. The herd diversification coping strategy has also been affected negatively by climate variability as frequent droughts have led to shortage of forage causing death of many livestock, in particular cattle. Livestock raiding by other livestock keepers and limited labour as the most able bodied members of the community migrated to urban areas in search of jobs has contributed to the weakening of herd diversification. Even herd maximization which involved the Borana community having large herds has been affected by climate variability. The respondents indicated that a shortage of feeds makes it hard for them to sustain large sizes of livestock. Shortage of labour was also mentioned as a factor that has led to the weakening of the strategy as some of the active members of the family have migrated to towns to look for employment. The emergence of new livestock diseases and the spread of the old ones have affected herd maximization. Cut and carry as a coping strategy has been affected by overgrazing, while some wild edible plants which used to be eaten by the Borana community had disappeared as a result of climate variability.

This study reported that over time, the Borana pastoralists have adapted to climate change through indigenous mechanisms, but unfortunately their adaptation strategies are losing efficacy due to climate variability. This study recommends that the government and other actors involved should assist the community with more sustainable and effective intervention measures to cushion the community from extreme vulnerabilities. There is need for government departments, NGOs and faith-based organizations to ensure full and effective participation of the local communities in the conception, design and implementation of sustainable solutions to reverse the effects of climate variability. It is also important for development agents to take into account their indigenous traditional knowledge and to promote best practices that can influence climate interventions.
References


Opportunities for the poultry industry in Kenya

D. M. Mwangi and A. M. Wachira

KALRO, Non-Ruminant Research Institute

Kenya’s population is estimated at 46.5 million people by end of 2015 (INFOSTAT, March 2015). Poverty levels among urban and rural populations also vary across regions, with 56 percent living below poverty line. This is despite Kenya attaining lower-middle-income status and becoming the fifth-largest economy in sub-Saharan Africa in 2014. Hunger, malnutrition, food security and climate change are still major concerns for the growing economy.

The importance of the agriculture sector in Kenya’s economy remains unchallenged. The sector employs 75% of the country’s labour force, provides raw materials for the agro-based manufacturing industries and accounts for 45% of government revenue. This sector is dominated by primary production of commodities, such as cereals (maize, wheat and rice), traditional food crops, industrial crops, export crops and livestock (beef, dairy, poultry and eggs, pigs and small stock). Smallholder farms, account for over 65% of the total agricultural output, while pastoralism is the main form of production within ASAL areas.

The livestock sub-sector is an important component of the Kenyan economy. Although dairy is by far the major contributor to this sub-sector, increased investment to the non-ruminant sector (chicken and pork) will increase feed conversion efficiencies from 12 percent in dairy to 23 percent for poultry and pigs (Cassidy et al. 2013). Over recent decades the poultry industry has made tremendous adjustments to meet the increasing demand for inexpensive and safe supply of meat and eggs. Its estimated that the poultry sector has been growing at more than 5 percent per annum (compared to 3 percent for pig meat and 1.5 percent for beef) and its share in world meat production increased from 15 percent three decades ago to 30 percent currently (FAO, 2006a).

Poultry farming in Kenya is also evolving from predominantly subsistence/extensive production systems to commercial/semi-commercial systems. The latter may be categorized into three namely: small, medium and large scale. While commercial and semi-commercial farms constitute 25% of the Kenyan poultry population, 75% are based on local improved chicken breeds. But despite their numbers, local chicken, only contribute half of the poultry products in the country. Pressure to lower production costs and increase supply has led to increased commercialization, made possible through the shift to larger, specialized and more integrated facilities, and through improvements in the use of improved genetics, optimized nutrition and new production technologies. The driving forces behind structural change in poultry production are market pull, innovation and economies of scale. Innovation and economies of size that characterize the livestock sub-sector have also served to separate poultry production from crop production. Large, specialized facilities today focus on producing poultry products, and purchase most of their feed.
Enhanced food security and specifically to address growing food insecurity in Kenya, concerted efforts among stakeholders are necessary to increase production of animal protein at a competitive price so that they are accessible/affordable to the general population. Besides the necessary economic reforms, massive investments in the poultry industry are one way of supplying affordable animal protein. Poultry products have few if any social or religious stigmas associated with their consumption. Hence, demand for live birds and eggs for consumption or as gifts during the festivities such as Christmas, New year, Eid al Fitr etc are high and always unmet. Many restaurants, hotels and supermarkets in urban and holiday towns are noted for sale of fast foods and barbequed chicken products. Excesses from intensive systems are exported within the region.

Availing production technologies in breeding and multiplication, organizing input supply systems for chicks, feed, vaccines and veterinary drugs, and developing market linkages for chicken and eggs are major market opportunities within the poultry value chain. A holistic and multi-disciplinary support for services such as extension, training, veterinary and credit are critical in supporting local chicken improvement programs. Other markets will come from use of poultry products in the manufacturing industry e.g. vaccines and drugs.

The availability of markets for poultry products in Kenya cannot be over emphasized. Market opportunities are there waiting for would be investors.

References;


The status of smallholder sheep production in selected Arid and Semi-arid Areas of Narok County, Kenya

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Abstract

Sheep is a major component of the pastoral livestock production system and contributes to gross national product through meat, wool and skin exports, to food production by converting roughages into meat and to employment. There is an increasing demand for mutton for domestic and export meat market. A study was conducted in the pastoral smallholder sheep production sites of Olulunga and Nturumeti, Narok County. A purposive sample of 32 households, five key informant interviewees and four Focused group discussions were conducted in November of 2014 to characterise smallholder sheep production and identify gaps in various segments of the value chain in the County. The results indicated that sheep are mainly owned and reared by male gender (81%) on average 7.5 hectares of land. Main sheep breeds; Red Maasai, Dorper, Merino and crossbreds were kept but preferred breeds were Dorper, Red Maasai and their crosses. The sheep main source of feeding was natural grazing (100% of respondents) with feed shortages being experienced in dry season by all (100%). Only 20% of respondents conserved surplus forage. The major feed shortage coping strategy was by practicing pastoralism and use of purchased forages. Major challenge was sheep diseases and shortage of feed during the dry spell. There was low (48%) usage of wheat straw and other crop residues even though most of the households grew wheat, maize and other pulses. Majority of the households, 75%, were not aware of sheep innovations and those aware, 50%, learnt from fellow farmers and 25% from non governmental Organization (NGO). The feeding regime was unimproved pasture grazing whose sustainability is questionable under the current threat of climate change. The results indicate that indigenous breed of sheep, Red Maasai, is still popular in the County. The research, extension as well as the marketing segment of the chain were relatively poorly involved resulting into inefficiencies. Indeed, the infusion of modern production innovations, technology and current marketing strategies is key in improvement of the sheep value chain.

Keywords: ASAL, smallholder, sheep, Narok
Introduction

Agriculture plays a crucial role in the economy of Narok County and in Kenya as a whole. In the country, it is a major foreign exchange earner and in most rural areas of the country, it is the source of livelihoods for most communities and provide stable employment opportunities to many. In Narok County, the integration of livestock and crop farming is thus a common practice in most rural areas. The county is a major wheat producer in the country. There is large scale wheat farming and in the smallholder production system, the wheat farming is mixed with livestock production, sheep being quite prominent (Maina, 2013; Katiku et al., 2013). Integration is for the purpose of diversification of incomes as well as for the benefits that livestock get from the crop residues while cropping benefits from livestock manures. The sheep reared are mainly the indigenous Red Maasai, Dorper, Black head sheep, Merino and their crosses. The exotic breeds are popular in the wetter areas, those neighbouring the Mau escarpment, whereas the local breeds are common in the lowland parts of the County which cover about 80% of the County area.

Narok County has an area of 1,839.8 km², human population of over 850,920 people, sheep population of 1,059,342, goat population of 683,132, lie South West of Kenya and has diverse climatic conditions and land use types spanning the agro ecological zones (1-V1). The low lands are largely semi-arid areas that account for the bigger part of the land mass in the county. It is only 8,497 km² of the total area of the County that is arable. The Narok community practice either pastoralism or agro pastoralism. Quite often, community livelihoods revolve mainly around agriculture and agro pastoralism with a very low diversity of other income streams and hence placing inordinately high pressure on the land.

Pervasive low productivity, partly because of the relatively low degree of commercialization of the livestock production and the related limited adoption of modern technology, is extensively reported albeit the wide and extensive body of knowledge and technology available in research domains in the country. (Hansen et al., 1986; Thompson, 1995; KARI, 2009). Quite often, the producers are reported to experience limited availability of knowledge of existing improved technologies to address the feed challenge (LAPSSET, 2012; Muthianiet al., 2013); poor breeding practices (Koskey, 2004); inappropriate routine husbandry practices (Koskey 2004; Koriretal., 2010); inappropriate helminth control practices (Gatongiet al., 1998; Nganga et al., 2006) and poor markets and marketing strategies (Juma et al., 2010). The situation is worse among the pastoralists. Therefore, there is urgent need to characterize the sheep value chain in the County to facilitate the identification of existing gaps. This data will be used by development agents to revamp the value chain and in identification of best bet and most economical sheep production techniques that can be commercialized through a research to business model in Narok County.

Objective

The objective of the study was to characterise the smallholder production in selected sites of the County and identify gaps in the value chain.
Materials and method

A checklist was used to gather information in a field survey conducted in two smallholder pastoral lowland sheep rearing sites, Nturumeti and Olulunga, in Narok East/North and Narok South Sub-Counties respectively in the month of November 2014. The survey, in three fronts, a household (HH) survey, Focused Group Discussions (FGD) and Key Informant Interview (KII) targeted 32, 4 and 5 respondents respectively based on a criteria of integrating sheep rearing with wheat farming.

Data management and analysis

The quantitative data was entered in the computer using excel spread sheet, synthesized and stored. Data containing qualitative variables was initially coded then up bold in the computer using excel, synthesized and likewise stored. The data was analyzed using SPSS (2003 ) for least square means and standard error of mean and confidence level reported at 95%. Summaries were reported in tables and used to develop figures (bar charts, pie-charts and line graph). The summaries were augmented with desk top values and used to make inferences on the status of the smallholder sheep value chain in Narok County.

General characteristics of sampled households in Narok County.

The household survey interviewed 32 respondents, sixteen from each of the two sub-Counties, Narok East/North and Narok South (Table 1).The villages were not densely populated, they had a mean household (HH) size of 24 persons. The most densely populated village had a HH size of 80 persons. Majority of the HH, 81%, were male headed with 19% as female headed. The average farm size per HH was 7.5 hectares. The data on farm size fit the description of smallholder production system (Muriuki et al., 1992; Tiffens, 1994). The fact that most of the HH are male headed means that consultation with the menfolk is necessary whenever new ideas are to be introduced. The small proportion of female headed HH provide convenient entry point for technologies and ideas that touch on the female gender.

Table 1: General characteristics of sampled households in Narok County

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>N</th>
<th>Std. Error of Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Of households in the village</td>
<td>24.63</td>
<td>24</td>
<td>5.116</td>
<td>80-2 (78)</td>
</tr>
<tr>
<td>Percentage of women headed households</td>
<td>19</td>
<td>21</td>
<td>5.108</td>
<td>100-0 (100)</td>
</tr>
<tr>
<td>Farm size per household (acres)</td>
<td>18.54</td>
<td>26</td>
<td>2.721</td>
<td>50-2 (48)</td>
</tr>
</tbody>
</table>

Sheep production in Narok County

The sheep breeds reared in Narok are the indigenous Red Maasai (RM), Pure Dorper, Merino and crossbreds (Figure 1). The indigenous Red Maasai was popular and was reared by 48% of the respondents. Twenty percent of the respondents kept crossbreds of different breeds of sheep. The least reared sheep breed was Merino. The local breeds of sheep are popular partly because of the frequent droughts in the County. However, if prudent livestock production principles, control of overgrazing by observing appropriate stocking rates and forage conservation, the exotic breeds and their crosses can be reared.
However, in terms of preference, the indigenous Red Maasai and Dorper had same ranking, 28.2% (Table 3). Whereas the RM were liked because of their relatively easy to manage characteristics, the Dorper were liked because they were early maturing just as reported elsewhere (Zonabend et al., 2014). Merino sheep were kept in the wetter Mau escapement area of Narok South because they were adopted to the cooler climatic area of the county.

Table 3: Ranking of preferred sheep breeds and reasons for ranking

<table>
<thead>
<tr>
<th>Breed of sheep</th>
<th>Indigenous Red Maasai Sheep</th>
<th>Crossbreeds</th>
<th>Pure Dorper</th>
<th>Crossbreeds-Dorper</th>
<th>Crossbreeds-Merino</th>
<th>Merino breeds</th>
<th>Unknown breeds</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranking of Preferred breed</td>
<td>48.1%</td>
<td>29.6%</td>
<td>11.1%</td>
<td>7.4%</td>
<td>3.7%</td>
<td>0</td>
<td>3.1%</td>
<td>100%</td>
</tr>
<tr>
<td>Reason for preference</td>
<td>Easy to manage</td>
<td>Early maturity</td>
<td>Early maturity</td>
<td>Cope with climate</td>
<td>High market value-weight</td>
<td>Able to cope with climate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Productivity of sheep in Narok**

The productivity potential of sheep in Narok County is shown in Table 4. Twining rate was reported to be higher in the crossbred sheep (12.4%) as compared to the indigenous RM, 9.40%. However, the crossbreds had an average daily Milk yield of 0.984 litres per day,
less than the 1.694 litre per day per sheep of the RM. The HH reported lactation lengths of 3.44 month and 3 months for the RM and the exotic breeds (Dorper) respectively. The shorter lactation period of the exotic breeds can translate to a higher fecundity than that of the indigenous RM. Much of the milk (75%) stripped from the sheep was for subsistence use at home and the remainder, 25%, sold to fund other services in the farm. With proper selection and breeding practices, dual purpose Dorper sheep can be bred and raised to target the market demand of large and fast growing animals that are also able to yield reasonable amount of milk for the HH needs and surplus for sale.
### Table 4: Sheep production characteristics

<table>
<thead>
<tr>
<th>Duration (months)</th>
<th>Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of lactation for indigenous sheep</td>
<td>6.08</td>
<td>0.93</td>
</tr>
<tr>
<td>Duration of lactation for exotic sheep</td>
<td>9.47</td>
<td>1.22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportion milk sold (%)</th>
<th>Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous sheep</td>
<td>25.4</td>
<td>7.03</td>
</tr>
<tr>
<td>Crossbred sheep</td>
<td>61.7</td>
<td>4.62</td>
</tr>
<tr>
<td>Exotic purebreds sheep</td>
<td>19.6</td>
<td>3.44</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average milk yield/day (lit) of local sheep</th>
<th>Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum milk yield/day (lit)</td>
<td>11.47</td>
<td>10.00</td>
</tr>
<tr>
<td>Minimum milk yield/day (lit)</td>
<td>1.38</td>
<td>1.83</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minimum milk yield/day (lit) of crossbred sheep</th>
<th>Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum milk yield/day (lit)</td>
<td>6.00</td>
<td>6.33</td>
</tr>
<tr>
<td>Minimum milk yield/day (lit)</td>
<td>0.38</td>
<td>0.83</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minimum milk yield/day (lit) of exotic purebreds sheep</th>
<th>Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum milk yield/day (lit)</td>
<td>18.00</td>
<td>17.18</td>
</tr>
<tr>
<td>Minimum milk yield/day (lit)</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minimum milk yield/day (lit) of indigenous sheep</th>
<th>Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum milk yield/day (lit)</td>
<td>3.44</td>
<td>3.44</td>
</tr>
<tr>
<td>Minimum milk yield/day (lit)</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
The challenges (Figure 2) experienced by the producers during the wet season were mainly threefold; sheep diseases (84%), wildlife menace (3.1%) and an array of other problems (13%) such as lack of herding labour and capital for purchase of restocking sheep. During the dry season (Table 5) the challenges were reported to be sheep diseases (87.7%), lack of feeds (6.3%) and other problems such as rustling and inter community conflicts (6%). Among the many diseases occurring in the area, the most prevalent ones (local vernacular name in parenthesis) are; sheep pox (olomoroj), enterotoxaemia (olodua), heartwater (ormilo), Foot and Mouth Disease – FMD (olkirobi) and gastrointestinal parasites. The worms (Table 6) were managed through regular deworming practice. Live weight and age were used to determine dose rate during deworming. Weight (Table 7) was the major criteria used by 73% of the respondents in determining the dose rate of the dewormers. The frequencies of deworming (Table 8) could at times go up to 4 times per year even though majority (48%) of the respondents did it three times per year. Majority of the diseases elucidated by the HH are controllable through vaccination. There is need to enlighten the community on the importance of prophylactics in sheep diseases.

**Figure 2: Challenges experienced by producers**

**Table 5: Sheep challenges during the dry season**

<table>
<thead>
<tr>
<th>Health challenge in sheep</th>
<th>Diseases(Enterotoxaemia, FMD, sheep pox, worm)</th>
<th>Lack of feeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenges</td>
<td>87.7</td>
<td></td>
</tr>
</tbody>
</table>

**Table 6: worm in sheep challenges during the wet season**

<table>
<thead>
<tr>
<th>If worm a major burden challenge in wet season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worms in sheep</td>
</tr>
<tr>
<td>County %</td>
</tr>
</tbody>
</table>
Table 7: Determining deworming dose rate for sheep in Narok

<table>
<thead>
<tr>
<th>% in County</th>
<th>Determination of deworming dosage</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Weight</td>
<td>Size</td>
</tr>
<tr>
<td>3.3%</td>
<td>73.3%</td>
<td>16.7%</td>
</tr>
</tbody>
</table>

Table 8: Frequency of deworming sheep in Narok

<table>
<thead>
<tr>
<th>Number of times (frequency) deworming in a year</th>
<th>% County</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>13.8%</td>
</tr>
<tr>
<td>3</td>
<td>48.3%</td>
</tr>
<tr>
<td>4</td>
<td>37.9%</td>
</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The cost of deworming sheep ranged between Ksh 550 to Ksh 1480 for lambs and adult sheep per year respectively (Table 9). The high figures are partly explained by the high frequencies of deworming. However, the current scenario can be reversed by adoption of better deworming regimes such as the strategic deworming practice (Gatongi et al., 1998) and enhance innovative sheep feeding practices (Syomiti et al., 2015).

Table 9: Cost of deworming lambs and mature sheep in Narok

<table>
<thead>
<tr>
<th>Category of sheep</th>
<th>cost of deworming lamb (ksh)</th>
<th>cost of deworming adult (ksh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>554.67</td>
<td>1486.00</td>
</tr>
<tr>
<td>N</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Std. Error of Mean</td>
<td>334.838</td>
<td>997.182</td>
</tr>
</tbody>
</table>

Feed resources for sheep in Narok

Sheep are naturally grazed in less improved pastures in Narok. As result, all the respondents (100%) reported to experience feed shortages particularly during the dry season. However, only 20% of respondents could conserve the surplus forage available during the wet season. The major feed shortage coping strategy (Figure 3) was by practicing pastoralism (75%) and use of purchased forages (12.5%). There was very low usage of wheat straw (3.1%) regardless of the fact that wheat was an integral part of the farm enterprise of the sampled HH. The introduction of better yielding forages, natural pasture grasses included (Manyeki et al., 2015) would go a long way in alleviating the problem. Moreover, advocacy on feed conservation, particularly during the growing season when forage materials are plentiful can enhance feed availability and hence improved animal production. Additionally, there is need to enhance the baling and utilization of the plentiful crop residues, wheat straw included.
The status of smallholder sheep production in selected Arid and Semi-arid Areas of Narok County, Kenya

Figure 3: Sheep feed shortage coping mechanism in Narok

The drought coping strategies practiced by the HH are not sustainable. They need to put more efforts in pasture development for long term benefits.

Figure 4 shows the practices used by HH to improve the natural pastures. Majority (75%) of the respondents practiced reseeding and the remainder (25%) did weed management. These are essential pasture improvement practices which coupled with manuring, which is plenty but rarely used, can lead to sustainable forage production for animal production as well as adoption of feed conservation practices (Ndathi et al., 2013).

Figure 4: Natural pasture improvement practices in Narok
Status of sheep innovations in Narok

Table 10 shows the husbandry practices commonly applied to sheep by HH in Narok County. Generally, aspects touching on breeding activities—whether having a breeding program, external sourcing of breeding sires, use of factors in selection of breeding rams and the use of seasonal breeding scheme for sheep—were extensively (over 60%) practiced by the HH. Management practices involving animal health, access to veterinary services, and ease of access to health services, were also extensively practiced by over 70% of the respondents. Among the aspects with the least application were the use of concentrates (20%) and use of crop residues (48%). The finishing of sheep by fattening for marketing was practiced by 50% of the interviewed HH. In order to commercialize sheep production, emphasis on adoption and practicing of sheep innovations by the HH is key.

Table 10: Innovations in sheep production enterprise in Narok

<table>
<thead>
<tr>
<th>Production Practice</th>
<th>Yes(% Practicing)</th>
<th>Not Practicing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practicing seasonal breeding program for sheep</td>
<td>71</td>
<td>29</td>
</tr>
<tr>
<td>Practicing continuous breeding program</td>
<td>15.6</td>
<td>84.4</td>
</tr>
<tr>
<td>Is inbreeding a problem</td>
<td>41.9</td>
<td>58.1</td>
</tr>
<tr>
<td>Factors for determining breeding</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Sourcing for breeding sires</td>
<td>61.3</td>
<td>38.9</td>
</tr>
<tr>
<td>Special management</td>
<td>76.7</td>
<td>23.3</td>
</tr>
<tr>
<td>Tethering on private land</td>
<td>73.3</td>
<td>26.7</td>
</tr>
<tr>
<td>Tethering on communal land</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>Access to veterinary services</td>
<td>84.3</td>
<td>15.2</td>
</tr>
<tr>
<td>Access to production inputs</td>
<td>14.3</td>
<td>81</td>
</tr>
<tr>
<td>Using concentrates</td>
<td>20.5</td>
<td>79.5</td>
</tr>
<tr>
<td>Using crop residues</td>
<td>48.4</td>
<td>57.6</td>
</tr>
<tr>
<td>Practicing sheep fattening for market</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Having easy access to health services</td>
<td>74.5</td>
<td>25.5</td>
</tr>
<tr>
<td>Having a breeding program</td>
<td>90.3</td>
<td>9.7</td>
</tr>
</tbody>
</table>

Among the practices used to manage inbreeding (Table 11), separation and castration was 44.4% and 38.9% respectively. The innovative apron system of breeding control was applied by 17% of the respondents. Majority of the HH (75%) used own bred sires with 15% using purchased rams. When selecting sires for breeding, body size was a major consideration which was practiced by 64% of the interviewees. The special management practices applied during breeding by most HH was supplementation (55%). The use of own bred ram is a practice that can lead to inbreeding if not well planned. The apron system combined with ram sharing can be useful in prolonging the lifespan of good breeding rams intended for use in animal improvement. The farmers were aware of prudent breeding practices (Mbuku, 2006; Verbeek, et al., 2007).
Table 11: Sheep breeding management practices

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Practice</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control of inbreeding practices</td>
<td>Castration</td>
<td>38.9</td>
</tr>
<tr>
<td></td>
<td>Separation</td>
<td>44.4</td>
</tr>
<tr>
<td></td>
<td>Apron</td>
<td>16.7</td>
</tr>
<tr>
<td>Main Sources of sires</td>
<td>Percentage using own bred ram</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Percentage using own bought ram</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Percentage using donated ram</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Percentage using communal ram</td>
<td>5</td>
</tr>
<tr>
<td>Factors for choice of breeding ram</td>
<td>Body size</td>
<td>64.3</td>
</tr>
<tr>
<td></td>
<td>Fast growth</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td>Colour</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>Breed</td>
<td>17.9</td>
</tr>
<tr>
<td>Special management practices</td>
<td>Supplementation</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Special paddocking</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Selective deworming breeding sire</td>
<td>15</td>
</tr>
</tbody>
</table>

The awareness to sheep production innovations and the rate of adoption (infusion) was low (Table 12). Some respondents reported reasonable exposures to sheep innovations; improved genetics was at 31.3% which majority (66.7%) had learnt from fellow farmers, castration of culled rams was 36.7% which 50% of them got from fellow farmers, use of baled hay was 27.7% and was learnt from three sources—fellow farmers (37.5%) from extension officers (37.5%) and from NGO (25%). Some 13.3% of the respondents were aware of ram sharing which they totally learnt from other farmers. Farmers (13.3%) were aware of reseeding, a pasture improvement innovation, which 50% of them learnt from their contemporaries and 25% of them learnt from NGO. Routine cleaning of sheep pen was among the innovations reported to have awareness and adoption levels of 61.5% and of 58.3% respectively which 88.7% of the respondents learnt from other farmers. The feeding of wheat straw was practised by 16.7% of respondents and 80% of them learnt it from other farmers. It had a medium level of adoption (60%). About 3.8% and 13% were reported to be aware of use of sheep management calendar and keeping of proper sheep records. They all learnt of the innovation from other farmers but the adoption levels were high, 100% and 66.7% respectively. The number of HH aware of strategic deworming of ewes and rams innovation was 19.4% while 23% were aware of strategic deworming of lambs which they totally learnt from fellow farmers and indicated that both had adoption level of 66.7%. The idea of lamb housing was practiced by 37% of respondents, was 100% learnt from other farmers, and an adoption level of 83%. Feeding hay feeding and use of commercial feeds was practised by 15% and 7.7% HH respectively which they mainly learnt from fellow farmers but had high adoption levels. Farmers (16%) aware of mineral supplementation innovation and 50% learnt of it from fellow farmers and extension officers respectively. The adoption level was 80%. These results indicate that the interviewed HH were not fully aware of important sheep innovations. They need to be capacity built on these innovations. Moreover, the fact that majority of the HH indicated that they got exposure of innovations from fellow farmers, the system can be explored in dissemination of modern research innovations. But care must be taken when using this medium, where the message is in correct, it can spread very fast in the community. The minority innovative farmers are good entry points of new innovations intended for the entire community.
Table 12: Awareness to sheep production innovations

<table>
<thead>
<tr>
<th>Awareness of sheep innovations</th>
<th>Awareness (%)</th>
<th>Not aware%</th>
<th>Source- by whom</th>
<th>Adoption level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved genetics</td>
<td>31.3</td>
<td>68.8</td>
<td>Fellow farmers-66.7% Ext-22.2, NGO-11.1%</td>
<td>High 87.5%</td>
</tr>
<tr>
<td>Ram sharing</td>
<td>13.3</td>
<td>86.7</td>
<td>Fellow farmer-100%</td>
<td>Medium- 100%</td>
</tr>
<tr>
<td>Castration of culled rams</td>
<td>36.7</td>
<td>63.3</td>
<td>Fellow farmers-50% NGO-50%</td>
<td>High 50%</td>
</tr>
<tr>
<td>Reseeding</td>
<td>13.3</td>
<td>86.7</td>
<td>Fellow farmers-50% NGO-25%</td>
<td>Medium-66.7</td>
</tr>
<tr>
<td>Weed management</td>
<td>10.7</td>
<td>89.3</td>
<td>Fellow farmers-66.7 NGO-33.3%</td>
<td>High-100%</td>
</tr>
<tr>
<td>Baled hay</td>
<td>27.7</td>
<td>72.3</td>
<td>Fellow farmers-37.5% Ext-37.5%, NGO-25%</td>
<td>High-37.5</td>
</tr>
<tr>
<td>Standing hay</td>
<td>20.7</td>
<td>79.3</td>
<td>Fellow farmers-40% Ext-20%, NGO-40%</td>
<td>High- 50%</td>
</tr>
<tr>
<td>Mineral supplementation</td>
<td>16.7</td>
<td>83.3</td>
<td>Fellow farmers-50% Ext-50%, Ext-20%</td>
<td>High- 80%</td>
</tr>
<tr>
<td>Wheat straw feeding</td>
<td>16.7</td>
<td>83.3</td>
<td>Fellow farmers-80% Ext-20%</td>
<td>Medium – 60%</td>
</tr>
<tr>
<td>Hay feeding</td>
<td>15.4</td>
<td>84.6</td>
<td>Fellow farmers-25% Ext-25%, NGO-25%, projects 25%</td>
<td>High – 50%</td>
</tr>
<tr>
<td>Use of commercial feeds</td>
<td>7.7</td>
<td>92.3</td>
<td>Fellow farmers-50% Ext-50%</td>
<td>High- 50%</td>
</tr>
<tr>
<td>Strategic deworming of ewes and rams</td>
<td>19.4</td>
<td>80.6</td>
<td>Fellow farmers-100%</td>
<td>High-66.7%</td>
</tr>
<tr>
<td>Strategic deworming of lambs</td>
<td>23.1</td>
<td>76.9</td>
<td>Fellow farmers-100%</td>
<td>High-66.7%</td>
</tr>
<tr>
<td>Lamb housing</td>
<td>37</td>
<td>63</td>
<td>Fellow farmers-100%</td>
<td>High- 83.3%</td>
</tr>
<tr>
<td>Routine cleaning of pen</td>
<td>61.5</td>
<td>38.5</td>
<td>Fellow farmers-88.9% Ext-11.1%</td>
<td>High- 58.3%</td>
</tr>
<tr>
<td>Record keeping</td>
<td>13</td>
<td>87</td>
<td>Fellow farmers-100%</td>
<td>High- 66.7</td>
</tr>
<tr>
<td>Use of sheep management calendar</td>
<td>3.8</td>
<td>96.2</td>
<td>Fellow farmers-100%</td>
<td>High- 100%</td>
</tr>
</tbody>
</table>

Sheep marketing in Narok

The Cost Benefit Analysis of sheep production were estimated based on the current average production cost of KES 1,581.60 and market price of KES 5,134.60 per sheep (Table 13). Cost and benefit associated with sheep production and marketing were evaluated by estimating the expected net present value (NPV), gross margin (GM) and cost benefit ratio (CBR). Based on these cost benefit parameters, a positive NPV and GM and a CBR above one was reported indicating that the costs invested in the sheep production are recovered and high benefits realised. The discounted net benefit was far
above zero implying that it was worthy investing in sheep production for enhanced future benefit. In addition, a sensitive analysis was conducted. An increase in price of sheep through strategic fattening technologies, breed and breeding programme and collective marketing bargaining approach would enhance the profitability of the enterprise. Equally a better result would be realized through the reduction of production though strategic deworming regime and proper utilization of wheat straws. A combination of the two scenarios would improve the profit of a small scale farmers by a greater margin.

Table 13: Cost Benefit and Sensitive analysis for sheep production

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Current status</th>
<th>10% increase in selling price</th>
<th>10% reduction in production cost</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Margin</td>
<td>3,553.00</td>
<td>3,908.30</td>
<td>3,711.10</td>
<td>4,224.60</td>
</tr>
<tr>
<td>Cost Benefit Ratio</td>
<td>3.2</td>
<td>3.5</td>
<td>3.6</td>
<td>3.9</td>
</tr>
<tr>
<td>Net Present Value (30% discounting value)</td>
<td>2,733.10</td>
<td>3,006.40</td>
<td>2,854.70</td>
<td>3,249.70</td>
</tr>
</tbody>
</table>

Possible options
- ✓ Strategic fattening technologies
- ✓ Breed and breeding
- ✓ Collective marketing bargaining approach
- ✓ Strategic deworming regime
- ✓ Proper utilization of wheat straws
- Combination of all

Recent studies suggest possible improvements in return on livestock production and marketing that include promotion of auctions (Green et al., 2005), that would stimulate increased competition in long-distance, perhaps through improved organization of local-level marketing and motorized transport cooperatives. Such interventions remain largely under tested and under-studied. This calls for the development agents (state government, NGOs, CIGs and the County governments) to investments in information forecast on prices, creation of pastoralist marketing cooperatives and the opening of financial institutions that might serve as safe repositories for livestock sales proceeds, and enterprise development (Thompson, 1995; Barrett., et al., 2003). According to the current study, the participation of the above institutions was minimal at the grass root level albeit their immense role in the development of the value chain.

Conclusions
From the study it was noted that sheep production in Narok is a predominant enterprise for the small scale farmers. However, there exists low adoption of production innovations which leads to below average productivity. The marketing segment still relies on the middlemen who are a threat to the producers in the value chain. The success of the efforts of developing the sheep enterprise in Narok County is greatly dependt on multi-institutional stakeholder involvement. The involvement of local institutions in improving
efficiency of the value chain cannot be over emphasized. The sheep producer need capacity building in sheep innovations particularly those related to feeds and feeding because of the threat of climate change and the dwindling land for traditional pastoralism.

Acknowledgement

The authors wish to express much gratitude to all persons involved in the work. Foremost, are the farmers without whom the data could not be obtained. The funding agency, IFAD, who availed the funds through ICARDA, channelled to the KALRO directorate, are sincerely appreciated. All other individuals and agencies involved in the work are acknowledged.

References


Key issues on feeds: quality of pastures, fodder and concentrates


Abstract
A major constraint to increasing livestock productivity in developing countries is the scarcity and fluctuating quantity and quality of the year-round supply of conventional feeds. In order to meet the projected high demand of livestock products, and to fulfill the future hopes of feeding the millions and safeguarding their food security, the better utilization of non-conventional feed resources which do not compete with human food is imperative. There is also a need to identify and introduce new and lesser known food and feed crops capable of growing in poor soils, which can play a vital role in control of soil erosion, bring economic benefits to farmers, enhance biodiversity, create jobs and bridge the wide gap between supply and demand for animal feeds.

This paper highlights quality indicators of cattle feeds and backgrounds of some measurements of feed quality often encountered in dairy industry; the potential of a novel approach using an in vitro rumen fermentation technique for evaluation of nutritional quality of non-conventional feed resources; many of the considerations discussed also apply to conventional feeds. This technique enables selection of a feed for high efficiency of microbial protein synthesis in the rumen along with high dry matter digestibility, and provides a basis for development of feeding strategies to better synchronise energy and nutrient release to maximise substrate fixation into microbial cells. This could lead to increase in the supply of protein to intestine and reduce methane production from ruminants. The nylon bag technique is a very robust and powerful tool with which to study several aspects of nutrition in ruminants. It is particularly useful in describing degradation characteristics of protein and roughages and also for rumen environment studies. For each purpose a slightly different approach has to be used. This article explains how this is best achieved.

Introduction
At farm level, dairy cattle are exposed to many feeds, with diets varying in different regions and farming systems. The productivity of a dairy system is highly dependent on the quality of feeds. This is because the feed quality determines the intake and availability of ingested nutrients for utilization by the dairy cattle. Consequently, farmers are not only faced with the problem of knowing the quality of the feeds but also the factors that influence the quality.

Feeds are assessed so that a judgment can be made on their nutritive value and the part that they can play in meeting an animal’s requirements for different production needs. Ideally, the information gathered from feed assessment can be used to select a range of feeds that will together make a balanced diet for the animal, meeting all its requirements for energy, protein, vitamins, minerals and of course water.
Laboratory methods have for many years been used to help define animal feeds, assess their nutritive value and provide data for the prediction of animal performance. Proximate analysis is a chemical method of assessing and expressing the chemical composition of a feed. It divides each feed into six categories and states the percentage of each that is present in the feed: (1) water (or dry matter); (2) total or crude protein; (3) fat (or ether extract); (4) ash (minerals); (5) crude fiber (incompletely digested carbohydrates); (6) nitrogen-free extract (readily digestible carbohydrate).

The nylon bag technique described by Ørskov et al. (1980) for the determination of the degradation of feedstuffs in the rumen at various incubation periods can be used to screen feeds at the initial stages of assessing their nutritive values. Applying the equation of McDonald (1981), \( p = a + b (1 - e^{-ct}) \), to describe the course of degradation of the feeds, the constants, \( a \), \( b \), and \( c \) obtained can also be used to predict feed intake and growth rate (Ørskov et al. 1988). Blummel and Ørskov (1993) reported that the in vitro gas production technique developed by Menke et al. (1979) could also be used to determine gas production at various incubation periods and these values could be used to describe the course of fermentation of the feeds, by applying the equation of McDonald (1981). These workers reported high positive correlation between the in vitro gas production and in sacco degradation of feeds at the various incubation periods (\( r = 0.95 \) to \( 0.97 \) ) (Blummel and Ørskov 1993). An animal’s feed intake, and how well that feed is digested, determines the feed’s production performance. The in vitro gas production technique is a relatively simple method for evaluating feeds, as large numbers of samples can be incubated and analyzed at the same time (Getachew et al., 2006). This technique is also important in determining the metabolizable energy of feeds and kinetics of their fermentation.

The objective of this paper is to provide highlights of information about quality indicators of cattle feeds and backgrounds of some measurements of feed quality often encountered in dairy industry. The highlights include physical indicators and some scientific feed evaluation methods that can be employed to determine feed quality.

**Physical indicators of feed quality**

The physical nature of the feeds can pose serious limitations to efficient utilization of a feed or a ration comprised of several feed resources. However, the influence of physical attributes of feeds on quality is often ignored. Some of the physical aspects that can limit the quality and utilization of feeds in dairy production are briefly discussed:

The nutritive quality of forages varies as they grow towards maturity. Consideration of the stage at which both biomass yield and nutrient content are optimal is therefore important. After attainment of maturity, the forages generally depreciate in nutritive value. This is mostly due to increase fibrous material, particularly lignin. For many forages, the leaves die off systemically after attainment of maturity, and this reduces photosynthetic activities. As a result, there will be reduced accumulation of nutrients: the yield does not increase anymore. These factors are important to be considered e.g. when harvesting forage for conservation as hay. For instance, when making hay from grass (e.g. Rhodes grass) and legumes (e.g. Lucerne) it is generally advisable
to cut at the onset of flowering up to the time of 50% flowering. For a vegetatively propagated forage such as Napier grass, cutting height is the most important physical consideration for quality. Studies have shown that optimum harvesting height for Napier grass range between 50-60 cm (dry season) and 130-140 (rainy season). Another disadvantage of a mature stage and dying leaves is that the leaves fall off and are lost from the roughage. The leaves in general contain most easy available feeding value.

### Texture

The physical/textural changes which occur as forages grow can impact on palatability, intake and animal digestive physiology. For instance, high intake of succulent young forages (e.g. Lucerne, vetch, clover and Comelina spp) may cause bloat. At young stage the dry matter (DM) content of some forages can be very low (e.g. sweet-potato vines and Napier grass), and this can limit the adequate intake of dry matter to support the desired level of production. The palatability can be compromised as the forages age because of increase in toughness and crude fibre. This can further complicate issues if some species and classes of livestock e.g. young ones are unable to consume fibrous old and tough forages or parts of.

### Ratio of stem and foliage

It is important to have knowledge of the nutritive attributes of the various morphological components of the individual forages. In fodder crops, the leaf is in most cases the most nutritive component, hence the need to consider the utilization of a forage when the biomass yield and leaf:stem ratio are optimal.

### Processing

Where the cattle are stall fed with chopped roughage, the particle size may play an important role in selection, intake and digestibility. For instance, the chop length of ensiled maize stovers have been shown to influence the selection where leafy parts are consumed more and the overall intake is reduced with increase in chop length. Also, where different feed resources are to be mixed, the particle size must be considered to enable homogeneity in mixing.

Some ingredients necessary in the diets may not be in appropriate physical/textural form for cattle intake. Generally, cattle do not prefer powdery or finely processed feeds. Also, feed resources like molasses (semi-liquid) need to be mixed appropriately with a carrier feed. Some feed additives or supplements are better provided in pellet or lick block forms e.g. calf pellets and mineral licks. It prevents selective intake.

### Appearance and Colour

Generally, feeds have their own typical appearance, which the farmers are or should be familiar with. The appearance can be an important attraction to both farmers and animals. Deviation from the typical appearance should be taken seriously as this may have implication on quality. The colour of specific feed resources can be good indicators for the quality of the feed. Thus feed users need to know the typical colour of feeds so that when there is deviation from the norm, precaution can be observed. For most fresh forages, green colour indicates good quality. For instance, greenness may depict good growing conditions, hence abundance of nutrients. It may also indicate absence
of diseases, pests and parasites. Appropriate colour can be used by farmers to judge the stage of harvesting. In concentrates and processed feeds it is more difficult to judge the quality on the colour. Whole grains on the contrary can be judged well on colour and shine.

**Freshness**
Freshness of the feeds can be indicated by e.g. colour, smell and/or presence of mould and temperature. Generally, the cattle intake will be negatively affected as the feed deteriorates in freshness. Consumption of stale feed can harm the cattle due to toxicity.

Presence of visible undesirable objects is also a good pointer to poor quality. The foreign bodies may include soil, pieces of glass, polythene, nails and metals and wood particles or rodent faeces. Visual inspection of feeds should not be neglected, because this can lead to harmful or at worse fatal consequences for the animals being fed. Be sure that there are no poisonous plants or parts included in the feed and no residues of pesticides or herbicides.

**Acceptability**
Cattle, like most animals have natural instinct of preference. It is therefore possible that a good feed may be rejected because animals are not familiar with it and have to get accustomed. On the other hand, rejection of certain feeds can be a good indicator of hidden factors which should be identified and eliminated to improve the intake. In this regard, it may be dangerous and unethical to provide such a feed in mixtures where the cattle cannot select and are forced to consume it. It is therefore necessary to ascertain the factors causing rejection and the benefits of such a feed before its use. One of the commonest feature of dairy cattle feeding in Kenya is variability of type and nature of roughage feed. This is due of fodder inadequacy and this has implications on acceptability and also utilization due to its effect on rumen microbe composition. It takes time for the rumen microbe composition to stabilize with change of diet and consequently digestibility and utilization of the feed.

**Scientific methods of feed evaluation**
The nutritive value of feeds is principally governed by their chemical composition, intake, digestibility and efficiency by which the nutrients are released. Consequently, there are several feed evaluation methods which have been developed to study the nutritive value of feeds. Different methods provide different quality measurements. The quality measurements of feeds include chemical composition, energy content, intake, digestibility and anti-nutritive factors. In general, the methods of feed evaluation can be classified into the following: (1) Chemical composition analysis in the laboratory (2) Laboratory based (*in vitro*) biological evaluation procedures and (3) Animal performance trials.
Chemical composition analysis

Proximate analysis

For improvements in nutrition it was essential to establish a means by which differing forages could be directly compared without blindly going through feeding trials. The first technique was developed by scientists working in Weende, Germany in 1865 and this rapidly became the official method for both human and animal food analysis worldwide. The process was referred to as the Proximate analysis or the Weende system. It was referred to as ‘Proximate’ because it approximates the values of different components of the feed. The Proximate analysis allowed each sample to be divided into six fractions: water or dry matter (DM), ash, crude protein (CP), ether extracts (EE), crude fibre (CF) and nitrogen free extract (NFE). The meaning of these components are described below:

**Dry matter**, represent net weight after completely removing water by drying.  
**Ash**, represents non-organic matter  
**CP**, represents true protein  
**EE**, represents fats and oils  
**CF**, represents hemicellulose, cellulose and lignin  
**NFE**, represents soluble sugars and starches

Fibre fractions

A more accurate and easier laboratory method of predicting fibre content in feeds than the Proximate system was designed by a scientist namely Peter Van Soest, in 1967. It considers that the plant cells are basically made of cell contents (sugars, starches, soluble proteins, pectins, lipids and vitamins) and cell-wall contents (cellulose, hemicellulose and lignin). In this method, the feed is partitioned into digestible and indigestible portions. The sample is first extracted with a solution which dissolves cell contents. The solution is termed Neutral Detergent Solution (NDS). The sample is extracted with NDS and the resulting residue is termed Neutral Detergent Fibre (NDF) which represents the cell-wall constituents. The weight which disappears represents the cell content. The cell contents are virtually digestible. The NDF is then extracted with Acid Detergent Solution and the resulting residue is termed Acid Detergent Fibre (ADF). The ADF contains mainly cellulose and lignin.

**Feed quality analysis by Energy partitioning**

Basically, feed organic nutrients are required by the animals for three things: These are (i) use as materials for the construction of body tissues (ii) synthesis of products such as milk and (iii) use as sources of energy for work done as shown in figure 1. The work done include both metabolic (heat increment and maintenance) and physical e.g. walking and feeding.
The feed is comprised of chemical ingredients which are broadly classified as carbohydrates, proteins, lipids and vitamins. Heat is released when organic material such feed is burnt. For this reason, methods have been developed to measure the quantity of chemical energy present in a feed by determining the amount of heat generated from complete burning a known quantity. This is referred to as gross energy (GE). Most of the common feeds have energy content of about 18.5 MJ/kg DM.

Not all the GE in consumed feed is available and useful to the animal. Some energy is lost from the animal through excretions and heat. The digestible energy (DE) is calculated by subtraction of faeces energy from GE. The DE represent the energy content of the digested nutrients.

The animal further loses energy containing-substances through excretion of urine and production of gases during metabolic processes. Metabolizable energy (ME) is what remains after subtraction of energy lost from urine and combustible gases resulting from the consumption of a feed. Loss of energy through methane (a combustible global warming gas) can be substantial, particularly for ruminants, hence can be of serious nutritive and environmental consequence.

The deduction of the HI of a food from its ME gives the Net energy (NE), which is the energy available to the animal for useful purposes such as body maintenance and various forms of production. Figure 1 is a summary of partitioning of feed energy within the animal.
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Table 1: Quality of some commonly available roughages in Kenya

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Table 2: Nutritive value of some commonly available concentrates and agro-industrial by-products in Kenya

<table>
<thead>
<tr>
<th>Feed No</th>
<th>Feed Name</th>
<th>DM %</th>
<th>NEM Meal/kg</th>
<th>CP %</th>
<th>RUP %</th>
<th>RDP %</th>
<th>CF %</th>
<th>ADF %</th>
<th>NDF %</th>
<th>Ash %</th>
<th>Ca %</th>
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Biological method of feed analysis

Three major biological digestion techniques are currently available to determine the nutritive value of ruminant feed. These are:

1) digestion with rumen microorganisms as in Tilley and Terry (Tilley and Terry 1963) or using a gas method (Menke et al., 1979), 2) in vivo incubation of samples in nylon bags in the rumen (Mahrez and Orskov, 1977) These biological methods are more meaningful since microorganisms and enzymes are more sensitive to factors influencing the rate and extent of digestion than are chemical methods (Van Soest et al., 1994).

In vitro gas method

In vitro methods for laboratory estimations of degraded feeds are important for ruminant nutritionists. An efficient laboratory method should be reproducible and should correlate well with actually measured in vivo parameters. In vitro methods have the advantage not only of being less expensive and less time-consuming, but they allow one to maintain experimental conditions more precisely than do in vivo trials.

In-vivo method

3.0 g of dry ground sample are put in 2 mm sieve in nylon bags. The bags in duplicate for each feed are then placed in the rumen of the fistulated steers and incubated at 0, 3, 6, 12, 24, 48, 72 and 96 hours. On removal, all the nylon bags are thoroughly hand washed with cold running water until no further coloured liquid could be extruded, and dried at 60°C for 48 h to determine the DM disappearance and the weight of bags + incubated samples recorded. The disappearance values are then fitted to the exponential equation: $Y = a + b \left(1-e^{-ct}\right)$ where $a$, $b$, and $c$ are degradation constants.

Where:

$Y = A$, the initial weight loss; $B = $ the asymptote of the exponential $b \left(1-e^{-ct}\right)$; $c =$ rate constant; $a + b = $ the potential degradability.
References


Analysis of tick control practices among smallholder dairy farmers in Kenya: The case of North Rift Kenya

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Abstract
Diseases are a major constraint limiting dairy cattle production with tick-borne diseases ranking among those of high economic importance. Controlling tick infestation through use of chemical acaricides is one control method commonly practiced by dairy farmers for tick-borne diseases. Whether dairy farmers adhere to the recommended tick control practices is an empirical question. A cross-sectional household survey was conducted in August – September 2013 among 181 randomly selected smallholder dairy households with an objective of characterizing tick control practices in North Rift Kenya. Among other results, the study revealed similar patterns of tick control among cattle vaccinated against East Coast Fever (ECF) and non-vaccinated cattle and use of significantly low acaricide concentrations. Thus, emphasis on proper acaricide application is recommended in enhancing dairy cattle productivity in the area.

Introduction
Livestock play an important role in contributing to rural livelihoods, employment and poverty reduction. They provide milk, eggs, meat, skins and hides, manure, traction power, transport, act as self-insurance, a means of sharing risk and act as collateral for financing. In addition to provision of livestock products for use by livestock producers, livestock are a source of cash income from sale of live animals or livestock products. In Kenya, cattle are an important component of the livestock subsector. According to statistics obtained from the 2009 National Housing and Population Census, an analysis of the number of livestock kept revealed 17.4 million cattle, ranking third in population after chicken and goats (Behnke and Muthami, 2011).

Diseases are a major constraint limiting dairy cattle production with tick-borne diseases ranking among those of high economic importance (Wesonga, et al., 2010). Tick-borne diseases such as East Coast Fever (ECF), Anaplasmosis, Babesiosis and Heartwater contribute to reduced productivity, increased production costs (high cost of tick control and treatment of tick-borne diseases) and loss of animals (through death). One of the methods commonly practiced by dairy farmers to control tick-borne diseases is use of chemical acaricides (Mugambi, et al., 2012). According to the Cattle Cleansing Act (GoK, 2013) cattle owners are expected to dip or spray their cattle at weekly intervals. Despite adoption of this regular tick control practice, tick-borne diseases such as ECF remain a major challenge to smallholder dairy farmers. Whether dairy farmers adhere to
the recommended tick control practices is an empirical question. In an attempt to fill this information gap, a study was conducted with an objective of characterizing tick control practices in North Rift Kenya. It is expected that an understanding of the tick control practices will be a pointer to the high tick-borne disease incidences and provide guidance and direction to future dairy development initiatives.

Methodology

A cross-sectional household survey was conducted within the period August – September 2013 among 181 randomly selected households in Uasin Gishu, Kericho and Nakuru Counties in North Rift Kenya. A semi-structured questionnaire was developed, pretested and administered by enumerators who were trained on the data collection tool, procedures and modalities. Data collected included the socioeconomic and demographic characteristics, acaricide application intervals, acaricide concentration and application methods. Data coding, entry and cleaning was done using Statistical Package for Social Sciences (SPSS) software. Descriptive statistics which included frequencies and cross-tabulations were generated and used to characterize farmers’ socioeconomic characteristics and tick control practices.

Results and Discussion

Descriptive statistics of the sample households

Majority (72.8%) of the sampled households’ main occupation was farming while 21.1% were salaried workers and 6.1% were self-employed off-farm. The mean age of household heads was 50 years with 92.2% being male-headed. Majority (95%) of the household heads were literate and had acquired basic primary education with a mean of 10 years of education, while 5% had not accessed any formal education. Eighty five percent (85%) of the households were married and living together with their spouses implying collective decision making while the rest comprised of those married but with one of the spouses living away, single and widowed.

Herd size

The cattle stocking rate ranged from 1-9 cows, with a mean of 3 cows per household in the study area. Sampled households owned different types of cattle as shown in Table 1.

Table 1: Type of cattle owned

<table>
<thead>
<tr>
<th>Type of cattle</th>
<th>Mean no. of cattle</th>
<th>Proportion (%) of households (N=181)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Indigenous milking cows</td>
<td>2.38</td>
<td>4.4</td>
</tr>
<tr>
<td>2 Crossbred milking cows</td>
<td>3.44</td>
<td>82.8</td>
</tr>
<tr>
<td>3 Cross-bred non-milking cows</td>
<td>2.50</td>
<td>19.9</td>
</tr>
<tr>
<td>4 Exotic milking cows</td>
<td>3.37</td>
<td>22.7</td>
</tr>
<tr>
<td>5 Exotic non-milking cows</td>
<td>4.22</td>
<td>5.0</td>
</tr>
<tr>
<td>7 Heifers</td>
<td>2.81</td>
<td>63.0</td>
</tr>
<tr>
<td>8 Steers</td>
<td>2.87</td>
<td>28.7</td>
</tr>
<tr>
<td>9 Calves</td>
<td>2.54</td>
<td>74.0</td>
</tr>
<tr>
<td>Overall</td>
<td>2.96</td>
<td></td>
</tr>
</tbody>
</table>
The most common type of cattle kept was cross-bred milking cows owned by 82.8% households, with each household keeping a mean of 3 cows.

**Tick Control**
All sampled households controlled ticks using acaricides. The most common application method was spraying (74% households) while 26% practiced cattle dipping. The study further revealed that most (63%) households applied tick control measures weekly while 35% carried out tick control activities once in a fortnight. Households vaccinating against ECF are expected to apply strategic or threshold tick control thereby reducing the frequency of acaricide application. Thus, a further analysis on tick control frequency among those who had vaccinated against ECF, and those who had not, was conducted but revealed similar patterns as shown in Table 2.

**Table 2: Frequency of acaricide application**

<table>
<thead>
<tr>
<th>Application frequency</th>
<th>Vaccinating households</th>
<th>Non-vaccinating households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once a week</td>
<td>69</td>
<td>58</td>
</tr>
<tr>
<td>Once a fortnight</td>
<td>29</td>
<td>38</td>
</tr>
<tr>
<td>Twice a week</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Once a month</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The study revealed that most of the vaccinating (68.5%) and non-vaccinating (58.5%) households carried out tick control activities once each week. This implies that despite vaccinating against ECF, households did not apply strategic or threshold tick control hence did not reduce the production costs as intended.

**Acaridae concentration**
Households applying acaricides to cattle through spraying purchased different brands from agro-dealers. Adhering to the recommended ratio of acaricide to water is important in ensuring efficiency of the acaricide. An analysis of quantities of acaricide mixed with water in preparation for spraying was conducted, which revealed that very little acaricide was mixed with excess water. A further analysis was conducted to evaluate whether there was a difference in the ratios used by vaccinating and non-vaccinating households as shown in Table 3.

**Table 3: Acaricide preparation ratios**

<table>
<thead>
<tr>
<th>Type of household</th>
<th>Mean quantities used during each application</th>
<th>Acaricide (ml)</th>
<th>Water (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccinating households</td>
<td></td>
<td>1.1</td>
<td>93</td>
</tr>
<tr>
<td>Non-vaccinating households</td>
<td></td>
<td>1.0</td>
<td>42</td>
</tr>
</tbody>
</table>

The study revealed that non-vaccinating households used higher concentrations of acaricide (1ml of acaricide mixed with 42 litres of water) for tick control than their vaccinating counterparts. A ratio computation revealed that non-vaccinating households...
used a ratio of 1:41,000 (litres of acaricide:water) while vaccinating households used 1:85,000. This concentration was very low for effective tick control compared to the recommended ratio of 1:500 for the Amitraz brands of acaricides.

**Effectiveness of acaricides**

An assessment of the effectiveness of spraying at household level was conducted based on tick clearance within 72 hours of acaricide application. Despite use of low concentrations, 46% of the households perceived the acaricides as highly effective, while 48% and 6% perceived it as moderately effective and not effective.

**Cost of tick control**

The cost incurred during each tick control activity was computed from the cost of acaricide and labour used as shown in Table 4.

### Table 4: Acaricide use

<table>
<thead>
<tr>
<th>Aspect in acaricide application</th>
<th>Mean quantities used during acaricide application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Units</strong></td>
</tr>
<tr>
<td></td>
<td><strong>n</strong></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>1 Amount of acaricide (ml) purchased each time</td>
<td>ml</td>
</tr>
<tr>
<td>2 Total cost of acaricide purchased</td>
<td>Kshs.</td>
</tr>
<tr>
<td>3 No. of times the acaricide is used</td>
<td>No.</td>
</tr>
<tr>
<td>4 Amount of water used in mixing the acaricide</td>
<td>Litres</td>
</tr>
<tr>
<td>5 No. of animals sprayed using the acaricide mixture</td>
<td>Numbers</td>
</tr>
<tr>
<td>6 Time used in acaricide preparation and application</td>
<td>Minutes</td>
</tr>
</tbody>
</table>

The mean amount of acaricide purchased each time was 205ml by vaccinating households at a mean cost of Kshs. 426.80. The acaricide purchased was used 3 times with its application carried out on a mean of 10 cows. Thus, the cost of acaricide used on one cow each time was estimated to be Kshs. 14.20 for vaccinating households and Kshs. 15.00 for non-vaccinating households.

The mean time used in acaricide preparation and application was 53 and 52 minutes for vaccinating and non-vaccinating households respectively. The mean daily wage rate in the study area was Kshs. 160.00 for labour provided for 6 hours, thus the mean cost of labour incurred during each acaricide application was estimated to be Kshs. 23.60 and Kshs. 23.10 for vaccinating and non-vaccinating households respectively.

Thus, the mean cost of spraying one cow was Kshs. 37.80 and Kshs. 38.10 per cow by vaccinating and non-vaccinating households respectively.
**Conclusion and Recommendation**

This study reveals that majority of the sampled households sprayed cattle with acaricides to control tick infestation while others dipped their cattle. The study further revealed that most households applied tick control measures weekly while carried out tick control activities once in a fortnight for households that had vaccinated cattle against ECF and those that had not.

An analysis of acaricide concentration revealed that sampled households used low concentrations of acaricide with households that had not vaccinated against ECF using a ratio of 1:41,000 (litres of acaricide:water) while vaccinating households used 1:85,000. This concentration was significantly low for effective tick control compared to the recommended ratio of 1:500 for the Amitraz brands of acaricides and is also likely to contribute to development of tick resistance to the acaricides. Providing information to farmers on the recommended acaricide concentration ratio would enhance their capacity for effective tick control as well as reduce the selection pressure for tick resistance to acaricides, thus contributing to reduction of tick-borne disease incidences.

**Acknowledgement**

The authors gratefully acknowledge the financial support of the Food and Agricultural Organization (FAO) and Kenya Agricultural and Livestock Research Organization (KALRO) for logistical support.

**References**


Abstract
The arid and semi-arid lands cover approximately 80 per cent of Kenyan land, which has been experiencing water shortages and drought that is becoming worse yearly. Climate change has had adverse effects on both the environment and livelihoods in Masailand. The coping strategies adapted by the community include fodder conservation, upgrading of local cattle for milk and beef production and irrigation to produce crops and horticulture. The diversification of livelihood opportunities can ensure food sufficiency for the pastoralists and also for sale to other regions. The pastoralists could break the vicious cycle of dependence on relief food due drought. With external support from stakeholders such as research, extension, micro finance and NGOs, the Masai will have a diversification of livelihood besides the traditional pastoralism. Our studies show that the Masais are not opposed to socio economic change as perceived by outsiders, they are naturally cautious because living in rangelands means living with uncertainty, where decisions made must be carefully evaluated. The government and stakeholders must identify priority policies and technologies towards development of agro-pastoral sector adaptive to current and future climate change effects.

Keywords: Climate change; livelihood diversification, Southern rangelands;

Introduction
The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2007) indicates that the warming of the climate system is unequivocal and observations shows an increase in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level. Climate change is likely to have major impacts on poor livestock keepers and on the ecosystems goods and services on which they depend, of which 80% of Kenya consists of arid and semi-arid lands. These changes will occur over the same period during which Africa’s population is projected to grow from 0.9 billion people in 2005 to nearly 2 billion by 2050 (UNDP, 2007). The impacts of climate change on the vulnerability livelihoods of resource-poor livestock keepers need to be better understood, so that adaptation to climate variability as well as to the risks associated with longer-term climate change can be determined and appropriate mitigation measures taken (Ongwae, J et al., 2005). Many livestock keepers in Africa are facing a highly volatile situation characterized by rapid changes in climatic conditions. But little is known about how climate interacts with other drivers of change in agricultural systems and broader development trends (Thorntorn et al., 2008). The impacts of climate change on the vulnerability of resource-poor livestock keepers need to be better understood as well as mitigation measures being undertaken by the community. The main objectives was to identify major environmental, socio economic
changes, coping strategies used by pastoralists to become resilient in the wake of climate change in the Southern Masai rangelands for last twenty years.

Materials and Methods

Study site: This study was carried out in the Southern Maasai rangelands of Kenya between November 2010 and June 2014 with the specific objective of assessing socio economic climate change coping strategies in the Southern rangelands of Kenya in Mashuru Sub-Country. Mashuru Sub-County occupies an area of 2192.6 km², comprises two divisions: Kenyawa and Mashuru. The 2009 census had 41,655 persons consisting of 20,974 males and 20,681 females. The Sub-County comprises 8810 households (N=8810) from which a sample size was determined using the formula by Kothari (2008): n = N/ 1+N (e²). Quantitative data were collected through a survey of 380 households randomly selected from ten locations in the district (Kothari, 2008). Qualitative data was gathered through workshops, focus group discussions and interviews with community leaders, stakeholders’ workshops organized to discuss over changes in their livelihood, social status, and land tenure and climate change over last 20 years.

Data analysis

Data coding, entry and cleaning was done using Statistical Package for Social Sciences (SPSS) software. Descriptive statistics which included frequencies and cross-tabulations were generated and used to characterize pastoralists’ socioeconomic, cultural changes, and climate change coping strategies.

Results

The socio network, mutual support and resource sharing are embedded in the Maasai social cultural values. In the Sub-County both pastoral (communal grazing) and agro pastoral (sedentary) systems are practiced. During rainy season, animals graze on the plains, dry period move to the hills, or other Counties in search of forage and water, protected areas with grasslands. Main livestock species kept are cattle, goats, and sheep, chicken. The mean annual rainfall received in the pastoral community for the last 10 years as shown in the line graph (1) below.

Line graph 1: Mean annual rainfall over ten year period in Mashuru Sub County, Kajiado County
Rainfall < 750 mm /year, irregular Dec-April, July-Oct dry season and temperatures:  
27°C -35°C. Rainfall has been reducing tremendously while the temperature has been on the increase for last ten years.

**Effects of rainfall reduction on the economic activities**

Recurrent droughts reduced the livestock species as shown in table (1). Dry River for sand harvesting, human and wildlife conflict over water in Ilkelunyeti location, new invasive species of weeds which are not edible by any livestock species: *Parthenium hysterophora* and *Camiphora africanus*. :-(Osilalei in the local dialect) inhibiting growth of pasture by hardening of soil.

**Table 1: Livestock population trends for last five years**

<table>
<thead>
<tr>
<th>Livestock species</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>667,000</td>
<td>422,000</td>
<td>350,000</td>
<td>302,000</td>
<td>95,534</td>
</tr>
<tr>
<td>Goats</td>
<td>741,000</td>
<td>630,000</td>
<td>495,000</td>
<td>445,000</td>
<td>27,000</td>
</tr>
</tbody>
</table>

Livestock population trend 2005-2009: *Source: Survey data*

Animal health and human health is directly and indirectly tied to climate change issues. According to recent research findings, it’s evident that ecosystem, animal health and economic impacts are tied to climate change (Slenning, 2010; McIntyre *et al.*, 2010; Gale *et al.*, 2009). As ecosystems are altered due to climate change effects, the relationship to those systems is changed.

**Table 2: Economic costs of livestock death due to drought in 2008/09 (Modal prices)**

<table>
<thead>
<tr>
<th>Livestock species</th>
<th>No. per household</th>
<th>Balance after loss</th>
<th>Deaths</th>
<th>Average cost kes</th>
<th>Total cost Kes (death loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>40</td>
<td>8</td>
<td>32</td>
<td>8000*</td>
<td>256,000</td>
</tr>
<tr>
<td>Goats</td>
<td>50</td>
<td>12</td>
<td>38</td>
<td>3000*</td>
<td>114,000</td>
</tr>
<tr>
<td>Sheep</td>
<td>50</td>
<td>8</td>
<td>42</td>
<td>3000*</td>
<td>126000</td>
</tr>
<tr>
<td>Total loss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>496,000</td>
</tr>
</tbody>
</table>

No. of households in Mashuru = 8810
Average loss per household Kes = 496,000
Total loss in the Mashuru Kes = 4,369,760,000
Climate change coping strategy

Table 3: Climate change coping strategy most used in declining order

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversification of livestock species</td>
<td>90</td>
<td>24</td>
</tr>
<tr>
<td>Migration/Movement</td>
<td>70</td>
<td>18</td>
</tr>
<tr>
<td>Diversification of income</td>
<td>62</td>
<td>16</td>
</tr>
<tr>
<td>Horticulture production</td>
<td>52</td>
<td>14</td>
</tr>
<tr>
<td>Fodder cultivation</td>
<td>52</td>
<td>10</td>
</tr>
<tr>
<td>Water pans</td>
<td>38</td>
<td>8</td>
</tr>
<tr>
<td>Taking children to school</td>
<td>30</td>
<td>6</td>
</tr>
<tr>
<td>Permanent houses</td>
<td>21</td>
<td>4</td>
</tr>
</tbody>
</table>

N=380 100%

**Diversification of livestock species:** There are various categories of livestock breeds kept in Mashuru Sub-County for income, milk and meat. The sahiwal is dominant and is preferred due to its dual purpose traits of milk and beef production, fast growth and adaptability to the dry climatic conditions. Dairy production using exotic breeds has started picking up in some homesteads and institutions such as boarding schools, churches, women groups where you find Friesian, Aryshire, Jersey and their Zebu crosses. The number of small ruminants (shoats) such being preferred due to their browsing nature in such for forage.

**Migration/movement:** Masais’ have resorted to de-stocking in case of drought in order to reduce to a manageable number. Pastoralists traditionally relied on herd mobility to cope with drought, migrate in such for pasture as far Mombasa, Nairobi. And Kenya Agricultural Livestock Research Organizations’ land at Kiboko Station, wildlife conservation areas such as the Amboseli National Park, Chyulu National Park and Nairobi National Park.

**Diversification of income:** Many pastoralists have been forced to abandon livestock to pursue sedentary lifestyles in urban centres for business occupation. Sand harvesting, charcoal burning, and investment in properties and buildings commercial houses, youth migration to towns in such for employment. Making handicraft products (belts, knives, clubs. Shoes) souvenirs selling locals and tourists. Community land ownership is coming to an end to individual land to encourage individual responsibility or private property care.

**Horticulture production:** Horticulture production: Some pastoralists have embraced cultivation of sorghum, tomatoes, bananas intercropped with beans, onions and water melons using irrigation for those living near Nuruturesh water pipeline and for the rich get water from bore hole drilled at home for creation of employment, food security and selling supplies to Nairobi, Machakos and Mombasa market in the absence traditional livestock economy due climate change.

**Fodder cultivation:** The pastoralists have embraced the cultivation of improved forages (Napier and hay) done women group. They purchasing forage from outside for dairy
cows, use during scarce/dry seasons. However, use of improved forages and skills in fodder conservation are still limited. There is therefore need for capacity building.

**Water pans:** Establishment of private water pans (silanga) for harvesting water, drilling communal boreholes for irrigation, domestic and livestock.

**Taking children to school:** Acquiring education and training is important to enable find employment in other sectors of the economy so it taken as a long-term investment.

**Permanent houses:** Permanent houses now a common feature in Masai land due unpredictable climatic condition both dry and rain periods.

**Discussion**

The arid and semi-arid lands cover approximately 80 per cent of Kenyan land, which has been experiencing water shortages and drought that is becoming worse yearly.

From our studies, the Maasais are not opposed to socio economic change as perceived by outsiders. They are naturally cautious because living in rangelands means living with uncertainty, where decisions made must be carefully evaluated. Similar observations were made by Cossins (1985) that pastoralists, like any other human group will change from one way or another if they perceive significant economic and social benefits.

The government and stakeholders must identify, prioritize policies, technologies, and to towards development of agriculture sector adaptive to current and future climate change.

**Conclusion**

Climate change has had adverse effects on both the environment and livelihoods in Maasailand. The copping strategies adapted by the community include fodder conservation, upgrading of local cattle for milk and beef production and irrigation to produce horticulture crops.

**Recommendation**

The studies show that, the Maasais are not opposed to socio economic change as perceived by outsiders. They are naturally cautious because living in rangelands means living with uncertainty, where decisions made must be carefully evaluated. With external support from stakeholders such as research, diversification of livelihood besides traditional pastoralism

**Acknowledgement**

The study team would like to thank the following people and organizations whose contribution laid critical cornerstones for this study: Livestock keepers and Chiefs, Livestock production Officers Kajiado, the Management of Isara resource Centre, market councils, NGO: World Vision and NIA. Funding for this study was made possible through KARI-KAPAP project.
Reference


Kajiado County livestock population: Survey data.


The 4th assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2007).

Evaluating climate-change adaptability and cattle-preference of forage plants in Marsabit Central district, Northern Kenya

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Abstract

Cattle production is the most important source of livelihood in Marsabit central district, northern Kenya, and it entirely depends on natural forages. Climate variability negatively impacts on forage dynamics within northern Kenya and this scenario may negatively affects cattle production system. Government and non-governmental organizations are putting effort to promote forage farming and in-situ forage conservation in face of climate change. This study aimed at identifying forage plants that are adaptive to climate change and also preferred by local zebu cattle, hence recommending them for conservation measures. Through participatory transect walk, feeding observations and focused group discussion, the study revealed local forages on mount Marsabit that are adaptive and also preferred by local zebu cattle. These forages include; Tinospora caffra root tuber, Pennisetum Mezianum Lake, Sorghum verticiliflorum steud and Cenchrus ciliaris L.

Introduction

Communities in rangelands of Kenya have shown to be vulnerable to stresses posed by climate change (Opiyo et al., 2014). Climate change and variability has reduced diversity of forage plants in northern Kenya, impacting negatively on cattle production. Important forage species are feared to become extinct in near future if appropriate measures are not taken. This calls for deliberate efforts to conserve endangered forages using in situ method or promoting forage farming.

There are non-governmental organizations and government bodies working on forage value chains in Marsabit County. Knowledge on forage plants can strengthen the on-going forage activities in the county. Feeding observations and use of pastoralist’s knowledge are methods that can be used to identify preferred and adaptive forage species (Kuria et al., 2012). In addition, information on preferred forage and adaptive forage species can guide farmers and development agents in right forage species for farming and in situ conservation (Sanon, H.O. et al 2005).

Materials and methods

The study was conducted in Marsabit central district, northern Kenya. Three locations (Songa, Dirib and Sagante) on mount Marsabit were purposively sampled.
The study employed the following methods;

Focused Group Discussion was used, in which, ten to fifteen knowledgeable pastoralists were identified with the help of local chief in each location of study. The purpose of the discussion was explained to the pastoralists and asked for their consent to participate. Questions on cattle-preferred and adaptive forage plants were presented and the pastoralists discussed and identified the required forage plants.

Furthermore, the pastoralist mothers were requested to collect 20 kg of each preferred and adaptive forages identified using Focused Group discussion. The weight of each collected forage plants were measured and confirmed to be having similar weight. Twenty (20) heads of cattle of similar weight and age were identified. Twenty (20) kg of each forage plants were placed on the ground and cattle were allowed to feed. The amount of forage plants remaining after feeding for 15, 30 and 45 minutes were recorded. The forage intake for each forage type were calculated by subtracting remaining weight from 20kg of forage plants. The highly selected forage was the one with smallest weight remains after livestock feeding. Coefficient of preference (COP) was calculated as the ratio between the intakes of each forage divided by the total intake. Additionally, participatory transect walk with herders was conducted and available forage plants were identified. There were two transects in each location. Each transect was two-km across the grazing unit. Cattle-preferred forages were identified and sampled at interval of 100M along each transect. Plot size of 10m X10 m was used to identify preferred forage trees and shrubs while plot size of 1m X 1m was used to identify cattle-preferred grass/herbaceous forages and also frequency of forage species were recorded.

Results and Discussion

Preferred forages that are adaptive and not adaptive based on pastoralists knowledge

Pastoralists in Marsabit central district identified best forages for their cattle and indicated their adaptive capacity to climate variability

Table 1: Pastoralists preferred forage plants and their adaptive capacity

<table>
<thead>
<tr>
<th>Pastoralists preferred forage plants</th>
<th>Adaptive (+) or NOT adaptive (-) to climate variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borana Local name</td>
<td>Scientific name</td>
</tr>
<tr>
<td>Dilalesa</td>
<td>Bothriochloa insculpta hochst</td>
</tr>
<tr>
<td>Halalo</td>
<td>Chrysopogon Aucheri Boiss</td>
</tr>
<tr>
<td>Ogono</td>
<td>Pennisetum Mezianum lake</td>
</tr>
<tr>
<td>Mela</td>
<td>Sorghum verticiliflorum steud</td>
</tr>
<tr>
<td>Gurbi Olla</td>
<td>Triumfetta Flavescense A. Rich</td>
</tr>
<tr>
<td>Ilmogor</td>
<td>Latipes senegalensis kunth</td>
</tr>
<tr>
<td>Ensille</td>
<td>Tetrapogon bidentatusphilger</td>
</tr>
<tr>
<td>Rupis</td>
<td>Tinospora caffra</td>
</tr>
<tr>
<td>Mattgudesa</td>
<td>Cenchrus ciliaris L.</td>
</tr>
</tbody>
</table>
Feeding observations confirmed cattle-preference for specific forage plants

Different species of forage plants identified by pastoralists as preferred and adaptive were offered to 20 heads of cattle. Each species of forages had similar weight of 20 kg in the beginning. The weight of forage remains were measured after 15 minutes, 30 minutes and 45 minutes for each forage species. The experiment was repeated two times and the result were as follows;

Table 2: Cattle preference for forage plants

<table>
<thead>
<tr>
<th>Types of forage plants</th>
<th>Boran local name</th>
<th>Scientific name</th>
<th>Average forage intake over 45 minutes (g)</th>
<th>Coefficient of preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gurbi Olla</td>
<td>Triumfetta Flavescense A. Rich</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Adha</td>
<td>Aspillia mossambicensis (olio) wild</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Ogono</td>
<td>Pennisetum Mezianum lake</td>
<td>8,000</td>
<td>0.098</td>
<td></td>
</tr>
<tr>
<td>Ilmogor</td>
<td>Latipes senegalensis kunth</td>
<td>9,000</td>
<td>0.110</td>
<td></td>
</tr>
<tr>
<td>Mattgudesa</td>
<td>Cenchrus ciliaris L.</td>
<td>13,000</td>
<td>0.159</td>
<td></td>
</tr>
<tr>
<td>Dilalesa</td>
<td>Bothriochloa insculpta hochst</td>
<td>15,000</td>
<td>0.183</td>
<td></td>
</tr>
<tr>
<td>Halalo</td>
<td>Chrysopogon Aucheri Boiss</td>
<td>17,000</td>
<td>0.207</td>
<td></td>
</tr>
<tr>
<td>Mela</td>
<td>Sorghum verticilliflorum steud</td>
<td>20,000</td>
<td>0.244</td>
<td></td>
</tr>
<tr>
<td>Total forage intake for 20 heads of zebu cattle (g)</td>
<td></td>
<td>82,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Feeding observation confirmed that the highly preferred forage plants are; Sorghum verticilliflorum steud, Chrysopogon Aucheri Boiss, Bothriochloa insculpta hochst and Cenchrus ciliaris L.
Highly preferred forage plants were also found to be scarce in Marsabit central district.

### Table 3: Status of preferred forage plants

<table>
<thead>
<tr>
<th>Forage types</th>
<th>Availability (frequency along the 4KM transect) during wet season</th>
<th>Availability (frequency along the 4KM transect) during dry season</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Borana Local names</strong></td>
<td><strong>Scientific names</strong></td>
<td><strong>A</strong></td>
</tr>
<tr>
<td>Ilmogor</td>
<td><em>Latipes senegalensis kunth</em></td>
<td>VS</td>
</tr>
<tr>
<td>Ogono</td>
<td><em>Pennisetum Mezianum lake</em></td>
<td>A</td>
</tr>
<tr>
<td>Mattgudesa</td>
<td><em>Cenchrus ciliaris L.</em></td>
<td>S</td>
</tr>
<tr>
<td>Dilalesa</td>
<td><em>Bothriochloa insculpta hochst</em></td>
<td>VS</td>
</tr>
<tr>
<td>Halalo</td>
<td><em>Chrysopogon Aucheri Boiss</em></td>
<td>VS</td>
</tr>
<tr>
<td>Mela</td>
<td><em>Sorghum verticiliflorum steud</em></td>
<td>A</td>
</tr>
<tr>
<td>Gurbi Olla</td>
<td><em>Triumfetta Flavescense A. Rich</em></td>
<td>A</td>
</tr>
<tr>
<td>Aspillia</td>
<td><em>Aspillia mossambicensis (olio) wild</em></td>
<td>A</td>
</tr>
<tr>
<td>Rupis</td>
<td><em>Tinospora caffra</em></td>
<td>A</td>
</tr>
</tbody>
</table>

Abundant (A) = > 50 plants, Scarce (S) = 10 – 49 plants, Very scarce/hardly seen (VS) = ≤ 10 plants

Participatory transect walk showed that the highly preferred forage plants like *Chrysopogon Aucheri Boiss* and *Bothriochloa insculpta hochst* are very scarce. These highly preferred forage plants may not be adaptive to climate variability and possibly will become extinct if appropriate conservation measures are not taken.

**Conclusion**

Identifying preferred forage plants using knowledgeable pastoralists in group discussion and confirming the results in feeding observation gives dependable findings. The study revealed that the highly preferred forage plants for cattle are not adaptive to climate variability, hence scarce in Marsabit central district. These forage plants which are preferred, less adaptive and scarce are; *Chrysopogon Aucheri Boiss*, *Bothriochloa insculpta hochst* and *Latipes senegalensis kunth*. The study recommends that the government and non-governmental bodies with activities of forage development should focus on forage plants that are both adaptive and preferred by cattle, and they include; *Cenchrus ciliaris L.*, *Tinospora caffra*, *Sorghum verticiliflorum steud* and *Pennisetum Mezianum lake*. 
References


Sub-theme:
Animal Genetic Resources
Beef cattle industry in Kenya: status and future prospects

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Summary

‘Business as usual’ investments in livestock, although necessary, are unlikely to deliver sustainable solutions that match the systemic changes currently being witnessed in the developing countries. In those countries, there is likely to be a rapid increase in demand for livestock products driven by increasing urbanization and rising incomes. Additionally, impacts of climate change and technological innovations, on low-input livestock production systems, may be substantial. Variations in these drivers will inevitably affect beef production systems in Kenya and beyond. Beef cattle producers in Kenya have steadily accumulated indigenous knowledge that will help them to adapt in the future, but the rapid rates of change witnessed may simply outstrip their capacity. This has injected a new urgency into accelerating the rates of genetic gain in beef breeding programs. This paper highlights the status of beef sector in the country and future prospects for well-planned breeding programs based on sound science.

1. Background information

The beef industry is one of fastest rising economic sub-sectors within the agricultural sector driven by growth of beef exports and the increases in population, urbanization and household income. The beef value chain is significant in that it covers a wide geography including arid and food insecure regions. 363,563 MT of beef was marketed in 2008 with a value of USD 650M. This equated to 2% of Kenya’s GDP in 2008. The growth in beef marketing is estimated at 3% annually and the development of the chain is significantly hampered by factors including: a ban on Kenyan beef products by the EU and neighboring countries, extreme deterioration of marketing infrastructure, drought and monopolistic behavior on the part of buyers taking advantage of pastoralists during drought periods.

The marketing of beef products is a major economic enterprise that engages many businessmen in the country. In Kenya, livestock marketing is largely in the hands of the private sector, with the government only offering regulatory and facilitation services. Among the EAC Partner States, Kenya has taken advantage of the high beef prices on the world market and opened up export markets in the Middle East. In 2011, Kenyan beef processors exported 15,000 tons of beef to Middle East. There is also some insignificant
intra-regional meat trade, with Kenya in the lead position, followed by Uganda and Tanzania.

Development of the beef industry in Kenya has lagged behind other agricultural enterprises due to policies that were unfavorable towards arid and semi-arid lands and the historically poor infrastructure development in the rangelands. The major constraints to the growth of the beef industry are lack of the prerequisite institutional framework, inadequate research based on ecological potential for beef development, endemic and emerging livestock diseases, recurrent droughts especially in ASALs, poor finishing, rampant insecurity especially in the Northern Rangelands, vulnerable traditional pastoral production systems, diminishing animal genetics, poor marketing channels and static prices of beef products among others.

2. Trends in beef production and contemporary production systems

Beef enterprise history in Kenya dates back to the colonial times. Commercial beef ranching has been practiced in Kenya since the 1920’s. Since then, the predominant beef cattle breed has been the Boran which originated from southern Ethiopia (Kimenye, 1983). By the beginning of the 1930’s, crossbreeding regimes had already been established between indigenous breeds and the exotic breeds such as Simmental, Charolais and Hereford. Therefore, the original populations of beef cattle had some exotic blood (Trail et al., 1984; Gregory et al., 1984; Chirchir, 2001). These cattle supplied most of the beef that was previously sold to a central marketing body, the Kenya Meat Commission (KMC), before liberalisation of the beef industry in 1987.

Beef production was initially practiced on large scale ranches of 1000 acres and above as well as by pastoralists in the ASALs. However, the land policy in Kenya that led to the subdivision of land in the late 1960’s contributed to a depression in beef output since a producer requires at least 100 breeding cows in an optimum stocking area of 1000 acres for sustainable production (Berry, 1993; Prettejohn and Retief, 2001). In an attempt to stratify the industry, a development project was put in place in 1968 at the request of the Government of Kenya (GOK) through the Agricultural Development Corporation (ADC) with the main objective of inducing stratification of the beef industry through the development of an economically viable feedlot finishing sector (Squire and Creek, 1973).

In 1973, a beef cattle recording scheme, the Kenya Beef Records (KBR) was established under the management of the Livestock Recording Centre (LRC) to support improvement of beef cattle. A number of large scale ranches, most of which are located in the ASALs, were involved in the scheme whose main objective was to provide management decisions on selection based on the records (Indetie et al., 2001). However, this scheme has not been very successful probably due to constraints related to uncommitted involvement of stakeholders, sub-optimal prevailing policies on livestock development, unclear breeding objectives and structure of the beef industry, diverse management, production and marketing systems for beef and beef cattle (Rege et al., 2001). In addition, there has been attempts to incorporate modern technologies in beef production development. These technologies include embryo transfer, oestrous synchronization, and in vitro fertilization, and are aimed at quick multiplication of genotypes to be availed to farmers.
World demand for beef is increasing more rapidly than supply, this is true of both developed and developing countries. In the coming decade there is every reason to expect an increasing gap between supply and demand for this commodity. Kenya is broadly self-sufficient in most livestock products but is a net importer of red meat. Nomadic pastoralism and agro-pastoralism contributed approximately 56 per cent of the total beef output in Kenya, about 30% contributed by steers and culls from dairy sub-sector. The ranches are estimated to supply 2-4% while the rest is coming from neighboring countries like Ethiopia, Uganda, Tanzania and Sudan. Kenyans consume an average of 15-16 kg of red meat per capita annually (meat and offal from cattle, sheep, goats and camels). Cattle are the most important source of red meat, accounting for 77 percent of Kenya’s ruminant off-take for slaughter (Behnke and Muthami 2011).

<table>
<thead>
<tr>
<th>Production systems</th>
<th>Total livestock head</th>
<th>Meat production (MT)</th>
<th>Offal production</th>
<th>Total contribution to red meat consumption (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenyan Pastoralists</td>
<td>11,915,973</td>
<td>223425</td>
<td>55856</td>
<td>47</td>
</tr>
<tr>
<td>Neighboring pastoralists</td>
<td>-</td>
<td>79081</td>
<td>19770</td>
<td>17</td>
</tr>
<tr>
<td>Dairy producers and other highlands</td>
<td>5,311,800</td>
<td>52454</td>
<td>13114</td>
<td>11</td>
</tr>
<tr>
<td>Commercial ranches</td>
<td>240,000</td>
<td>8670</td>
<td>2160</td>
<td>2</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>17467773</strong></td>
<td><strong>363630</strong></td>
<td><strong>15274</strong></td>
<td><strong>77</strong></td>
</tr>
</tbody>
</table>

**Source:** Behnke and Muthami 2011

The Agricultural Census 2009 data, recorded the cattle herd at approximately 10 million heads of which, an estimated 90% are in the hands of small scale farmers and pastoralists. The beef industry has been ranked as one of Kenya’s fast rising economic sectors through exports to overseas countries and is projected to hit Kshs 70 billion mark in the next five years. Beef production is estimated by Ministry of Livestock Development to have grown from 287,000mt in the year 2001 to about 300,000mt by year 2008. This has been a steady trend to the as reflected in the FAO figures for beef production in Kenya in 2009 and 2010, which were 290,000mt in both years.

**Figure 1:** Beef production (1990 – 2012)

**Source:** FAOSTAT, 2014
Recent marketing studies estimate that total beef consumption in Nairobi and Mombasa is 91,000MT and 15,000MT respectively per annum. This translates to about 850,000 animals per annum. In terms of corned beef, the country is currently relying on imports of the same. The estimated national demand for canned beef in Kenya is 333MT. Each head of a mature bovine produces four cases of corned beef. Thus to meet the national demand for corned beef, you require 10,200 mature bovines per year. The per capita consumption of beef is estimated at 8 kg out of a total red meat consumption of 10.4 kg per year. Total consumption of beef and offals is estimated at 241,481 MT per year. Overall, Kenya has an annual deficit of beef amounting to 40,000 MT. The current deficit is being met by 20% of cattle imported on-hoof from neighbouring countries across porous borders and consumption of white meat.

3. Constraints of beef production in Kenya

Livestock nutrition is one of the most important constraints on increased livestock production, especially during dry season when forage quality and quantity is low. Declining natural pasture is primarily the result of two factors namely increasing population pressure and environmental degradation. Rising human and animal populations are exerting pressure on the fragile rangelands ecosystems leading to degraded pastures. It is also observed that there is systematic disappearance of palatable pasture species. In beef production systems, over-stocking leads to over-grazing and land degradation especially in communal pastures.

Water is crucial to the sustenance of livestock. The key challenge with regard to water is limited availability. People and animals frequently have to travel long distances to access water and drought is frequently the cause of extensive animal losses in ASALs and wastage of productive potential of the people – waste of time looking for water. Better management of existing water sources and more strategic location of watering points in dry season grazing areas is important. Permanent watering points, such as boreholes have had the unintended effect of sedentarising pastoralists leading to extensive degradation of rangelands around them.

Diseases and pests continue to be a challenge in rangelands where beef rearing is practiced. The vastness of the ASALs combined with the poor physical infrastructure have worked together to render the provision of animal health services in the ASALs especially difficult. The porous international borders in the ASALs make disease surveillance and control difficult. Diseases and pests ultimately constrain the productivity of this resource and the ability of the people to build a sustainable livelihood around it.

As with other natural resources, the poor state of physical infrastructure is a major constraint to the development of the livestock production system. Roads and telecommunications are poor in all ASAL areas making access to and information about vital markets in both ASAL and non-ASAL areas difficult and expensive.

In many livestock systems, poor breeding results from inadequate artificial insemination (A.I.) and lack of improved breeding bulls. This is worsened by high calf mortality, long calving intervals and mastitis as a result of poor livestock management. Through research, the Government has developed various technologies and has intensified its
extension services on veterinary and animal production. Technologies on disease control include vector chemical control, chemoprophylaxis and immunization. Technologies on proper livestock management and livestock nutrition have been developed and are being extended to farmers by extension officers, in order to improve farmers’ awareness and management skills. However extension services in rangelands are weak.

4. Possible modifiers of future beef production and consumption trends

4.1. Per capita income and urbanization

Urbanization will offer opportunities to business in Kenya and will require the development of innovative products to meet the specific needs of the urban poor and wants of an emerging consumer class. The demand for livestock and their products is on the increase, largely due to the increasing human population, urbanization, and improvements in income levels and changes in dietary preferences (Delgado 2005). The trends in demand will be for both increased quantity, especially as incomes rise, and for increasing quality, particularly among urban consumers who purchase livestock products from supermarkets. Such factors have enormous consequences for both the volume of global food demand and its composition: these increases in cereals and meat will need to be produced from the same land and water resources as currently exist. While the increased demand will probably be met mostly by increases in chicken and pig production, ruminant populations are also likely to increase substantially.

4.2. Science and technology

New and improved technology has been a key driver of agricultural productivity growth (Hazell and Wood 2008). Many publicly funded international and national agricultural research organizations have taken important steps in recent years to better address issues of sustainability related to technology design and development. There have been also considerable developments in the field of natural resource management in recent years. The trend is, however, for the continuing globalization and privatization of agricultural science; the private sector has much less incentive to undertake this kind of ‘public goods’ research.

Much evidence points to a serious disconnect between science and public perceptions. Marked distrust of science is a recurring theme in polls of public perceptions of nuclear energy, genetic modification and, spectacularly, anthropogenic global warming. One of several key reasons for this distrust is a lack of credible, transparent and well-communicated risk analyses associated with many of the highly technological issues of the day. Social concerns could jeopardize even the judicious application of new science and technology in providing enormous economic, environmental and social benefits. If this is to be avoided, technology innovation has to take fully into account the health and environmental risks to which new technology may give rise. Serious and rapid attention needs to be given to risk analysis and communications policy.

Ethical concerns may play an increasing role in affecting the production and consumption of livestock products. Recent high-profile calls to flock to the banner of global vegetarianism, backed by exaggerated claims of livestock’s role in anthropogenic global
greenhouse gas emissions, serve mostly to highlight the need for rigorous analysis and credible numbers that can help inform public debate about these issues.

4.3. Changes in socio-cultural conditions

The impacts of changes in socio-cultural conditions may be profound, but such changes are almost impossible to predict, and their implications may be so far-reaching. These changes can occur at various levels. For example, recent changes in life-style expectations are inducing the Maasai pastoralists in Kenya and Tanzania to become croppers and businessmen, in order to be much better linked to the market economy and the possibility of generating cash for themselves (BurnSilver, 2007). Livestock contribute substantially and directly to food security and to human health. For poor and under-nourished people, particularly children, the addition of modest amounts of livestock products to their diets can have substantial benefits for physical and mental health (Neumann et al., 2003). Livestock also serve as financial instruments, by providing households with an alternative for storing savings or accumulated capital, and they can be sold and transformed into cash as needed.

In Kenya, social relationships are partly defined in relation to livestock, and the size of a household’s livestock holding may confer considerable social importance on it. The sharing of livestock with others is often a means to create or strengthen social relationships, through their use as dowry or bride price, allocations to other family members and loans (Kitalyi et al., 2005). Social status in livestock-based communities is often associated with leadership and access to (and authority over) natural, physical and financial resources.

There are thus considerable pressures pastoralists communities in the ASALs, as many households become more connected to the cash economy, access to key grazing resources becomes increasingly problematic, and cultural and kinship networks that have supported them in the past increasingly feel the strain. Inevitably, the cultural and social roles of livestock will continue to change, and many of the resultant impacts on livelihoods and food security may not be positive.

4.4. Climate change

For the SSA, overall increases in mean temperatures and decreases in mean rainfall are expected. These scenarios are undeniably clear, with impacts already affecting ecosystem functions and processes, biodiversity and human population (Cooper et al., 2008). Increasing climate variability will undoubtedly increase livestock production risks as well as reduce the ability of livestock keepers to manage these risks. The challenges to the pastoral production systems are many, and worldwide, adaptation strategies campaigns have taken a centre stage.

In Kenya, there are attempts for use of weather information to assist pastoralists in managing the risks associated with rainfall variability and, the design and piloting of livestock insurance schemes that are weather-indexed (Mude, 2009). Many factors determine whether specific adaptation options are viable in particular locations. More extensive adaptation than is currently occurring is needed to reduce vulnerability to future climate change, and adaptation has barriers, limits and costs (IPCC, 2007).
4.5. Competition for resources

Livestock are an important agent for the management of risk in the ASALs. The absolute livestock numbers are on the increase and already threatening the health of habitats in the ASALs, making it increasingly difficult for pastoralists to gain access to the feed and water resources. In the future, grazing systems will increasingly provide ecosystem goods and services that are traded (Thornton, 2010), but how future beef production from these systems may be affected is not clear. The pastoral production system will continue to be critical to future food security, as over two-thirds of the Kenyan population live in these systems. Some of the higher potential mixed systems are already facing resource pressures, but there are various responses possible, including efficiency gains and intensification options (Herrero et al. 2010). Increasing competition for land in the future will also come from biofuels, driven by continued concerns about climate change, energy security and alternative income sources for agricultural households.

Worldwide, freshwater resources are relatively scarce. Increasing livestock numbers in the future will clearly add to the demand for water, particularly in the production of livestock feed. More research is needed related to livestock water interactions and integrated site-specific interventions, to ensure that livestock production in the future contributes to sustainable and productive use of water resources (Peden et al. 2007).

5. Infrastructural development in supporting beef systems

In 1996, the government implemented economic and structural reforms in the agricultural sector, which led to changes in policy framework aimed at accelerating agricultural growth, increasing productivity and expanding rural employment (Government of Kenya, 1996). This was to be achieved through deregulation of domestic markets for all agricultural commodities to facilitate private sector participation in agricultural production, processing and marketing in the liberalized market system (Government of Kenya, 1996). During this period, there was a restructuring of the Ministry of Agriculture, Livestock Marketing and development to reorient its role and its strategic functions to facilitate private sector initiatives with an emphasis on providing improved research, extension and other services to farmers. At the same time, there was privatization of veterinary services and farm produce marketing. The aim of these measures was to increase the efficiency of production and facilitate market competition.

It was during this period that policies governing land use in the rangelands and agricultural research were revised, leading to an increase in ranching activities and research to improve beef production in the rangelands. The Kenya Agricultural Research Institute (KARI) was charged with the generation and dissemination of knowledge and technology to enhance livestock productivity through joint donor-financed research projects. Restructuring included streamlining user charges to reflect acceptable cost sharing and cost recovery for the financing of research and to emphasize the application of science and technology to agricultural development. Rangeland research was to be aimed at increasing productivity, favouring beef production, which was also reflected in the revision of the Science and Technology Act. This led to improvements in beef output both by ranchers and pastoralists who sourced their replacement stock from the improved stock of the ranchers, thus enabling the exchange of genetic material.
The beef industry development programme proposed in 1968 that led to the establishment of the National Beef Research Centre (NBRC) was a primary step towards a well-organized beef production improvement programme. In this initiative, the Boran breed was identified as the most productive beef breed for the harsh arid and semiarid environments of Kenya. However, the programme was not fully implemented due to over-reliance on donor funding, and the breeding, production and marketing systems remained diverse and decentralized. Private large scale ranches and group ranches and pastoralists are main supplies of beef in the country. Nationally Kenya Animal Genetic Resource Center preserve semen for Boran and other exotic breeds. There are breeder groups like Boran and Sahiwal cattle breeders association to maintain the breeds’ standards. There is a need for development of recording system for breed evaluation and selection purposes. Establishment of animal genetic resources (AGRS) for conservation of breeds. In addition, development of institutional framework to inform animal breeding in the country as support to this proposal there is need to establish animal genetic resource board as regulatory authority.

6. Policy review and advocacy to enhance beef production

According to the POLICY Project (1999), Advocacy is a set of targeted actions in support of a specific cause and involves a process of raising voices in an effective manner so as to influence public opinion. The activities around Advocacy are geared towards, educating, creating and/or increasing awareness among the general public, the government and the private sector. The major aim of advocacy is to highlight issues confronting communities and the need to align policies, laws, research and development towards addressing the issues at hand. Advocacy therefore provides an opportunity for the voiceless to be heard and their interests to be entrenched in the laws of the land. Lobbying, as an integral part of Advocacy, is the active persuasion of government and policy makers as well as the private sector, to enact or modify legislation, policies or programs for the benefit of interest groups or for public good. As for the Beef industry, the Kenya Livestock Producers Association (KLPA) the Kenya Livestock and Marketing Council (KLMC) and the Livestock Traders Society of Kenya (LTMS-K) are traditionally predisposed to spearheaded most of the Advocacy activities. Considering that the benefits from the Livestock subsector spreads well beyond these organizations, it would be prudent for other institutions to offer active Advocacy support towards the revitalization of the Beef sector.

To underscore the need for advocacy in revamping the Beef industry in Kenya, it is important to highlight some numbers that magnify how much we loose by inaction. In 1975, The Lomé Convention opened a big door for the Beef industry in Kenya, by establishing a quota-guaranteed access to the European market under the Beef/Veal Protocol (Laaksonen et al., 2015). The Protocol opened the EU market for a massive 400,000 Metric tonnes of Beef and Veal quota for Kenya. The failure to establish clear-cut disease free zones resulted in the quota being awarded to Botswana (Otini, 2012). There has been a strategic shift to sub-Saharan and Middle Eastern markets with a much lower export penetration in European Union mainly restricted to ham and sausages (IGAD, 2013). The total value of domestic off take is estimated at a staggering figure of approximately KSh 54 Billion with a cattle population rising to over 17 million heads.
A report from USAID (2012) on end market analysis reveals a vibrant domestic market that still forms a profitable sink for meat in Kenya. A major highlight of this report is the complex meat supply chain that could form the basis for Advocacy activities.

Policy Quote (i)

“An outdated and fragmented legal and regulatory framework still remains a challenge to the development of the agricultural sector yet, because this is the foundation of the economy, it is indispensable to the attainment of the objectives of Vision 2030’s economic pillar. In particular, the existing regulatory framework—of which the antiquated Agriculture Act (Cap. 318) is an integral part— is not fully supportive of private sector-led agricultural development in the liberalized economic environment.”

Gachimbi et al., 2011, Kenya, State of the Environment and Outlook 2010
Supporting the delivery of Vision 2030

In this brief, a deliberate attempt is made to focus on the breaks-in-the-chain as well as the bottlenecks that require policy change. The Livestock Policy Initiative (LPI) by IGAD (Behnke and Muthami, 2011) that combines regional country efforts in enhancing the contribution of the livestock sub-sector to food security and poverty reduction forms a valid platform to pursue policy change in the Beef industry. For the Kenyan case, finding the breaks-in-the-chain and the bottlenecks to be targeted for intervention requires appreciation of the complex meat supply chain affecting both the domestic and export markets (Fig xxx).

Fig. 2. A detailed Kenya Livestock Value Chain Map (Source: ISAID, 2012).
**Breaks-in-the-chain:** From production to marketing, the major areas of concern include, breeds and breeding, feeds and feeding, transport and communication, prices and value addition. In addition to these, supporting services such as financing and formation of collective bargaining groups are key to the success of the Beef industry.

- **Breeding Policy:** Management of breeding has been attempted with varying levels of success, covered mainly by the National Livestock Policy and recommendations within the proposed Animal Breeding Policy and Animal Breeding Bill (Kosgey *et al.*, 2011). There is still no active breeding policy in Kenya.

- **Grazing and Pasturelands:** Beef cattle production systems in Kenya are predominantly pasture based (Kahi *et al.*, 2006). High livestock population in the fragile Arid and Semi Arid Lands is considered one of the major courses of increased land degradation. Since the Swynnerton Plan of 1954-1959, a land use policy aimed at developing grazing schemes (Ng’ethe, 1992), there seems to be no major efforts currently aimed at managing land use for Pasture based beef production. An improved version of this grazing system is the concept of group ranching.

- **Trekking routes and costs:** The physical amenities and surcharges involved in crossing through counties and municipalities.

- **Animal Health:** A typical flow for any meat supply chain would include disease control as an integral part of the meat supply chain within the objective of quality control. In the Kenyan case, this break in the chain can generally be termed as the lack of an organised framework for Quality Assurance. It has resulted in the loss of a big Export Market.

- **Security:** Cattle rustling and theft of stock are major concerns in the Meat business

- **Slaughter infrastructure:** Regional access to reliable slaughter houses for maintenance of live weight and carcass quality.

- **Pricing and Branding:** CTA (2013) highlights that Pricing issues seem to be in favour of other competitors in the Global market, with importers in targeted markets claiming that Kenyan meat prices are higher the stiff competition faced on regional and Middle Eastern markets from suppliers in Ethiopia, Sudan and Djibouti notwithstanding.

**Bottlenecks:** The bottlenecks that hinder the success in implementation of solutions to the above breaks-in-the-chain have to do mainly with Political will. The main Bottleneck being implementation of recommendations as well as the legal requirements resulting from Policy briefs. Specifically, to the above breaks in the chain, the systematic bottlenecks that need Advocacy action are hereby outlined;

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Policy Quote (ii)

“Efforts to develop Kenya’s meat exports are complicated by the informal cross-border trade with Ethiopia, Tanzania and Somalia”

Unblocking the bottlenecks

**Breeding Policy:** Major advances have been done here. The Kenya Institute for Public Policy Research and Analysis has already published a final draft of the National Animal Breeding Policy. To implement any Policy, enabling laws need to be enacted accordingly. In the case of Animal Breeding, Kenya has moved further to develop a bill towards achieving the Broad policy goals, namely, the Draft Animal Breeding And Improvement Bill 2010 (GOK, 2010). It is unclear whether this bill has been tabled in parliament for discussion, or whether a law has been enacted in that respect. Action is needed to speed up the processing of this important bill that will enhance the participation of Beef Cattle Breed Societies like the Boran cattle Breeders Society and others to participate fully in the business of Meat and Cattle garmplasm.

**Grazing:** Beef cattle production is bound to be affected by the National Land Policy, as it is predominantly pasture based. Rangelands are increasingly being degraded and vast landmasses are now privatized. Privatisation has contributed to conservation of Pastures due to controlled grazing, however, a majority of Pastoralists are negatively affected by the shrinking access to pasture lands. There is a law in Kenya overseeing the use of land (The Land Act 2012), however, Nyariki *et al.* (2009) observed that Pastoralists seem to be at a crossroads due to the on-going privatization of customary owned land with common pool resources. The sub-division into individual holdings and subsequent provision of title deeds has opened up large tracts of land - formerly grazing lands - to speculators and cultivators. Pastoralists supply almost 60% of the beef consumed in Kenya, their voice needs to be heard.

**Trekking routes and surcharges:** There are taxes and fees that include local taxes imposed by municipalities along the various stock routes, namely; movement permits, veterinary and health inspection fees and other marketing fees. Unfortunately, sometimes traders are forced to pay illegal taxes and bribes that unnecessarily increase costs, resulting in value chain inefficiencies that hinder livestock trade (Muthee, 2006). A radical departure from trekking-based livestock trading system must now emerge. USAID (2012) recommends positioning of carefully sited water points, with feed provisions along the routes, and possibly the construction of holding grounds along trekking routes and at market sites. Similarly, Animal ferrying trucks need to be redesigned to allow for the safe movement of livestock while still enabling loading of consumer goods.

**Animal Health:** The recommendations for veterinary intervention are well known. Disease control is well developed in Kenya. However, implementation of the quarantine policy and disease free zone strategy has been weak. Probably due to security concerns in the livestock trading zones as well as priority settings in the new County government systems. Another reason could be that the vibrant domestic market may be negatively affecting this objective. Seemingly, the absence of the export market has not hampered successful beef production. Looking ahead, the extra earnings from the export market will lead to economic progress and thus, should be approached as a national economic agenda. That would mean looking again into the Animal Diseases Act.
Security: Security of livestock in the beef industry must be approached from both human and wildlife attacks are indeed legal issues. Notably, the observations of Greiner (2013) show that there is a disguised relationship between politics and cattle raids. The issue of security is everyone’s problem, and affects by extension the beef industry. The findings of Kaimba et al. (2011) indicate that policies pursued by successive governments to curb livestock insecurity have failed to work. The study suggests a possible reason for this unexpected outcome as being the fact that the traditional conflict solving institutions are being undermined by newly created administrative structures that are by law not subject to the traditional institutions. Do we need to review The Stock and Produce Theft Act?

Slaughter infrastructure: The concentration of the terminal beef markets in major urban centers, means slaughterhouses tend to also be located in urban towns (Aklilu et al, 2002). Obviously, the traders avoid meat losses due to rotting in the absence of refrigerated transport options. Decentralising slaughterhouses means establishing a well organised refrigerated transport system. The other option is to decentralise the Kenya Meat Commission (KMC). Satellite processing plants within Livestock hotspots could improve offtake and prices for farmers.

Pricing and Branding: Does the Kenyan made Beef have a brand name? is the price competitive? Key factors that precede answers to these questions relate to identification and traceability. Matete et al. (2010) investigated strengths and weaknesses of a Livestock Identification and Traceability Systems (LITS). One important observation of this study was that the LITS needs to be a public sector driven mandatory system with a high degree of private sector participation because of budgetary support, human resource availability and a more significant level of credibility. Branding has the advantage of pricing, however, export market is competitive with respect to price. Efficiency right from production to marketing is key for the success of this objective. Laws are needed to spearhead a revolution in this aspect and support the Branding of Stock Act.

General outlook on Policy and Advocacy

The Cabinet Secretary in charge of Agriculture, Livestock and Fisheries is by extension the chief Advocate of the Beef Industry agenda and revitalization. Through the State Department of Livestock, the non-profit Producers’ and Traders’ organizations that promote organized production and marketing of livestock have to reinvent their mandates having earlier been created mainly to fill the gap left by the collapse of the Kenya Meat Commission (KMC) and the Livestock Marketing Department (LMD). The reestablishment of the KMC has been less than perfect. The lucrative Export market is still elusive as concerted efforts towards quality assurance especially towards disease control are still lacking. Kenya has enacted progressive laws for livestock management (Text Box 1). The enactment of the Animal Breeding and Improvement laws will play a major role in contributing to improving productivity of the beef industry in concert with the supporting acts of the laws of Kenya.
The Beef industry will need the active deployment of expertise by the Academia working in collaboration with Livestock producers and traders for solutions to seal up the breaks-in-the-chain by designing mechanisms to circumvent the current bottlenecks that have perpetually crippled the implementation of workable solutions.

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Preliminary selection results for body weight in indigenous chicken in Kenya


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Abstract

Body weight at 12 weeks of age records of 443 indigenous chicken, progeny of 44 sires were used to estimate preliminary results of selection for growth in indigenous chicken in Kenya after two generations of selection. Estimated breeding values were estimated using a sire model. Mean body weight at 12 weeks (BW12) among males and females was 666.7 and 550.1 g in generation 0, respectively. For generation 1, the respective body weight were 743.7 and 574.3 g. Mean estimated breeding values for both males and females for generation 1 were 177.9 and 17.4 g and were higher than those for generation 0, which were estimated at -1.1 and 1.6 g, respectively. The preliminary results of this study indicate a favourable change in BW12. Further analyses will quantify correlated response in subsequent body weights and egg production to inform the direction of the indigenous chicken genetic improvement programme.

Introduction

The low genetic potential of indigenous chicken (IC) for egg and meat production (Safalao, 2001) limit their potential to improve rural livelihoods through improved nutrition, income generation and employment creation, their low productivity limits the exploitation of this potential. This renders them less competitive compared to exotic and industrial poultry breeds. Egg production of IC is estimated to be 40 to 100 eggs in 3 to 4 clutches per year with an average egg weight of 35-45 g (Ajayi, 2010; Kingori et al., 2010). On the other hand, mature live weights of IC of 0.7 to 2.1 kg for females and 1.2 to 3.2 for males have been reported (Lwelamira and Kifaro, 2010; Ngeno, 2011). There is enormous between and within ecotype variation which can be utilised to improve egg production and growth performance of IC (Bett et al., 2012).

Nevertheless, there is substantial genetic diversity among IC genetic resources in Kenya (Ngeno, 2011; Magothe, 2013) which can be exploited through selection to improve traits of economic importance. However, there has been an effort to improve the performance of IC through selection. Previous genetic improvement efforts have mainly been through crossbreeding, which apart from resulting in limited improvements, has also been accompanied by new challenges in relation to high cost of production inputs,
availability of breeding stock and unavailability of inputs (Bett et al., 2011). In a previous study on IC in Kenya, Magothe et al. (2010) found that body weight at 12 weeks was highly heritable and favourably and highly correlated with subsequent and preceding body weights. This study then recommended use of BW12 to improve growth in IC in Kenya. The objective of this study was therefore to estimate preliminary genetic trend of BW12 for IC in Kenya.

Materials and Methods

Growth data were collected from 436 12-week old indigenous chicken birds from the Indigenous Chicken Improvement Project, Egerton University. The records were made between 2012 and 2014. Each bird was individually tagged to facilitate pedigree recording and measurement of individual weights. The feeding and routine management of the birds are described elsewhere (Miyumo et al. 2015)

Additional information included sex, ecotype, cluster and genotype of bird. Pedigree information of each bird was also recorded on the sire line only. The data is summarised in Table 1.

Table 1: Data structure

<table>
<thead>
<tr>
<th>Generation</th>
<th>Number of Sires</th>
<th>Number of progeny</th>
</tr>
</thead>
<tbody>
<tr>
<td>G₀</td>
<td>20</td>
<td>285</td>
</tr>
<tr>
<td>G₁</td>
<td>22</td>
<td>158</td>
</tr>
</tbody>
</table>

Statistical analysis

Significant effects and covariates for subsequent genetic analyses were determined using SAS package (SAS, 2003). Variance-covariance components were estimated and estimated breeding values (EBVs) were calculated using MTDFREML software (Boldman et al., 1993) fitting univariate sire model. BW0 was fitted as a covariate in the analysis of BW12. Other fixed effects included generation, sex of bird and cluster. The model used in matrix notation was as follows:

\[ y = Xb + Zs + e \]

where \( y \) is a vector of observations; \( X \) and \( Z \) are known incidence matrices relating records to fixed and random sire effects, respectively; \( b \) is a vector of fixed effects (generation, sex and cluster and covariates; \( s \) is a vector of random sire effects; while \( e \) is a vector of residuals.

Results and discussion

Body weight at 12 weeks of age (BW12) for males and females are given in Table 2. The results confirm that sexual dimorphism exists for body weight in indigenous chicken. Males were significantly (P<0.05) heavier than females. The BW12 for males is similar in Generation 0 is similar to that reported by Magothe et al. (2012) for the same population.
Table 2: Response to selection for body weight (g) ± standard deviation at 12 weeks in Kenyan indigenous chicken

<table>
<thead>
<tr>
<th>Generation</th>
<th>All</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>G₀</td>
<td>595.1</td>
<td>666.7</td>
<td>550.1</td>
</tr>
<tr>
<td>G₁</td>
<td>662.6</td>
<td>743.7</td>
<td>574.3</td>
</tr>
</tbody>
</table>

G₀=first generation; G₁=second Generation

Response to selection in BW12 in both sexes was positive and was higher in males than in females. This could be attributed to higher selection intensity among males compared to females. Also, most of the females were retained for further evaluation of egg production. Males in G₁ had a mean BW12 that was higher than 668.8 g reported by Magothe et al. (2010) for the same population, indicating that it is possible to improve body weight in indigenous chicken through selection (Magothe et al., 2010).

Mean breeding value and their accuracies are given in Table 3. Mean EBVs for males in G₁ was positive and negative in G₀, further confirming the positive genetic change in BW. On average males in G₁ were 178 g heavier than those in G₀, indicating an upward trend in BW12.

Table 3: Mean estimated breeding values for body weight (g) and mean accuracy for BW12 for Kenyan indigenous chicken

<table>
<thead>
<tr>
<th>Generation</th>
<th>All</th>
<th>Males</th>
<th>Rₜᵣ</th>
<th>Females</th>
<th>Rₜᵣ</th>
</tr>
</thead>
<tbody>
<tr>
<td>G₀</td>
<td>11.7</td>
<td>67.9</td>
<td>-1.1</td>
<td>68.5</td>
<td>1.8</td>
</tr>
<tr>
<td>G₁</td>
<td>36.4</td>
<td>68.5</td>
<td>177.9</td>
<td>67.5</td>
<td>17.4</td>
</tr>
</tbody>
</table>

Rₜᵣ = mean accuracy of estimated breeding value

Females in G₁ were about 16g heavier than those in G₀. The lower genetic change among females can be attributed to the low intensity of selection among females. The accuracies of EBVs were medium and similar for males and females (Table 3). A study by Niknafs et al. (2013) reported a genetic trend of 4.78 for BW12 in Mazandaran native chicken of Northern Iran. Lariviére et al. (2009) reported an increase of BW11 from 924.70 g ±206.84 g to 1443.64 g ±145.79 g in males and from 766.51 g ±176.99 g to 1128.99 g ±106.26 g in females of Ardennaise chicken breed after three selection cycles. Genetic improvement of growth and reproduction traits is accompanied by a concomitant increase in inbreeding (Nicknafs et al., 2013), which has been shown to cause a decline in reproductive performance in chicken (Kamali et al., 2007; Sewalem et al., 1999). Subsequent matings need to consider coancestries among mates to avoid build-up of inbreeding in the population.
Conclusion

Preliminary selection process in indigenous chicken in Kenya yielded a favourable genetic change in BW12, implying that this trait can be improved through selection. However, more reliable results will be required by analysing response to selection after a number of generations have been analysed. The effect of improving body weight on reproductive performance also needs to be quantified.

Acknowledgements

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Consumers’ preference and behaviour towards indigenous chicken meat and eggs

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Abstract

The objective of this study was to determine consumers’ preferences and behaviour with regard to indigenous chicken (IC) meat and eggs. Survey data obtained from consumers from three regions of Kenya was analysed to identify consumers’ preferences towards IC meat and eggs. Analysis was carried out in three stages. The first was crosstab analysis to generate descriptive statistics. Secondly was a principal component analysis technique to extract principal components that explained the maximum variance within the data. Thirdly was to define consumer clusters in accordance with their preferences and behaviour using cluster analysis. Results suggested that sex of the bird, body weight, tenderness, flavour, juiciness, salt content, meat colour, smell, fat and price were the most important sources of variation influencing the preferences and behaviour of IC meat consumers. Based on magnitude and sign, five meat preference clusters were identified; non-specific, fat, weight, sex-tenderness and meat-quality sensitive consumers. For eggs, two clusters were egg size and egg yolk colour sensitive consumers. Through identification of the IC meat and egg preferences, producers and breeders can understand and respond to consumer preferences more efficiently and allow segmentation of market.

Introduction

Indigenous chicken (*Gallus gallus domesticus*) genetic resources are important for food, nutrition, income security, socio-cultural and spiritual purposes among the poor rural households in Africa. They account for 58.3% of the total chicken meat and 46.7% of the total number of eggs produced in Kenya (Ngeno 2011). This proportion will significantly rise due to rapid human population growth resulting in urbanization and decreasing agricultural land area, increasing income, eating habits and lifestyle (Bett, 2012, Ngeno, 2011). Despite the ever-increasing demand for IC products, consumer needs based on IC characteristics and its products (meat and egg) remain unknown. Therefore, the breeders and producers are unaware of the market demands thus hindering exploitation of available market opportunities. This calls for an investigation of consumer attitudes and preferences towards IC meat and eggs. An understanding of the consumers’ preferences and behaviour with regard to IC meat and eggs is a prerequisite to addressing their needs. Additionally, recognition of the needs of their potential consumers enables IC producers
and marketers to focus on those identified characteristics in their final IC products. The objective of this study was to determine consumers’ preferences and behaviour towards IC meat and eggs.

**Methodology**

**Data collection**

The study was carried out in Western (Kakamega and Siaya counties), North Rift Valley (West Pokot and Turkana counties) and South Rift Valley (Bomet and Narok counties) regions of Kenya. Six divisions per county with the highest populations of IC in rural households were selected based on chicken population estimates of MOLD (2010) and Okeno (2012). Data was collected from both rural and urban (all the towns and market centres within the selected divisions) willing households. In overall, 550 respondents were interviewed from the three regions using structured questionnaires. A total of 203 (52 urban and 151 rural dwellers), 168 (46 urban and 122 rural dwellers) and 179 (31 urban and 148 rural dwellers) respondents in Western, North and South Rift Valley regions respectively were interviewed. The main features in the questionnaire were to obtain information on respondent’s consumption preference based on perception of meat quality properties (tenderness, juiciness, fat amount, flavour, salt content, colour and smell), chicken appearance characteristics (body plumage, body weight, general body condition), chicken genotype, age of chicken, type of chicken preferred (cocks, hen, cockerels and pullets), preferences of IC meat parts and price. Information on preferences based on egg attributes (egg size, yolk colour and shell colour) and price data were also collected.

**Statistical analysis**

Analysis was carried out in three stages. The first was crosstab analysis to generate descriptive statistics. Secondly was a principal component analysis (PCA) technique to extract principal components (PC) that explained the maximal variance within the data. Thirdly was to define consumer clusters in accordance with their preferences and behaviour using cluster analysis. Statistical analyses were carried out using SPSS (SPSS, 2011). A non-parametric Kruskal-Wallis test was used to evaluate whether the regions or counties have effects on the consumers’ preferences and behaviour towards IC meat and eggs. A principal component analysis technique was used to extract PCs that explained the maximum variance within the data. The PCs scores with greater or equal to 1.0% eigenvalues were subsequently examined using the cluster analysis to group the consumers. The PC scores in each cluster were statistically analyzed using PROC GLM of SAS (SAS, 2009) to determine whether they were significantly different or not. The model fitted was: $Y_{ijk} = \mu + C_i + PC_i + \epsilon_{ijk}$, where $Y_{ijk}$ is the dependent variables ($i = \text{CL1...CL5 for meat, ECL1 and ECL2 in eggs}$), $\mu$ overall population mean, $C_i$ county effects ($i = \text{Siaya, Kakamega, Bomet, Narok, West Pokot and Turkana}$), $PC_i$ PCs score effects ($i = \text{PC1...PC5}$) and $\epsilon_{ijk}$ random residual effect.
Results

Principal component analysis

Principal component analysis indicated that 19 PCs affect consumers’ meat preferences and their eigenvalues are shown in Table 1. Using the output from iteration, there were seven eigenvalues greater or equal to 1.0% with each accounting for over 5.29% of the total variance. The 7 components solution explained 77.8% of the total variance. From PC8 to PC19, PC had low variance values ranging from 0.00 to 5.06% which were difficult to clearly define their meanings hence neglected. Results for egg indicated two eigenvalues greater than 1.0% (Table 1). The latent root criterion for number of factors to derive for eggs indicated two components to be extracted for the variables. The two components for eggs explain 70.8% of the total variance in the variables.

Table 1: Eigenvalues and variance obtained from principal components (PC)

<table>
<thead>
<tr>
<th>Principal component</th>
<th>Total</th>
<th>% of variance</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5.34</td>
<td>28.1</td>
<td>28.1</td>
</tr>
<tr>
<td>2</td>
<td>2.81</td>
<td>14.8</td>
<td>42.8</td>
</tr>
<tr>
<td>3</td>
<td>1.96</td>
<td>10.33</td>
<td>53.2</td>
</tr>
<tr>
<td>4</td>
<td>1.37</td>
<td>7.21</td>
<td>60.4</td>
</tr>
<tr>
<td>5</td>
<td>1.18</td>
<td>6.22</td>
<td>66.6</td>
</tr>
<tr>
<td>6</td>
<td>1.13</td>
<td>5.96</td>
<td>72.6</td>
</tr>
<tr>
<td>7</td>
<td>1.00</td>
<td>5.29</td>
<td>77.8</td>
</tr>
<tr>
<td>Egg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.13</td>
<td>37.5</td>
<td>37.5</td>
</tr>
<tr>
<td>2</td>
<td>1.00</td>
<td>33.3</td>
<td>70.8</td>
</tr>
<tr>
<td>3</td>
<td>0.88</td>
<td>29.2</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2 shows relative contributions of the eigenvectors for the PCs with eigenvalues greater than or equal to one for each question. For meat, majority of eigenvectors were positive with some few being negative. All egg variables in PC1 were positive (Table 2). Egg size and egg yolk colour preference was positive (0.99) and negative (-0.09) respectively in PC2.
Table 2: Eigenvectors of the principal components (PC) with greater or equal to 1% eigenvalues

<table>
<thead>
<tr>
<th>Preference by consumers</th>
<th>PC1</th>
<th>PC2</th>
<th>PC3</th>
<th>PC4</th>
<th>PC5</th>
<th>PC6</th>
<th>PC7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Preference of cock</td>
<td>0.11</td>
<td>0.82</td>
<td>0.16</td>
<td>0.30</td>
<td>0.29</td>
<td>-0.03</td>
<td>-0.07</td>
</tr>
<tr>
<td>2. Preference of hen</td>
<td>-0.03</td>
<td>0.05</td>
<td>0.83</td>
<td>0.08</td>
<td>-0.28</td>
<td>-0.02</td>
<td>0.18</td>
</tr>
<tr>
<td>3. Preference of pullets</td>
<td>-0.20</td>
<td>-0.95</td>
<td>-0.14</td>
<td>-0.14</td>
<td>0.00</td>
<td>0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>4. Preference of cockerels</td>
<td>0.11</td>
<td>-0.09</td>
<td>-0.85</td>
<td>-0.33</td>
<td>-0.13</td>
<td>0.01</td>
<td>-0.08</td>
</tr>
<tr>
<td>5. Preference of plumage colour</td>
<td>-0.37</td>
<td>-0.27</td>
<td>-0.02</td>
<td>0.08</td>
<td>-0.71</td>
<td>0.00</td>
<td>0.06</td>
</tr>
<tr>
<td>6. Preference genotype</td>
<td>-0.42</td>
<td>-0.12</td>
<td>-0.12</td>
<td>-0.67</td>
<td>-0.03</td>
<td>0.17</td>
<td>0.07</td>
</tr>
<tr>
<td>7. Preference body size</td>
<td>0.21</td>
<td>0.22</td>
<td>0.66</td>
<td>-0.26</td>
<td>0.07</td>
<td>-0.03</td>
<td>-0.29</td>
</tr>
<tr>
<td>8. Preference age</td>
<td>-0.05</td>
<td>0.30</td>
<td>0.03</td>
<td>0.09</td>
<td>0.06</td>
<td>-0.81</td>
<td>-0.05</td>
</tr>
<tr>
<td>9. Preference weight</td>
<td>-0.07</td>
<td>0.05</td>
<td>0.16</td>
<td>0.58</td>
<td>0.67</td>
<td>0.16</td>
<td>-0.17</td>
</tr>
<tr>
<td>10. Preference general body condition</td>
<td>0.53</td>
<td>-0.21</td>
<td>-0.30</td>
<td>0.35</td>
<td>-0.24</td>
<td>0.41</td>
<td>0.30</td>
</tr>
<tr>
<td>Egg</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Preference of egg shell colour</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2. Preference of egg yolk colour</td>
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<td></td>
<td></td>
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<tr>
<td>3. Preference of egg size</td>
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<td>4. Preference of egg yolk size</td>
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<td></td>
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<tr>
<td>5. Preference of egg shell colour</td>
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<tr>
<td>6. Preference of egg yolk colour</td>
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<tr>
<td>7. Preference of egg yolk size</td>
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<tr>
<td>8. Preference of egg shell colour</td>
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<td></td>
</tr>
</tbody>
</table>

PC1 = Principal component 1; PC2 = Principal component 2; PC3 = Principal component 3; PC4 = Principal component 4; PC5 = Principal component 5; PC6 = Principal component 6; PC7 = Principal component 7.
Cluster analysis

Table 3 presents the mean values of PC scores for IC meat, indicating the relative contribution of each question. Respondents were classified into 5 clusters (CL1 to CL5). Results in Cluster 1 (CL1) revealed negatives values except for PC3, PC5, and PC6. Cluster 2 (CL2) had relatively high positive values in PC7. The PCs scores in cluster 3 (CL3) were positive except in PC6. The PC5 in CL3 had relatively high positive value. Cluster 4 (CL4) had strongly negative and positive values in PC3 and PC4 respectively. Cluster 5 (CL5) had positive values in PC1 and PC2, and negative in PC3 to PC7. Egg clusters (ECL1 and ECL2) obtained by the cluster analysis are presented in Table 4. Cluster 1 (ECL1) indicated negative value in PC1 and positive scores in PC2. In Cluster 2 (ECL2), PC1 and PC2 had positive and negative values respectively.
### Table 3: Least square means and standard errors of principal components scores and clusters for meat

<table>
<thead>
<tr>
<th>Cluster</th>
<th>PC1</th>
<th>PC2</th>
<th>PC3</th>
<th>PC4</th>
<th>PC5</th>
<th>PC6</th>
<th>PC7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Cock</td>
<td>Hen</td>
<td>Tenderness</td>
<td>Weight, Meat part</td>
<td>Price</td>
<td>Fat</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Pullet</td>
<td>Cockerel</td>
<td>Plumage colour</td>
<td>Egg shell and yolk colour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CL1: 210 | 0.4±0.08 | 0.6±0.11 | 0.4±0.10 | 0.4±0.08 | 0.3±0.10 | 0.1±0.08 | 0.3±0.10 |

CL2: 97  | 0.01±0.00 | 0.4±0.00 | 0.1±0.00 | 2.1±0.00 | 3.4±0.10 | 0.2±0.00 | 6.3±0.10 |

CL3: 86  | -0.3±0.10 | 0.2±0.00 | 0.1±0.00 | 2.1±0.00 | 3.4±0.10 | 0.2±0.00 | 6.3±0.10 |

CL4: 73  | 0.14±0.09 | -0.45±0.08 | 0.1±0.00 | 2.1±0.00 | 3.4±0.10 | 0.2±0.00 | 6.3±0.10 |

CL5: 84  | 1.3±0.10 | 0.7±0.10 | -0.2±0.10 | -0.4±0.10 | -0.6±0.10 | -0.1±0.00 | 2.1±0.00 |

Means in a row with one or more letters in common are not significantly different (P>0.05). N, number of respondents in each cluster. PC1 to PC7 are PC 1 to 7; CL1 to CL5, cluster 1 to 5.

### Table 4: Least square means and standard errors of PC scores (PC1 and PC2) for egg clusters (ECL1 and ECL2)

<table>
<thead>
<tr>
<th>Cluster</th>
<th>PC1</th>
<th>PC2</th>
<th>ECL1 (P&lt;0.001)</th>
<th>ECL2 (P&lt;0.001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Egg shell and yolk colour</td>
<td>Egg size</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Egg yolk colour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ECL1: 313 | -0.41±0.10 | 1.29±0.11 | 84  | 73  |

ECL2: 237 | 0.14±0.09 | -0.45±0.08 | 84  | 73  |

Means in a row with one or more letters in common are not significantly different (P>0.05). N, number of respondents in each cluster.

Consumers' preference and behaviour towards indigenous chicken meat and eggs.
Discussion

Clustering of consumers based on their preference(s) using principal component analysis: Based on the magnitude and sign of the eigenvectors values for the PCs, the meanings of the PC1 to PC7 could be interpreted as follows; PC1 is an indicator of the requirement for all the IC attributes, PC2 is an indicator of the requirement for cock (positive values) and not pullets (negative values), PC3 is an indicator of hen preference (positive values) and dislike of cockerels (negative values), PC4 is an indicator for the requirement for tenderness (positive values), PC5 is an indicator of the requirement for weight and meat parts (positive values) and are less concern with plumage colours (negative values), PC6 is an indicator of the requirement for price (positive values) with age of birds not a factor (negative values). The PC7 can be used as an indicator of the requirement for fat (positive values).

Clustering of consumers based on their preference(s) using cluster analysis: From the cluster analysis results, CL1 consumers did not demand a lot of IC meat quality attributes, prefer meat from hens and not cocks, not concern with tenderness and fat as indicated by negative value in PC1, PC2, PC3 and PC7 respectively. Respondents in CL1 also showed sensitivity to price, weight and meat parts. Consumers in this CL1 were classified as non-specific consumers. Consumers in CL2 paid attention to the amount of fat in IC meat and can be termed as fat-sensitive consumers. PC scores in CL3 were highly positive for PC5 which indicated their first choice for weight and meat parts. The CL3 respondents can be categorized as weight-sensitive consumers. The CL4 consumers had equal strong negative and positive values in PC3 and PC4 respectively. Based on magnitude and sign of PCs in CL4, CL4 gives priority to sex of the bird (hen) and tenderness, and can be termed as sex-tenderness sensitive consumers. CL5 are concern with meat qualities including juiciness, flavour, salt content, colour and smell. The CL5 consumers can be termed as meat quality-sensitive consumers. Latent root criterion for number of factors indicated that there were 2 components (PC1 and PC2) to be extracted for egg preference variables. Principal component 1 is an indicator of overall egg attributes of egg shell, yolk colour and size. The PC2 is an indicator of preference for egg size (positive values) or egg shell and yolk colour (negative values). ECL1 respondents do not consider the egg shell and yolk colour instead they are concern with egg size as shown by strong positive PC2 values. Therefore, ECL1 consumers can be clustered as egg size-sensitive consumers. Cluster 2 consumers were not concern with egg size instead they are concern with egg yolk color and can be termed as yolk color-sensitive consumers. The results of egg yolk sensitivity indicated that yolk colour and their variability is consumer’s parameter for evaluating egg quality. Therefore, producers in the studied regions can adjust the feed ingredients to produce eggs with yellow yolk that match consumer preferences.

Conclusion

Meat consumers can be grouped into 5 clusters; non-specific, fat, weight, sex-tenderness and meat-quality sensitive consumers. Two clusters of eggs consumers were egg size and egg yolk colour sensitive. Through identification of the IC meat and egg preferences,
Marketers, producers and breeders can understand, and respond to consumer preferences more efficiently and allow segmentation of market.

**Recommendations**

Further sensory evaluation studies are required to ascertain consumer’s perception on IC meat and eggs.

**Acknowledgments**

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**References**


Prevalence of multiple resistant *Haemonchus* and *Ostertagia* species in goats and cattle in Machakos, Eastern Kenya

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Abstract

Anthelmintic resistance has seriously undermined helminth control in ruminants. Faecal egg count reduction tests (FECRT) conducted between 5th January 2015 and 22nd February 2015 established prevalence of anthelmintic resistant nematodes in a goat and a cattle herd. Study animals were identified through a pre-treatment faecal egg counts (FECs) where 116 goats and 60 cattle with FECs ≥150 were selected. The animals were allocated into four treatment groups namely the control (untreated), valbazen, Nilzan plus and ivermectin using a complete randomised design. Valbazen and Nilzan plus were administered *per os* at 10 mg/kg and 7.5 mg/kg, respectively to the experimental goats and cattle. Ivermectin was injected subcutaneously around the neck at 200 mcg/kg. Fourteen days post-treatment, experimental animals in each of the 4 groups were faecal sampled for FECs and persisting nematode species. Goats treated with valbazen, Nilzan plus and ivermectin had FEC reduction of 16%, 90% and 98%. This showed that Valbazen and Nilzan plus were ineffective against nematodes of goats. *Haemonchus* species persisted amongst goats treated with the 3 drugs. Valbazen, Nilzan plus and Noromectin treatment of cattle resulted in 98%, 95% and 99% reduction in FECs. Although all the 3 drugs are effective against nematodes in cattle, *Ostertagia* species persisted amongst cattle treated with the 3 drugs. Molecular tools are needed to confirm prevalence of multiple resistant *Haemonchus* and *Ostertagia* species in the semi-arid region of Kenya.

Keywords: Anthelmintic resistance; *Haemonchus*; Cattle; Goats; *Ostertagia*; Refugia

Introduction

Helminthosis is a major cause of mortality and sub-optimal productivity in pastoral farming systems across sub-Saharan Africa (SSA). Compared to the temperate climatic zones, the impact of gastro-intestinal helminths in the SSA could be higher since the tropical climate is associated with a wider range of agro-ecological factors suitable for the survival of diversified hosts and helminth species (Sissay *et al.*, 2006). Heavy
helminth infections if left untreated could be fatal to calves and small ruminants in addition to causing sub-clinical disease in adult cattle associated with lowered productivity, premature culling and making animals unsuitable as replacement breeding stock (Murphy et al., 2006).

Although grazing management and treatment of animals using anthelmintic drugs (ADs) are the common strategies used in the control of helminths in livestock, ADs are by far the most favoured method by livestock keepers (Coles et al., 2006). Despite the continued use of ADs, production losses still remain high. This could be due to the poor quality of ADs (Monteiro et al., 1998) and the increasing threat of anthelmintic resistance (AR) that has been reported in many parts of the world (Kaplan, 2004).

In most small ruminant production systems, anthelmintic resistant nematodes are a problem of major economic concern to farmers (Kaplan, 2004). Several reports on AR especially those associated with benzimidazoles (BZ) in the small ruminant production systems have been reported. In Kenya notable BZ resistant nematodes in the sheep and goat production systems reports have been documented (Wanyangu et al., 1996; Maingi et al., 1998; Waruiru et al., 1998; Gatongi et al., 2003). The same has been reported in Tanzania (Bjorn et al., 1990; Ngomuo et al., 1990; Keyyu et al., 2002), South Africa (Van Wyk et al., 1999; Vatta et al., 2001; Bakunzi et al., 2003), Zambia (Gabrie et al., 2001), Nigeria (Mbah et al., 1992), Cameroon (Ndamukong and Sewell, 1992), Zimbabwe (Mukaratiwa et al., 1997), and Ethiopia (Sissay et al., 2006). On the other hand, AR is scantily reported in cattle possibly because of the infrequent use of anthelmintics on this class of animals (Kaplan, 2004). The few reports on AR in bovine mostly originate from regions where cattle are kept under grazing management systems like in New Zealand (Coles, 2002), South America (Soutello et al., 2007; Suarez and Cristel, 2007) and Europe (Coles, 2002; 2004; Demeler et al., 2009).

It is commonly accepted that resistant genes exist as rare alleles in natural populations (Michel et al., 1982; Prichard, 1990; Jackson, 1993) and that anthelmintic resistance develops when selection pressure is high. The two main factors which select for resistance and accelerate resistance development are treatment frequency and a high number of anthelmintic treatments with the same anthelmintic family for years (Sykes et al., 1992). At the KALRO Katumani goat herd, albendazole has been used as a preferred anthelmintic interrupted for over 20 years raising suspicion for possible resistance by the common gastro-intestinal nematodes. It is reported that although sheep, cattle and goats may harbour similar nematode parasites, the BZ dose needed for treating goats should be slightly higher (Chartier et al., 1999; Hennessy and Alvinerie, 2002; Sangster et al., 1993) than that for sheep and cattle. In many farms, similar BZ doses are used for treating the animals hastening the risk of BZ resistant nematodes development in goats.

There exists empirical evidence to suggest that the risk for AR increases with underdosing, lack of anthelmintic class rotation and high drench frequency (Domke et al., 2011), justifying the need for regular evaluation of the efficacy of common anthelmintic drugs used in worm control regimes. This continuous analysis of the treatment response of the marketed anthelmintic drugs will ensure that farmers are adequately advised on the appropriate drugs to use as dewormers hence assuring them of value for their

Prevalence of multiple resistant Haemonchus and Ostertagia species in goats and cattle in Machakos, Eastern Kenya
money. The aim of this study was to investigate the prevalence of AR for the common anthelmintics used for controlling worms in cattle and goat flocks and to also identify the resistant nematode genera in selected large-scale farms around Machakos, Eastern Kenya.

Materials and Methods

Study area

The study was carried out in two large-scale farms: a goat herd at KALRO Katumani and a cattle herd at New Astra ranch. Both herds are located in the Machakos County, Kenya (Fig 1).

Figure 1. Study herds

The two herds are located 20 km apart within agro-ecological zone lower midland 4 (LM 4) (Jaetzold and Schmidt, 2006) where bimodal rainfall pattern is experienced. The long rains start in mid-March to early May while the short rains start in mid-October to mid-December (Rao et al., 2011). The total rainfall for the two seasons is approximately 450 mm and is not only erratic but also poorly distributed in time and space.

In this zone, agro-pastoralism is practiced and farmers commonly grow cowpeas, pigeon peas green grams, beans and cassava to some limited extent. They also rear cattle which include the boran, zebu and recently introductions of Friesian and zebu crosses. The small East African goats (SEAG), Galla goats and Toggenburg and the Galla/SEAG crosses are reared. Although sheep is still a minority animal, the few who have sheep keep the red Masai sheep and dorper. The cattle and goats within LM 4 are extensively grazed on common pastures with minimal supplementation.

Experimental animals

A total of 116 experimental goats were purposively selected from a goat herd of 230 at KALRO Katumani on the basis of their faecal egg counts (FECs). These goats were dual purpose goats; a composite breed consisting of Galla and the SEAGs. The experimental goats were identified after screening all goats aged at least 3 months for their FECs
with those whose FECs $\geq 150$ qualifying as experimental animals. Before the final list of goats was compiled, those which for one reason or the other had received anthelmintic treatment in the last three months were dropped from the list of experimental animals.

At the New Astra cattle herd, 60 experimental cattle were also purposively selected from a population of 155 cattle aged between 3 months and 12 months identified from the general herd and ear-tagged. A FEC screening exercise was undertaken to identify those with FECs of $\geq 150$ which were included as experimental cattle. Like for the experimental goats, any cattle which had been treated with anthelmintics in the last three months were also dropped from the list of experimental animals. The list of 60 eligible cattle was prepared for ease of follow-up.

**Experimental design and treatments**

The experiment was undertaken in three stages namely the pre-treatment FEC screening stage, treatment of selected animals and post-treatment FECs between 5<sup>th</sup> January 2015 and 22<sup>nd</sup> February 2015. A complete randomised design was used during this study where the experimental goats and cattle were randomly allocated into four groups namely; the control (untreated) group, valbazen® (albendazole 10%) treatment group, Nilzan plus® (Levamisole and oxyclozanide) treatment group and Noromectin® (ivermectin) treatment group (Table 1).

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Dose used</th>
<th>No. goats</th>
<th>No. cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>NT</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>Valbazen® (Albendazole 10%)</td>
<td>10mg/kg</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>Nilzan plus® (Levamisole and oxyclozanide)</td>
<td>7.5mg/kg</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>Noromectin® (Ivermectin)</td>
<td>200mcg (0.2 mg)/kg</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>116</strong></td>
<td><strong>60</strong></td>
</tr>
</tbody>
</table>

*NT=untreated control*

Both goats and cattle within the valbazen treatment group received 10 mg/kg of albendazole 10% (valbazen, Ultravetis EA Ltd) instead of the 7.5mg/kg *per os* to accommodate the higher albendazole dose for goats. The goats and cattle on Levamisole 1.5%, and Oxyclozanide 0.382% (Nilzan plus, Cooper Kenya Ltd) received 7.5mg/kg *per os*. The ivermectin treated goats and cattle received 200mcg/kg of ivermectin 1% (Noromectin, Norbrook Pharmaceuticals Ltd, Schering, UK) which was injected subcutaneously around the neck region. The treatments were calculated on the basis of body estimated using a weighing band.

**Faecal egg counts reduction test**

Faecal egg counts from experimental animals were analysed for helminth eggs during the pre- and post-treatment phases. The pre-treatment faecal sampling and FECs were undertaken between 5<sup>th</sup> and 15<sup>th</sup> January 2015 while the post-treatment faecal
sampling and FECs were conducted between 3rd and 5th February 2015, 14 days after treatment. This was to allow for comparison in FECs for experimental animals for the four experimental groups before and after treatment to measure the effect of drugs on helminth egg shedding.

Faecal samples for each experimental goats and cattle belonging to each of the four treatment groups were collected per rectum and appropriately labelled with animal tag number, breed, sex, date and herd identity. The samples were packed in separate bags and zipped before they were delivered to the helminthology laboratory at the Veterinary Research Institute, KALRO Muguga in an ice-packed cool boxes.

The FECs were done using modified McMaster technique (Kaufmann, 1996). Briefly, 4 g of faeces were weighed and put into a petri dish. Some saturated sodium chloride solution was added and thoroughly mixed and stirred using two wooden spatulas. The suspension was transferred into a measuring cylinder by straining through a sieve before more saturated salt solution was added to make it 60 ml. The suspension was then transferred into a sealable container and properly mixed by gentle shaking. Both chambers of the McMaster slide (Chalex, Wallowa, USA) were carefully loaded with the suspension to avoid transferring air bubbles in the counting chambers and eggs counted using a compound microscope at × 40 magnification. The eggs per gram faeces (EPG) or faecal egg counts (FECs) was calculated as the number of eggs counted multiplied by a correction factor of 50.

Copro-cultures

Identification of the prevailing GINs in the study area was done to show which species were sensitive and which ones were resistant to the three test anthelmintic drugs. Copro-cultures were done using the method described by Kaufmann (1996) between 5th and 18th January 2015 for the pre-treatment phase and 8th and 22nd February 2015 for the post-treatment. Briefly, about 50g of faecal samples from the experimental goats and cattle belonging to the albendazole treatment group, Nilzan plus treatment group, ivermectin treatment group and untreated control group were separately pooled by treatment group. The 8 (4 for goats and another 4 for cattle) pooled faecal samples were broken down into fine particles using a wooden spatula and mixed with vermiculite (Rajapack®, Birkenfeld, Germany) and tap water, ensuring they remained moist and crumbly but not really wet. The mixture was then filled into 8 separate plastic culture dishes identified by treatment group and animal before partially covering them and incubating at 27ºC for 7 days. Larvae 3 were recovered using the Baermann technique and their identification done as described by Kaufmann, 1996. Morphological features used in the identification were the shape of the anterior part and the number of gastro-intestinal cells of the 3rd stage larvae.

Data analysis

The arithmetic mean, percentage reduction and 95% confidence interval of the FECs for the 4 treatment groups were calculated by the method described by Coles et al. (1992). The percentage reduction is 100 (1 - x̄t/ x̄c) where x̄ is the arithmetic mean of the FEC,
t, treatment groups (valbazen®, Nilzan plus®, Noromectin®) at day 14 post-treatment and \(c\) is the control group FEC at 14 day. The 95% confidence interval was calculated by applying the formula \(100[1 - \bar{x}_t/\bar{x}_c \exp (-2.048\sqrt{Y^2})]\) for the lower limit and \(100[1 - \bar{x}_t/\bar{x}_c \exp (+2.048\sqrt{Y^2})]\) for the upper limit. \(Y^2\), the variance of reduction was calculated as:

\[Y^2 = \frac{\text{Variance of treatment group}}{n, \text{ for treatment group}} \times \bar{x}_t^2 + \frac{\text{Variance of control group}}{n, \text{ for control group}} \times \bar{x}_c^2\]

The interpretation of the FECR test results (Coles et al., 1992) was as follows: resistance was declared where the percentage reduction in FECs was < 95% and where the lower 95% confidence interval was < 90%. Where only one of the above conditions was accomplished, emerging resistance was suspected.

**Results**

The mean pre-treatment FECs for the experimental goats were 1989 for the control group, 2261 for the valbazen treatment group, 1942 for the Nilzan plus treatment group and 2112 for the Noromectin treatment group (Table 2). A notable reduction in FECs between the pre-treatment and post-treatment phases of for the goats belonging to the control group was observed. This notwithstanding, the FECRT results displayed in Table 2 shows that valbazen treated goats only had 16% reduction indicative of presence of albendazole resistant GIN nematodes within the goat herd (Table 2). Nilzan plus (Levamisole 1.5%/Oxyclophon 0.382%) treatments in goats resulted in a 90% reduction in the FEC output indicating likely presence of levamisole resistant GINs in the goat herd. Noromectin (Ivermectin) treatment resulted in a higher reduction percentage of 98% meaning the drug was effective against majority GINs in the studied goat herd.

**Table II Faecal egg count reduction test results for the KALRO Katumani goat herd**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>Valbazen®</th>
<th>Nilzan plus®</th>
<th>Noromectin® (ivermectin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size, n</td>
<td>29</td>
<td>28</td>
<td>28</td>
<td>23</td>
</tr>
<tr>
<td>Mean FEC (pre-treatment)</td>
<td>1989</td>
<td>2261</td>
<td>1942</td>
<td>2112</td>
</tr>
<tr>
<td>Mean FEC (post-treatment)</td>
<td>669</td>
<td>564</td>
<td>65</td>
<td>13</td>
</tr>
<tr>
<td>% reduction</td>
<td>-</td>
<td>16</td>
<td>90</td>
<td>98</td>
</tr>
<tr>
<td>95% LL CI</td>
<td>-</td>
<td>-42</td>
<td>83</td>
<td>92</td>
</tr>
<tr>
<td>95% UP CI</td>
<td>-</td>
<td>50</td>
<td>94</td>
<td>100</td>
</tr>
<tr>
<td>Interpretation</td>
<td>Resistant</td>
<td>Resistant</td>
<td>Susceptible</td>
<td></td>
</tr>
</tbody>
</table>

FECs=Faecal egg counts; LL=Lower limit of the 95% confidence interval and UP=Upper limit of the 95% confidence interval

Of the 116 goats selected to participate on the study, 8 (1 each from the Valbazen® and Nilzan plus®) could not be traced at the time of post-treatment faecal sampling. Some of
the goats had died shortly after being selected.

Copro-culture of pooled faecal samples from goats during the pre-treatment phase established that a number of GINs were prevalent in the goat herd at Katumani. *Haemonchus* species was the most prevalent GIN species followed by *Trichostrongylus, Oesophagostomum* and *Telardorsagia (Ostertagia)* in that order (Figure 2).

![Gastro-intestinal nematode species](image)

**Figure 2.** Pre-treatment larval culture results showing the different GIN species prevalent within the Katumani goat herd.

However, copro-culture results for the day 14 post-treatment sampling had *Cooperia* species manifesting itself in addition to *Haemonchus, Telardosargia (Ostertagia), Trichostrongylus* and *Oesophagostumum* species (Table 3).

Table III Percentage of infective GIN Larvae by Genus of the KALRO Katumani Goat Flock

<table>
<thead>
<tr>
<th>Nematode 3rd stage larvae (%)</th>
<th>Control</th>
<th>Valbazen®</th>
<th>Nilzan plus®</th>
<th>Noromectin®</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Haemonchus</em></td>
<td>36</td>
<td>31</td>
<td>28</td>
<td>100</td>
</tr>
<tr>
<td><em>Telardorsagia (Ostertagia)</em></td>
<td>30</td>
<td>28</td>
<td>56</td>
<td>-</td>
</tr>
<tr>
<td><em>Trichostrongylus</em></td>
<td>-</td>
<td>13</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Cooperia</em></td>
<td>34</td>
<td>27</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td><em>Oesophagostumum</em></td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*Haemonchus* species was the most dominant GIN species which persisted in all the three anthelmintic treatment groups. It’s prevalence among albendazole treated goats was 31%, 28% among Nilzan plus treatment group and 100 % among the ivermectin treated goats (Table 3). On the contrary, 28% of *Telardosargia (Ostertagia)* and 56% *Trichostrongylus* species persisted among the valbazen and Nilzan plus treated goats. The prevalence of *Cooperia* species was 27% and 16%, respectively for the valbazen and Nilzan plus treated goats.
The mean pre-treatment FECs for the study cattle were 475 for the control group, 514 for the valbazen treatment group, 604 for the Nilzan plus treatment group and 443 for the ivermectin treatment group (Table 4). Like was the case for goats, there was a general reduction in FECs for the control group from a mean FEC of 475 to 342 comparing the pre-treatment and post-treatment phases. Valbazen treated cattle had reduction in FECs of 98% meaning the majority of GINs in the study cattle were still sensitive to valbazen (Table 4). Nilzan plus treatment resulted in a 95% reduction in the FEC output also a sign that GINs in the study cattle were still sensitive to levamisole. Ivermectin treatment resulted in the highest reduction percentage of 99% meaning the drug was effective against majority GINs in the study cattle.

Table IV Faecal egg count reduction test results for the New Astra bovine herd

<table>
<thead>
<tr>
<th>FECRT</th>
<th>Control</th>
<th>Valbazen®</th>
<th>Nilzan plus®</th>
<th>Noromectin®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size, n</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Mean FEC (pre-treatment)</td>
<td>475</td>
<td>514</td>
<td>604</td>
<td>443</td>
</tr>
<tr>
<td>Mean FEC (post-treatment)</td>
<td>342</td>
<td>8</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>% reduction</td>
<td>-</td>
<td><strong>98</strong></td>
<td><strong>95</strong></td>
<td><strong>99</strong></td>
</tr>
<tr>
<td>95% LL CI</td>
<td>-</td>
<td>90</td>
<td>85</td>
<td>91</td>
</tr>
<tr>
<td>95% UP CI</td>
<td>-</td>
<td>99</td>
<td>98</td>
<td>100</td>
</tr>
<tr>
<td>Interpretation</td>
<td>Susceptible</td>
<td>Partial resistance</td>
<td>Susceptible</td>
<td></td>
</tr>
</tbody>
</table>

FECs=Faecal egg counts; LL=Lower limit of the 95% confidence interval and UP=Upper limit of the 95% confidence interval

Cultured pooled pre-treatment faecal samples collected from cattle resulted showed prevalence of *Haemonchus* species as the most common followed by *Trichostrongylus*, *Oesophagostomum* and *Ostertagia* (Figure 3).

![Figure 3](image)

Figure 3. Results of the larval cultures indicating the different GIN species prevalent within the New Astra cattle flock

The post-treatment faecal sample culturing indicated the prevalence of *Haemonchus, Trichostrongylus, Ostertagia, Oesophagostomum and Cooperia* species in the treated cattle (Table 5).
Multiple drug resistant Ostertagia species persisting in valbazen with a prevalence of 50%, 100% in Nilzan plus and Noromectin treatments, respectively (Table 5). The prevalence of Haemonchus species resistant to albendazole was 50%.

Disucssion

The findings by this study on the three test drugs; Valbazen® (albendazole 10%) Nilzan® plus (levamisole 1.5% and oxyclozanide 3%) and Noromectin® (ivermectin 1%) on their effect on shedding of helminth eggs showed that ivermectin, a member of the macrocyclic lactones (MLs) was efficacious against GIN parasites in both cattle and goats treated with this drug. There is hence a ray of hope for farmers who rear livestock extensively to still rear healthy and productive livestock free of infectious helminths provided that ivermectin is used rationally. Although, the overall treatment response of ivermectin in reducing FECs of GINs by this study agreed well with those reported in other studies (Wanyangu et al., 1996; Maingi et al., 1998; Waruiru et al., 1998; Sissay et al., 2006), the presence of Haemonchus contortus populations amongst ivermectin treated goats is course for worry since failure to eliminate this GIN species is likely to result in serious economic losses in terms of reduced productivity and in severe cases mortalities of affected animals (Uhlinger et al., 1992).

Obvious suspicion of resistance to both albendazole and levamisole was evident among the studied goats. Although this study pioneered investigation on anthelmintic resistance in livestock under extensive system of management, the findings were in accordance with resistance situation in small ruminants under intensive production systems (Wanyangu et al., 1996; Maingi et al., 1998; Waruiru et al., 1998) Similar albendazole and levamisole resistant nematodes has been reported in Ethiopia (Sissay et al., 2006) in Tanzania (Bjorn et al., 1990; Ngomuo et al., 1990; Keyyu et al., 2002) in South Africa (Van Wyk et al., 1999; Vatta et al., 2001; Bakunzi et al., 2003) among other places. Despite the evidently clear prevalence of albendazole resistant GINs in goats, evidence for GINs resistant to levamisole was borderline. Moreover, this finding was quite unexpected and surprising since this levamisole has not been used as an anthelmintic in Katumani before. However, because the efficacy of levamisole in treated goats was 90 % it suggests existence of a window of opportunity for slowing the resistance as suggested by Bakunzi (2003).

Although many reports on GIN resistance in sheep and goat farms in SSA (Bjorn et al., 1990; Wanyangu et al., 1996; Mukaratiwa et al., 1997; Maingi et al., 1998; Waruiru et al., 1998; Gatongi et al., 2003; Sissay et al., 2006) have been made, AR in cattle GINs
is a still a rare occurrence. This is perhaps because of the low frequency of anthelmintic treatments in cattle. One of the first reports on anthelmintic resistance in cattle in Africa was made in Mali where one study suspected presence of albendazole resistant GIN populations in cattle (Mungube et al., 2013). Contrary to the findings by Mungube et al. (2013), the present study has shown that albendazole is still efficacious against GINs within the cattle flock studied. However, levamisole, an imadathiazole tested in this study failed to produce an appreciable treatment response (FECRT was <95%) amongst treated cattle. This increased suspicion about possible presence of levamisole resistant GIN populations in the cattle at New Astra ranch. It is not clear why this was the case since levamisole is rarely used as an anthelmintic although it was strongly linked to the inflows into the ranch of breeding stock sourced from anthelmintic resistance hotspot areas within the central highlands and Rift Valley of Kenya (Maingi et al., 1998; Waruiru et al., 1998).

The magnitude of anthelmintic resistance involving levamisole was less severe in the New Astra ranch compared to the KALRO Katumani flock. This is could be because differences in the husbandry practices and management levels. At the New Astra ranch, anthelmintic treatment is selectively done (treatment of the calves and sick animals) compared to the mass treatments done at Katumani. The infrequent use of anthelmintic drugs reduces the risk of resistance development since a reservoir of susceptible worms remains within the population which helps to dilute the resistant alleles (Hoste et al., 2002). At the New Astra ranch, close interaction between cattle and wild herbivores like giraffes, wildebeests, antelopes and zebras is beneficial in maintaining refugia. The interfacing of cattle with wildlife ensures that the GINs in cattle after they are exposed to anthelmintic treatments are constantly diluted or replaced by the GIN nematodes from wildlife which are unexposed to drugs. This helps to delay resistance development in agreement with the consideration by most parasitologists that levels of refugia is the single most important factor contributing to selection for anthelmintic resistant parasites (Van Wyk, 2002). Maintaining parasites in refugia is a key point in controlling and delaying the development of resistance, because the susceptible (anthelmintic sensitive) worms genes are preserved (Waghorn et al., 2008).

Nematodes in goats are likely to develop resistance against common BZ formulations faster than those in sheep, cattle and goats (Chartier et al., 1999; Hennessy and Alvinerie, 2002; Sangster et al., 1993). This is because goats metabolise anthelmintics more rapidly than other domestic ruminants which may also accelerate the rate of selection for resistance in nematode parasites in goats. Moreover, at KALRO Katumani, goats are kept intensively at high stocking rates which sometimes forces them to graze instead of browsing hence predisposing them to severe problems of GINs as observed by Sissay et al. (2006). Under the intensified rearing conditions, very frequent treatments with anthelmintic drugs are practiced in response to the high helminth infection risk precipitating in the earliest and worst cases of anthelmintic resistance recorded in ruminant livestock (Jackson et al., 1992; Sykes et al., 1992). Anthelmintic resistance can also be selected at lower treatment frequencies, especially when the same drug is used over many years. This actually confirms that the high GIN prevalence of albendazole resistant populations could have been precipitated by the fact that this drug has continuously been used in the control
helminths at Katumani for well over 20 years. Coles (1995) reported the development of AR even when only two or three treatments were given annually.

It is known that the commonest GINs of small ruminants include *Haemonchus contortus*, *Teladorsagia circumcinta*, *Trichostrongylus axei*, *Nematodirus* spp, and *Cooperia* spp (Radostits *et al.*, 2002). *Haemonchus contortus* and *T. circumcincta* represent most of the parasite burdens seen in small ruminants, with *H. contortus* being present in highest numbers. Anthelmintic resistance is present in all of these parasites, but the prevalence is highest for *H. contortus*, making it the most economically important GIN of sheep and goats (Uhlinger *et al.*, 1992). This assertion was confirmed by the results of this study. With anaemia as the principal pathologic effect from infection with *H. contortus* (Radostits *et al.*, 2002), FAMACHA (van Wyk *et al.*, 2002; Kaplan *et al.*, 2004) can be an effective tool for identifying animals that require treatment (but only for *H. contortus*) instead of the blanket after every 3 months treatment regimens where all animals are drenched irrespective of their anaemic status. Using the FAMACHA will ensure that the number of anthelmintic treatments administered are greatly reduced which in turn is likely significantly diminish selection pressure for resistance and concomitant reduction in drug costs (Fleming *et al.*, 2006).

The results by this study showed a general reduction in faecal egg outputs comparing the FECs of the control group at pre-treatment and at post-treatment. This seemed to suggest that season influences helminth egg shedding in agreement with observations by Mungube *et al.* (2013). It has also been reported that there is suppression of nematode egg output during the dry season, attributed to the different survival mechanisms of the various nematodes (Kaufmann and Pfister, 1990). Some nematode species like *Cooperia*, *Bunostomum* and *Oesophagostomum* survive in their hosts as adults during the dry season compared to *Haemonchus* species which are hypobiosed (Kaufmann and Pfister, 1990). This was actually confirmed by this study since eggs of *Cooperia* species which were not detected during pre-treatment phase (rainy season) were among those detected during the post-treatment phase sample collection which occurred during the dry season.

In conclusion, it is clear from the results by this study that ivermectin is still effective against GINs in both cattle and goats. Despite this, prevalence of multiple resistant *Haemonchus* in goats treated with ivermectin and of *Ostertagia* species in the study cattle treated with the same drug is course for worry for most animal health practitioners and farmers within Machakos County.

**Recommendations**

- Discontinue the use of albendazole 10% for worm control in goats in and around KALRO Katumani.
- Despite the prevalence of multiple resistant *Ostertagia* species in cattle, albendazole 10% still remains an effective anthelmintic in the control of GINs in cattle.
- Since *Haemonchus* species were prevalent amongst both cattle and goats, adoption
of FAMACHA for making treatment decisions will rationalize and prolong the use of anthelmintics especially ivermectin.

- Adoption of integrated worm control practices like pasture management, improved nutrition among others may be of help in the face of multiple resistant *Haemonchus* and *Ostertagia* species

- Further studies using more robust molecular tools are needed to confirm prevalence of multiple resistant *Haemonchus* and *Ostertagia* species in the semi-arid region of Kenya.

- Further studies to establish anthelmintic handling and use practices as well as quantify active ingredients in marketed albendazole 10% and Nilzan plus should be conducted.

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**References**


Artificial insemination use in Kenya and prevailing constraints

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Abstract
Using cross sectional data from all 47 Counties in Kenya, data was collected to identify the constraints faced by farmers as they use Artificial Insemination (AI) on their cattle. The data reveals that about one quarter of cattle keepers in Kenya use AI. The price of AI however is cited as the most common constraint faced by farmers. Ineffective AI is also another important constraint for about 27% of AI users. MCA analysis applied to data from a 2013 survey does not appear to conclusively reflect these constraints, the character of farmers and location (County of residence) tried to conform to earlier study focusing on the same subject. Further examination of the data is recommended while suggestions are made to deal with the price of AI as well as make the service more effective.

Keywords: Constraint, multiple correspondence analysis

Introduction
Artificial insemination (AI) in cattle was first performed in Kenya in 1935 and was confined to the collection and use of semen from bulls on individual farms and its use within the same farms. It was originally used to combat epivag and other infectious infertility diseases (FAO, 1977). Since then, its use has risen steadily. The Central Artificial Insemination Station (CAIS) was established in 1946 for the production of semen. Since 1966 through the Kenya National Artificial Insemination Services (KNAIS), AI service is credited to have contributed to the growth of the dairy herd in Kenya. Following the SAPs, the distribution of semen was reorganized and privatized with the KNAIS and it was later left under the supervision of the District Veterinary Offices. By 2001, AI provided through KNAIS had suffered a major decline starting 1985 when about 450,000 inseminations were registered and declined to 90,000 inseminations in the year 2000. In 1986 there was a major policy change, which introduced cost sharing in A.I service that were hitherto subsidized through KNAIS. However, this has seen an increase due to change of delivery mechanisms from the vet department to private sector agents and by 2007, this had returned back to 480,000 inseminations (Strategic Business Advisors, 2008). A slump in the latest reorganizations have seen the creation of the Kenya Animal Genetic Resources Centre (KAGRIC) which replaced CAIS but with the mandate of “producing, preserving, and conserving, animal genetic material (semen embryo, tissues and live animals) and rearing breeding bulls for provision of high quality disease free semen to meet the national demand and for export”. It continues to produce the semen
and works loosely with Kenya Stud Book, the Dairy Recording Services of Kenya and the Livestock Recording Center as well as companies like WWS, ABS, Semex and HighChem (E.A. Dairy). At the moment, Kenyan imports of bovine semen are estimated to be growing at 11% annually with the US sharing 73% of this market dominated by 5 suppliers viz American Breeders Service (ABS), Worldwide Sires Ltd., Cooperative Resource International (CRI), Alpha Genetics, and Sierra Besert Breeders Ltd valued at US$1.6 million (Kamau and Diaby, 2008). AI service is now in private hands conducted by technicians from approved AI training centers or by qualified vets. Many Farmers Cooperative Societies in the country have trained inseminators providing AI service to members of their organizations.

AI use in Kenya is generally low, even in Central Highlands areas which are noted for their lead in dairy production, its use was estimated at about 37% with the rest using bull service (Bebe, Thorpe, Udo, & Mulinge, 2000) whereas in the late 1990s, AI use was estimated at about 20% (Omiti, 2002). However, 54% of households prefer AI and its low use (actual use) is attributed to constraints of low availability and perceived high costs. Following liberalization in 1992 delivery of AI and other services which used to be done by the public sector have gone down. Despite the fact that there has been privatization of AI services livestock farmers have not adopted this service in a large scale.

Whereas dairy production in Kenya is the most commercialized in Eastern African region, there are few production constraints at producers’ level which militate against its growth. These include feeds, diseases as well as breeding challenges. With respect to the latter, a number of authors have attempted to provide an analysis of factors that lead farmers to choose different breeding methods for their dairy herds. For instance, in Bomet, a study showed that availability of AI service and farmers’ formal education, existing knowledge, experience, income sources, record keeping, and heat detection ability significantly influenced farmers’ use of AI (Mwangi et al, 2004). Other factors mentioned in this study include bull dominance, extension education coverage, marketing and livestock diseases while cost of AI and farmers’ personal characteristics such as age and gender did not appear to significantly affect the use of AI. Murage and Ilatsia, (2011) also conducted a study in central Kenya and results indicated that besides costs, accessibility to AI services, effectiveness, education, herd size, and location influence the choice of AI service. Similar results are also reported in Kajiado and Narok Counties (Khainga et al, 2015). A baseline survey commissioned by SDCP in 9 counties where an IFAD supported program is being implemented showed that nearly 56% of farmers selected the breeding method on the basis of the cost the service delivery and only 25% on the characteristics of the breed (Fibec Ltd, 2009). In general, the study found that 43% of the farmers in the programme area preferred to use AI services for breeding while 57% preferred bull service. In these counties, AI use stood at just 13% before the IFAD program to 57% in 2010. The cost element is also mentioned in a 2008 report commissioned by land O’Lakes covering Kericho, Bomet, Sotik, Koibatek, Keiyo, Nandi North, Nandi South and Trans Nzoia (Fibec Ltd, 2008). In addition, this earlier
A report indicates preference for bull service where distances from AI services is great. These reports show that there are disparities in preference for AI.

In Uganda, availability of extension services, record keeping practice and availability of milk markets are shown to determine AI use (Mugisha, Kayiizi, Owiny, & Mburu, 2014) in addition to awareness of the AI technology, milk production and sales, and quality of AI services provided to the farmers (Kaaya et al, 2005). In Ethiopia, a similar set of variables appears responsible for AI use (Tefera, Lagat, & Bett, 2014).

This paper briefly summarizes the landscape for AI use in Kenya and attempts to describe the relationship between constraints to AI usage and geographical location.

**Methodology**

Data used in this paper comes from a recent (2013) nationally representative sample of households in 47 counties commissioned by the Agricultural Sector Development Support Programme (ASDSP). A total of 12,654 farming households were interviewed after being selected using the proportionate to population size technique, based on the total number of farming households in each county. Actual data collection was performed by enumerators drawn from respective counties and who were supervised by a county coordinator who was involved in their recruitment and training. A structured questionnaire was used to capture data necessary for the exercise. This survey instrument was designed to capture a range of indicators for use by the ASDSP in its monitoring activities. Among the comprehensive list of parameters measured in this survey were household socio-economic characteristics, level of production and productivity for major agricultural and livestock commodities, consumption, marketing, and food/nutrition security, access to financial and insurance services. The questionnaire was pre-tested and actual data collection commenced in late September 2013 and ended in October 2013. Data entry was undertaken thereafter by clerks recruited and trained for the purpose.

In this paper, the authors explore for associations between counties and different constraints faced by cattle farmers in the use of AI. Using data from this survey, the authors used an exploratory technique to explore and establish the nature of associations between these sets of variables. We employ Multiple Correspondence Analysis (MCA); a technique that can reveal latent patterns in complex data sets, thereby helping to describe these patterns geometrically by locating each variable as a point in low-dimensional space. To implement this analysis, we use the FactoMineR (Hasson 2007 quoted in Lê, Josse, & F., 2008) a package for multivariate data analysis with R (R Development Core Team, 2014).

**Results and Discussion**

This study revealed that 65% of the 12,654 respondents kept cattle (local, crosses and exotic) and 27% of those who kept cattle had used AI within the last 12 months. In addition, 24% of those who kept cattle had accessed AI services from different providers. The main AI providers mentioned were individual private AI practitioners (47.6%), agro-
vet dealers (26.8%), government extension (11.4%), and private companies (6.1%). Many were satisfied with the service as shown by Table 1.

Table 1: Use of AI and satisfaction experienced by respondents (percent)

<table>
<thead>
<tr>
<th>Satisfaction level</th>
<th>Purchased AI in last 12 months?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Very dissatisfied</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Neutral</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>Satisfied</td>
<td>54</td>
<td>60</td>
</tr>
<tr>
<td>Very Satisfied</td>
<td>9</td>
<td>13</td>
</tr>
</tbody>
</table>

Respondents also gave a listing of constraints that they faced in accessing AI services. Just about one fifth (20%) did not report any constraint. However, the rest of the respondents gave a number of constraints, the most frequently cited being high prices and ineffectiveness of the AI input (Table 2). Access to AI at the right time was only important to 3.6% of respondents. A number of AI users did not indicate any constraints.

Table 2: Constraints cited as important with the use of AI by farmers keeping cattle in Kenya

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Very dissatisfied</th>
<th>Dissatisfied</th>
<th>Neutral</th>
<th>Satisfied</th>
<th>Very satisfied</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>High prices /Affordability</td>
<td>1.5</td>
<td>2.6</td>
<td>7.5</td>
<td>26.8</td>
<td>4.6</td>
<td>43.0</td>
</tr>
<tr>
<td>Ineffectiveness of inputs e.g. AI services</td>
<td>1.4</td>
<td>3.3</td>
<td>4.7</td>
<td>14.2</td>
<td>3.0</td>
<td>26.6</td>
</tr>
<tr>
<td>No constraint</td>
<td>0.7</td>
<td>1.1</td>
<td>1.9</td>
<td>12.7</td>
<td>3.9</td>
<td>20.3</td>
</tr>
<tr>
<td>Lack of access to inputs at the right time</td>
<td>0.3</td>
<td>0.2</td>
<td>0.8</td>
<td>2.0</td>
<td>0.3</td>
<td>3.6</td>
</tr>
<tr>
<td>Distance to input market</td>
<td>0.3</td>
<td>0.2</td>
<td>0.6</td>
<td>1.6</td>
<td>0.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Un availability of inputs</td>
<td>0.0</td>
<td>0.2</td>
<td>0.5</td>
<td>0.9</td>
<td>0.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Adulteration of inputs</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.6</td>
<td>0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>No access to desired brand/type of input</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.3</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>No input in right packaging/dosage</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.3</td>
<td>0.0</td>
<td>0.3</td>
</tr>
</tbody>
</table>
A chi square test (Table 3) however reveals that there was an association between the different constraints and the county of residence (p>0.05). For instance, some constraints (not very commonly encountered) such as adulteration were reported only in Bungoma, Kiambu, Kirinyaga, Kisii, Nyamira, Meru, Embu, Trans-Nzoia and Nairobi Counties. Ineffectiveness of AI was mentioned mainly in Baringo, Kiambu, Kisii, Meru, Muranga, Nairobi, Nyandarua, Nyeri and Nakuru. Ineffective AI problem appeared more serious in Baringo, Busia, Kisii, Machakos, Nandi, Nyamira and Trans Nzoia. Farmers in Bomet, Migori and Tharaka Nithi on the other hand appeared to have problems with timeliness of AI. All AI users in Homa bay and Tana River cited high prices as the main constraint to AI use. Other counties did not fare well at least 50% of AI users in Elgeyo-Marakwet, Embu, Kajiado, Kiambu, Kisumu, Machakos, Migori, Muranga, Narok, Nyandarua, Siaya, Taitataveta, Tharaka an Vihiga Counties cited price as the major constraint to AI use. In Kajiado, distance to secure AI services was a problem to at least 50% of the AI users while the same constraint was cited in Kitui by one third of AI users. It was only in Kericho and Kirinyaga where at least 50% of users did not cite any constraints with respect to AI use.

Table 3: Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>715.442</td>
<td>288</td>
<td>000</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>453.682</td>
<td>288</td>
<td>.000</td>
</tr>
<tr>
<td>No of Valid Cases</td>
<td>1572</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results from the MCA failed to reveal the structure of the relationships among the variables shown on Figure 1 since the first two dimensions only explain barely 5% of the association among the variables. Apparently, these are the same variables mentioned as important determinants of AI use in a number of research articles on the subject of AI use in Kenya and other neighboring countries. Discussion of this result is therefore not pursued in the present paper.

Figure 1: MCA plot of variables using R package FactoMineR
**Conclusion and Recommendation**

These results provide a glimpse into the AI landscape that describes the Kenyan case and suggests that constraints may have a geographic basis as well. The veracity of the existence of some constraints (e.g. adulteration an ineffective inputs) need to be examined and tackled since ineffectiveness of AI is the second most important constraint that farmers face. For AI services to be successful the farmers need to be trained on appropriate time detection. Prices of the AI input also will need to be addressed. In the data, AI is mainly provided through private individuals (46%) and agro-vets (16%) while government provides 11% of the input. This will require the input of the newly restructured KAGRIC to reduce prices of AI.

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