# Animal Production Society of Kenya

## Sustainable Livestock Innovation and Technology: Roadmap to Improved Food and Nutrition Security

**Proceedings of the Animal Production Society of Kenya 2018 Scientific Symposium held on 4th to 6th April 2018 at Sportsman Arms Hotel, Nanyuki**

# Proceedings of the Animal Production Society of Kenya 2018 Scientific Symposium

**THEME**

**Sustainable Livestock Innovation and Technology: Roadmap to Improved Food and Nutrition Security**

**4th to 6th April 2018**

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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.

Agriculture in Kenya generally, and livestock production specifically, is at crossroads. There is persistent food shortages arising from rapidly increasing human population, amidst inability to significantly increase productivity. This is being compounded by a host of other trends: urbanization, policy environment and associated impacts particularly on small producers with limited abilities to compete in input and output markets. Aging farming community, climate change and its complex relationships with livestock production systems, and low investments in agriculture are other emerging trends for consideration.

It is determined that demand for livestock products in Kenya will increase several folds by 2050. The trend of increased demand is currently not matched by increase in productivity. Yet, this growing demand for livestock products presents an opportunity for Kenya: in the form of contribution towards economic growth, as well as to the resilience and productivity of producers' livelihoods, and to the food security. This is well articulated in the government development blue print – generally - prioritized and summarized as **THE BIG FOUR**.

However, unmanaged increases in livestock production could also results in increased pressure on natural resources (particularly water and land), increased levels of greenhouse gas emissions, and the potential for more people to contract zoonotic diseases. It is also recognized that smallholders in mixed crop-livestock farming systems will continue to be the main producers of ruminant (cattle, goat and sheep) products until 2050. For monogastrics (such as chickens and pigs), most of the expansion will be through intensive production systems. While the smallholder will remain critical in dairying and chicken sub-sectors in Kenya, livestock development strategies and plans are currently not being intentional and deliberate in addressing some of the key challenges facing value chains in which smallholders operate. Key issues here are access to inputs – including land, financing, appropriate genetics, feeds, and animal health services- as well as markets.

The APSK 2018 scientific symposium provided opportunity for rational discussions on these livestock trends and sought ways of addressing the associated challenges while harnessing existing opportunities and innovations under the overarching theme "Sustainable Livestock Innovation and Technology: Roadmap to Improved Food and Nutrition Security".

We would like to express our gratitude and special thanks to the sponsors of the conference. We thank presenters and authors of papers, 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 proceeding; responsibility for its content rests entirely with the authors.

It is our hope that the APSK 2018 scientific symposium proceedings will provide useful reference material for those interested in understanding the major trends and associated issues covered during this conference.

**Samuel M. Mbuku, PhD**
**Chairman, Animal Production Society of Kenya**

# SPEECH BY THE CABINET SECRETARY AND CHIEF GUEST DURING THE OFFICIAL OPENING

**Distinguished guests,**

**Ladies and gentlemen,**

It gives me great pleasure to be with you here today to inaugurate this special occasion of the annual Animal Production Society of Kenya Scientific symposium and Exhibition. It does provide a unique occasion for the Animal Production Professionals, development partners, input suppliers, farmers and students to exchange technologies and innovations.

Ladies and Gentlemen,

The overall goal of the government of Kenya is to eradicate poverty, illiteracy and diseases. At the global level, Kenya subscribes to the 17 Sustainable Development Goals (SDGs); which came into effect in 2015. Out of the 17 SDGs five are of relevance to the growth of the Agriculture sector namely; SDGs 1: End poverty in all its forms everywhere, SDGs 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture, SDG 5: Achieve gender equality and empower all women and girls, SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; and SDG 10: Reduce inequality within and among Countries.

**Ladies and Gentlemen,**

At the Continental level, Kenya subscribes to all the tenets of the African Union (AU) and its organs. Relevant to the agriculture sector and the livestock sub-sector, is the Comprehensive African Agriculture Development Programme (CAADP) under NEPAD and the renewal of the CAADP commitments in 2014 through the Malabo declaration in which the African heads of state resolved to;

- Commitment to enhance investment finance in agriculture at 10% of public spending targets
- Commitment to ending hunger by 2025
- Commitment to halving poverty by 2025, through inclusive agricultural growth and transformation
- Commitment to boosting intra-African trade in agricultural commodities and services And
- Commitment to mutual accountability to actions and results.

**Ladies and Gentlemen,**

The livestock industry is a key driver of Kenya's economy. It is crucial in enabling Kenya attain the ultimate goal of becoming a **'Middle–income'** Country by the year 2030. Moreover, the sector employs close to 50% of Kenya's Agricultural labour force and is a primary source of livelihoods for over 6 million Pastoralists and Agro-pastoralists in the Arid and Semi-arid Lands (ASALs).

Furthermore, the sector accounts for about 10% of the entire GDP and 42% of the agricultural GDP. It also supplies the domestic requirements for meat, milk and dairy products, and other livestock products and accounts for 30% of the total marketed agricultural products. The sector earns the Country substantial foreign exchange through export of live animals, hides and skins, dairy products and some processed pork products.

**Ladies and gentlemen,**

At the national level, the Kenya Vision 2030 remains the economic blue print to guide the country's development agenda in the coming years. The aim of Vision 2030, is to create '' a globally competitive and prosperous Country with a high quality of life''. In the Vision agriculture and livestock sectors are envisaged to be innovative, commercially-oriented and modern.

**Ladies and Gentlemen,**

Vision 2030 is implemented through five year Medium Term Plans (MTPs) and since inception two MTPs have lapsed and presently MTP III which runs from 2018 to 2022. During MTP III agriculture is expected to grow at a rate of 7% through implementation of several measures that include increasing production and productivity, disease and pest control, crop and livestock insurance, post-harvest management, market development, natural resource management, increased investment in the sector, strengthening institutions, policies and systems, increasing youth and women participation in modern agriculture, and implementation of regional and international protocols and commitments.

**Ladies and Gentlemen,**

The Agriculture Sector Development Strategy (ASDS) of 2010 to 2020 was formulated to guide the contribution of the agriculture sector to the vision 2030 is also undergoing review due to changes in the operational environment. The new strategy- Agriculture Sector Transformation and Growth Strategy (ASTGS) focuses on Agricultural Transformation from small scale subsistence production to a sustainable, equitable and remunerative agricultural sector.

**Ladies and Gentlemen,**

ASTGS has prioritized five policy and investment goals for the national and county levels namely:

- Food, feed and nutrition security,
- Manufacturing and agro-processing,
- Eradication of extreme poverty,
- Increasing productivity and competitiveness, and
- Wealth and job creation.

**Ladies and Gentlemen,**

The Government has spelt out the "Big Four" priority areas/sectors in which to focus for the next five years 2018-2022; namely;

i) Food and nutrition security,
ii) Manufacturing and agro-processing
iii) Universal health care and
iv) Affordable housing

The livestock sector and Animal production professionals have a big role to play in actualizing priority areas numbers i), ii) and iii).

**Ladies and gentlemen,**

I understand that Animal production Society of Kenya (APSK) draws its membership from Ministries, Departments and Agencies, Research Institutions, Universities and the private sector. To date, the Society has an active membership of 300 which is projected to double by 2022.

Moreover, the purposes and objectives of the Society which include provision of a common forum for exchange of ideas; dissemination and adoption of technologies; support to members in self development; strengthening of regional and global linkages; contribution to the development of animal production related policies, and provision of professional advice on the development of the livestock industry; will contribute greatly towards the realization of the ‘’Big Four’’ development agenda.

**Ladies and gentlemen,**

The theme of the 2018 Animal Production Scientific Symposium and Exhibition “Sustainable Livestock Innovations and Technology: roadmap to improved food and nutrition security’’is apt.

In line with the theme of the Symposium, there will be presentations of research findings, topical panel discussions and stakeholders’ exhibitions. The theme will further give impetus to the realization of the Vision 2030, SDGs, and the ‘’Big Four’’.

**Ladies and gentlemen,**

Following the enactment of the APSK Act 2017, there is a new momentum to revitalize the society and give it more visibility and voice in the sector.

I am informed that the 2018 – 2022 APSK Strategic Plan maps out the way forward for the society in the next five years and is a commitment by members to transform the society into a model professional body. In addition, the enactment of the Animal Production Professionals’ Bill 2018 will further entrench the society and boost its capacity to execute its mandate.

**Ladies and gentlemen,**

As you are aware, the Cabinet Secretary responsible for Livestock Development is the Patron of APSK. I want to assure APSK leadership and its members that the Ministry will continue to support you.

**Ladies and gentlemen,**

It is now my pleasure to declare the 2018 APSK Scientific Symposium and Exhibition officially open.

Thank you and God bless you.

# APSK Symposium 2018 held at sportsman's Arms Hotel, Nanyuki.

## Speech

### Dr. Hon Mutunga Member of Parliament,Tigania West

Hon Mutunga attended the APSK symposium which was held at sportsman's arms hotel, in Nanyuki from 4th to 6th April 2018. He managed to attend the symposium for one day namely 4th April 2018.

He started by thanking the APSK secretariat for organizing the forum which was attended by many stakeholders which included farmers, government officers, international, regional, local organizations, private investors, Universities and research Institutions. He thanked various organizations which had supported the symposium.

Hon Mutunga worked as livestock officer in the former Ministry of Agriculture and Livestock in various capacities since 1988 to the year 2001. From 2001 he left the ministry and he got a job in KENFAP where he worked for more than 15 years when he engaged in private sector and in 2017 he joined politics and he was elected as the MP of Tigania West in Meru.

In his speech he stated that since he worked in the Ministry of livestock in various capacities this qualified him to be a dormant member of APSK. He talked about the big four priority areas of the Nation of Kenya. The big four agenda entails boosting manufacturing, universal health coverage, food and nutrition security, and supporting the construction of at least 500,000 affordable houses by 2022. These agendas of Kenya are projected to boost economic growth to at least seven per cent per year and they are supposed to guide the development *agenda* of the country in the period 2018-2022. These *four* areas are expected to bolster strong inclusive economic growth. Hon Mutunga indicated that Agriculture is key in the fulfilment of the big four development agendas of Kenya. He said livestock is key in promoting the actualization of the big four and this being the case APSK should be engaged. He said livestock production is important and it is a sector which makes a big contribution to the Kenyan economy and food security and as a result it cannot be ignored. He also stated that currently the demand for livestock products have continued to go up as a result of ever increasing population and urbanization as a result there is urgent need to promote livestock production and productivity in the Country. He said there is need to improve the production of livestock products in both quality and quantity. Dr. Mutunga also said that there is need to promote value addition of livestock products and also to increase in production of livestock through introduction of appropriate livestock breeding programmes.

According to Hon Mutunga for livestock enterprise to achieve it socio economic potential there are key issues which needs to be put in place ;-

- Having enabling policy and legal framework
- Creating of an enabling environment for the sector development
- He also stated that since the livestock sector has a lean work force there is need to include positions of internship in the policy framework so as to increase production and productivity in the livestock sector.

In addition he stated that for the livestock sector to achieve its socio economic potential there some questions which needs to be answered according to him these includes;

1. What do individuals do at their level?
2. What is being done at the market level?
3. Why are we importing agricultural products from our neighboring countries instead of using our own? He gave a case of maize importation from Uganda instead of using maize from North Rift.
4. How are we improving food and nutritional security and also institutional capacity in the agricultural sector?

5. He also indicated that there is still hard science
6. How are we going to enjoy the benefit?
7. What are the researchable problems in the problems in the value chain?
   - How are we addressing the problems faced in the ASALS particularly in the social support systems?

He said that there is need to contextualize the problems which are being faced in the nation depending on Geographical location and also modes of production in a given area.

Hon Mutunga stated that policy and legislation issues are really tricky. He gave examples of some Acts which the parliament has been struggling with such as;

1. Hides and skins bill (316)
2. Livestock breeding bill
3. Livestock feed bill
4. Poultry bill
5. National dairy policy
6. National bee keeping policy
7. Small livestock production policy

But he said that there is need to define livestock professional's bill which has not been done. Therefore he promised that he was willing to ensure that Animal professional bill will be enacted.

# POLICY, VALUE CHAINS, MARKETS AND OTHER CROSS – CUTTING ISSUES AFFECTING LIVESTOCK PRODUCTION

# Milk Vending Machine Innovation for Retailing Milk: operation costs, consumer perceived risks and milk quality in Kenyan markets

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## Abstract

Milk vending machine is a retail innovation promising quality and cost saving to consumers who demand low cost raw milk and a business opportunity for entrepreneurs in Kenya. This study reports operating costs, consumer perceived risks and quality of milk from vending machines. Information was collected at the milk market outlets in Nairobi, Nakuru, Kisumu, Kakamega and Eldoret towns. The operating costs average KES 123,200 annually, of which 58.4% was servicing of the machine, 17.5% water and electricity and 24% licensing and permits charged by regulating authorities. Milk was retailed at margins of KES 5 to 10 a litre with returns to business of KES 1,000 to 15,000 a day. In a random sample of consumers, those associating milk with high health risks were substantially lower for vending machines (<15%) than for mobile traded milk (15 -58%), farm supplied milk (98-38%) or processed milk (12-30%). Compliance with the KeBS standards for milk quality was higher for milk vending machines compared to plastic containers in microbiological quality indicators (74.4 vs 31% in TVC; 79.5 vs 41.4% in TCC). However, vending machines did not offer better compliance in quality standards over plastic containers in milk density (100 vs 100%), solids not fat (46.6 vs 41.4%), hydrogen peroxide (92.3 vs 96.6%) or antibiotics presence (96.3 vs 93.1%). However, milk contamination with AFM1 exceeded Codex standards of 50 ppt for vending machines (120.87±24.63 ppt) but not for plastic containers (35.61±20.10 ppt), with samples found non-compliant more in vending machines compared to plastic containers (50.0 vs 63.6%). Results show that operating costs of vending machines are high for an average entrepreneur, consumers associate it with reduced risks, it has better compliance with quality standards than with plastic containers for microbial contamination, but testing for milk quality is necessary.

**Keywords**: Raw milk, Quality standards, Distribution, Plastic containers

## Introduction

Milk vending machines are a retail innovation offering quality and cost saving to consumers who demand low cost raw milk and can offer business opportunities to entrepreneurs. This innovation is relevant in the Kenyan milk market where at least eight in ten litres (86%) of the marketed milk is raw due to a strong consumer preference for low cost raw milk (Bebe et al., 2017). However, regulating authorities discourage trading raw milk for public health safety reasons (Gok, 2010, KDB, 2015). Therefore scaling innovations in milk retailing that assures safety to consumers share welcome in the dairy sector (Unnevehr, 2015). In Kenya, milk vending machines retail chilled pasteurised milk in strategic locations targeting urban consumers. They are found in supermarkets, milk bars and shops, and few on farms. Regulations require that milk is chilled, pasteurised and every batch be replaced every 24 hours. Observing these practices should ensure that high quality is retained over long period of time to minimise loss from spoilage and assure quality to consumers.

For consumers, introduction of milk vending machines is an alternative to mobile traded milk which they associate with high risks and trade malpractices (Ndungu et al., 2016). Automated milk dispensing minimises milk handling which should enhance hygiene standards. Automation allows for selling of any volume desired by the consumer into their own containers thus reducing price relative to that of packaged milk. In addition, automated recording of all transactions is advantageous for business management to entrepreneurs. These safety and business advantages of milk vending machines can explain its rapid uptake in the towns where urban consumers are targeted.

Though milk vending machines can offer to consumer milk safety assurance and to entrepreneurs business advantages, operating costs could be prohibitive. The machines are imported and do not qualify for tax exemption, regulating authorities charge several licenses and permits for milk business and cost of clean water and electricity could be substantial. High operating costs could be a disincentive to practicing high hygiene standards required when operating milk vending machine such as ensuring that milk is always pasteurized and does not last over 24 hours in the dispenser. When not observed, these can potentially affect the safety and quality of milk marketed in vending machines. This study was a consumer and market survey to estimate the operating costs, consumer perceived risks and quality of milk from milk vending machines compared to plastic containers because these used in raw milk retailing in Kenya.

## Methodology

Consumers, entrepreneurs and milk were sampled at the milk vending machine outlets in Nairobi, Nakuru, Kisumu, Kakamega and Eldoret towns. Consumers coming out of milk market outlets were approached for interview using a structured questionnaire. Premises with milk vending machines were identified then the operator approached for interview that was guided by check list to capture the operational costs, the sales and revenues. Interviews with consumers and operators of milk vending machines were conducted at the milk business premises only when consent was granted. At the milk market outlets (in Nairobi, Nakuru, Kisumu, Kakamega and Eldoret towns), small quantities of milk were purchased for laboratory analysis. Milk samples were submitted to an accredited commercial food and industrial laboratory for analysis in Nairobi within four to six hours in cooler box. The quality indicators analysed were Total Viable Counts (TVC), Total Coliform Count (TCC), milk density (g/ml), Solids not fat (SNF), antibiotics presence, hydrogen peroxide and aflatoxin M1.

## Results and discussion

### Operating costs of milk vending machine

Milk vending machines in the market are of 200 to 1500 litres capacity worth between KES 150, 000 to 700, 000 and mainly imported from Italy and China. Entrepreneurs buy milk at market price between KES 55 and 60 a litre and then retail at a margin of KES 5 to 10 a litre. On average, milk sales a day reached 1500 litres for machines at the Cooperatives, 600 litres in the supermarkets, and 200 litres for milk bars. This translates to a return of KES 1,000 to 15,000 a day, which demonstrates that milk vending machines offer business and employment opportunities in the dairy value chain to milk vendors, distributors as well as farmers and transporters.

For the consumers, a litre of milk obtained at KES 60 to 70 from vending machine is a saving of KES 50 to 60 compared to milk retailed at KES 120 for the same volume when is processed and sold in packets. This is evidence that milk vending machine should be relevant milk retailing innovation in low income markets where consumers express strong preference for low cost fresh milk (Trienekens and Zuurbier, 2008; Unnevehr, 2015).

However, the operating cost are substantial from the indicative figures obtained from the field (Table 1). On average, it cost KES 123,200 annually, of which over half (58.4%) goes to servicing the machine, 17.5% to paying water and electricity bills and 24% to obtaining licensing and permits charged by regulating authorities- the county governments and the Kenya Dairy Board. The machine purchase price together with the operational costs suggest that it is a relatively high capital investment for average small entrepreneurs, with the potential to remove them out of this business. The high cost partly arise from taxation policy in Kenya which presently does not classify milk vending machine as dairy equipment and therefore attracts high import tax. Cleaning of the machine may pose milk quality and safety issues because it is unknown how hygiene of the equipment is maintained by the vendors, yet quality inspections may not be regular in a market characterised by low compliance, trade malpractice (Ndungu et al, 2016) and most of the contracts between farmers and individual consumers as well as traders and middlemen are informal and subject to contract breaches (60%), as observed by Mailu et al. (2014).

**Table 1**: Cost of operating a milk vending machine business in Kenya

| Cost item | KES/year | % |
|---|---|---|
| Servicing | 72,000 | 58.4 |
| Water and electricity | 21,600 | 17.5 |
| County business permits | 18,000 | 14.6 |
| Kenya Dairy Board license | 6,000 | 4.9 |
| Food handlers certificate | 3,600 | 2.9 |
| Public health certificate | 2,000 | 1.6 |
| **Total** | **123,200** | **100.0** |

## Consumer perceived risks of raw milk

Figure 1 illustrates the perceived high risks that consumers (%) associate with raw milk retailed in milk vending machines, retailed by mobile traders and in supermarkets. Consistently, fewer consumers associated milk vending machine with high risk of adulteration, bacterial load, unhygienic handling and antibiotic residues than they do associate with the mobile traded milk. In the random sample, consumers associating milk with high risks were fewer for vending machines (<15%) compared to mobile trader milk (15 -58%), farm supplied milk (98-38%) or processed milk (12-30%). This is a demonstration of high consumer confidence levels with the quality of milk from vending machines. For the consumers, risks posed by milk in vending machines was not different from those from processed milk except for presence of chemical preservatives. This implies that consumers do not consider milk from vending machines as entirely safe and non-compliance across quality indicators was about 24%. Consumers are thus suspicious that entrepreneurs add chemical preservatives, a malpractice common in raw milk trade to prolong shelf life (Ndungu et al, 2016; Kirno at al. 2016). This observation implies that quality testing and food safety control is necessary for traded milk in vending machines.

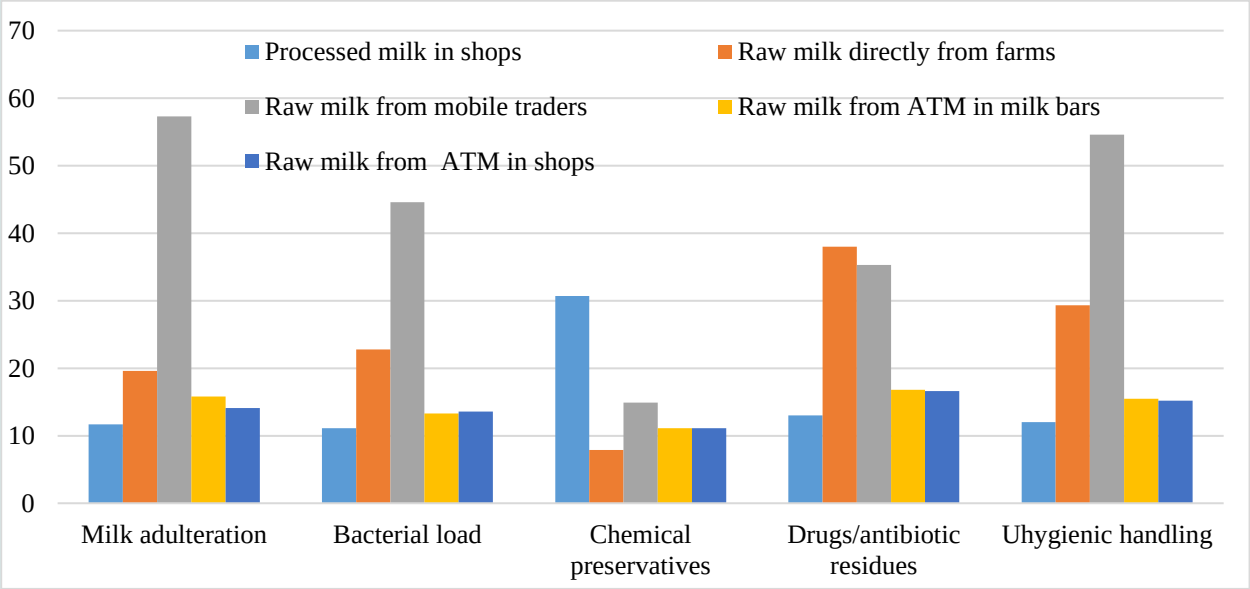


**Figure 1**: Perceived high risks that consumers (%) associate with traded raw milk

## Milk quality

Compliance with milk quality was in reference to the standards of the Kenya Bureau of Standards (KEBS), except for aflatoxin, for which Codex standard of 50 ppt maximum limit was applied, because KEBS adopts Codex standards where local standards are undeveloped.

Results of milk quality tests (Figure 2 and Table 2) show that compliance with the KeBS standards for milk quality is higher for milk vending machines compared to plastic containers in microbiological quality indicators (74.4 vs 31% in TVC; 79.5 vs 41.4% in TCC). However, there was 18 to 24% noncompliance with the KeBS standards for milk sampled from vending machines. This is evidence that milk traded in vending machines should be tested for quality and consumers educated that boiling is necessary prior to consumption. Giacometti et al. (2012) in a study of quality of raw milk in vending machines in Italy did provide evidence that appropriate handling, maintaining low temperatures, consumer education concerning boiling before consumption are necessary to prevent foodborne infections linked to raw milk consumption.

Vending machines do not offer better compliance in quality standards over plastic containers in milk density (100 vs 100%), solids not fat (46.6 vs 41.4%), hydrogen peroxide (92.3 vs 96.6%) or antibiotics presence (96.3 vs 93.1%). Results on milk density with total compliance are indicative of absence of adulteration with water, skimming or sugar. Other quality indicators of relevance to consumers are presence of antibiotics, aflatoxin and hydrogen peroxide presence, with results indicating some potential health hazards and thus room for improving compliance.

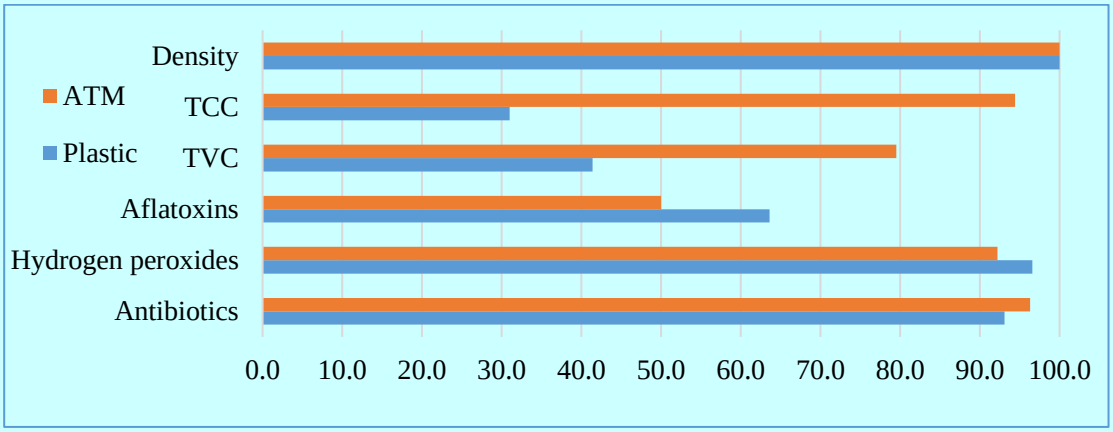


**Figure 2:** Milk samples from vending machines (ATM) and plastic containers complying with the KEBS Standards (%) and Codex standards for the aflatoxin

Contamination of milk with AFM1 exceeding Codex set standard of 50 ppt was observed in milk vending machines (120.87±24.63 ppt) but not in plastic containers (35.61±20.10 ppt) (Table 2). Of the samples tested, ccompliance was lower in milk vending machines compared to plastic containers (50.0 vs 63.6%). This is important because aflatoxin and antibiotics in milk cannot be eliminated even by heating or other processing. The observed levels of aflatoxin contamination of milk compare with previous observation by Kirino et al., (2016) in raw milk sampled in Nairobi peri-urban areas (128.7 ppt) with 55% samples exceeding the Codex maximum safe limit. Why the aflatoxin concentration was 3.4 times higher in milk vending machines than for plastic containers was unclear. Aflatoxin in milk can be attributed to feed, so the origin of the milk delivered to vending machines may provide the answer. Entrepreneurs of vending machine source milk from few farms, and these are likely feeding aflatoxin contaminated feeds. In contrast, mobile traders bulk milk from several sources, likely diluting the aflatoxin concentration.

**Table 2**: Quality of milk sampled from vending machines (ATM) and plastic containers and percent (%) complying with the KEBS Standards (%) and Codex standards for the aflatoxin

| Quality indicator | Milk sample | Mean | Compliance with the KEBS Standards (%) |
|---|---|---|---|
| Total Viable Counts (TVC) (log 10 cfu/ml) | ATM (N=39) | 3.02±0.45 | 79.5 |
| | Plastic (N=29) | 3.95±0.44 | 41.4 |
| Total Coliform Count (TCC) (log 10 cfu/ml) | ATM (N=39) | 2.36±0.39 | 74.4 |
| | Plastic (N=29) | 3.45±0.39 | 31.0 |
| Density (g/ml) | ATM (N=39) | 1.027±0.0003 | 100.0 |
| | Plastic (N=29) | 1.027±0.0002 | 100.0 |
| Solids not fat (SNF) | ATM (N=39) | 8.44±0.07 | 43.6 |
| | Plastic (N=29) | 8.36±0.07 | 41.4 |
| Antibiotics | ATM (N=39) | | 96.3 |
| | Plastic (N=29) | | 93.1 |
| Hydrogen peroxide | ATM (N=39) | | 92.3 |
| | Plastic (N=29) | | 96.6 |
| Aflatoxin M1 (ppt) | ATM (N=39) | 120.87±24.63 | 50.0* |
| | Plastic (N=29) | 35.61±20.10 | 63.6* |

- Codex standards for aflatoxin milk

From the milk quality tests in this study, three issues on milk quality and safety emerge. One, that compliance with quality standards is better when retailing milk in vending machines than with plastic containers for microbial contamination (TVC and TCC). Two, that consumers need be sensitized and educated to take own precautions by boiling milk from vending machines before consumption. Three that it is necessary to test and enforce quality controls for all milk delivered to vending machines. The Kenya Dairy Board (KDB) can enforce this by strengthening regular random quality checks of milk test done by the operator and tests by KDB.

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# Evaluation of the Impact of Smallholder Dairy Commercialization Programme: Implications for Household Food Security

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Smallholder Dairy Commercialization Programme

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## Abstract

Many researchers, inter-governmental organizations, governments, and donors have long held the position that smallholder dairy production and marketing can be an effective mechanism for alleviating poverty and increasing food security in regions well-suited for milk production, such as those located in central and western Kenya. However, the empirical evidence for this causal linkage remains narrow and it still requires further investigation. The overall objective of this paper was to carry out an ex-ante impact evaluation of Smallholder Dairy Commercialization Programme. The specific objectives were to compare the impact of smallholder dairy commercialization programme beneficiaries and the control group with respect to: (i) milk production; (ii) milk marketing; and (iii) household dietary diversity. This paper utilized the theory of change and the logic model, and quasi-experimental methods, in particular the propensity score matching. The results revealed that both total milk production and milk sold is higher for SDCP compared to the control group. Those farmers selling to the market are able to obtain selling price that is 31% higher than the price received by non-beneficiaries. Overall, the total value of milk sold observed by SDCP farmers is 43% higher in value in comparison with that of farmers who are not members of the group. Thus, this evidence suggests that there were positive impacts on milk production and marketing. The results further revealed that programme beneficiaries were able to exhibit higher levels of food diversification towards more nutritional food items, demonstrated by the impact estimate of 0.16 for household dietary diversity score. Therefore, SDCP beneficiaries had higher household food security levels compared to the control group. The quantitative results provide useful information on the impacts of a complex project on smallholder dairy farmers that can be replicated in other regions in Kenya and in other neighboring countries with similar market characteristics. Nutrition should be explicitly included in projects during the design stage.

**Key Word**: SDCP, milk, production, commercialization

## Introduction

The Global Hunger Index (GHI) scores reflect declining hunger for all regions of the developing world in recent decades, yet Africa south of the Sahara and South Asia stand out for having hunger levels that are substantially higher than those of the other regions (IFPRI, 2017). The problem of hunger is evident in Kenya. According to Kenya 2014 Demographic and Health Survey Atlas, 11% of Kenyan children are underweight. The dairy industry has a contribution to make in lowering hunger. The dairy industry in Kenya forms a significant part of the rural economy accounting for 14% of agricultural Gross Domestic Product (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 country (IFAD, 2006). Livestock can produce a regular supply of nutrient-rich animal-source food (ASF) that provide a critical supplement and diversity to staple plant-based diets (Randolph *et al*, 2007; Asfaw, 2009). The Government of Kenya, in collaboration with the International Fund for Agriculture Development (IFAD) and beneficiaries, implemented the Smallholder Dairy Commercialization Programme (SDCP) in 2006 up to 2017. The goal of the programme was to increase income and nutrition of smallholder dairy farmers depending substantially on production and sale of milk and milk products for their livelihood. The promotion of livestock production is widely believed to support enhanced diet quality and child nutrition, but the empirical evidence for this causal linkage remains narrow and ambiguous (Kabunga *et al*, 2017). There is a need to carry out an ex-ante impact evaluation of SDCP to determine if the programme achieved its objective in comparison to smallholder farmers who did not participate in it (control group) in 2006.

Experimental and quasi-experimental methods are after the-fact evaluations that use a randomized control trial or other counterfactual to determine the impact of the intervention compared to the status quo (So *et al.*, 2015; Ahmed *et al.*, 2003). This paper utilizes the theory of change and the logic model, and quasi-experimental methods, in particular the propensity score matching.

Many researchers, inter-governmental organizations, governments, and donors have long held the position that smallholder dairy can be an effective mechanism for alleviating poverty and increasing food security in regions well-suited for dairy production, such as those located in western Kenya (Kibiego *et al.*, 2016; Baltenweck, *et al*., 2000; Staal, *et al*., 1997). However, the empirical evidence for this causal linkage remains narrow and it still requires further investigation. Consequently, the aim of this study is to gain insight into the impact of livestock production and marketing improvement in counties covered by SDCP. The promotion of livestock production is widely thought to support enhanced diet quality and child nutrition (Mosites *et al*, 2015; Kabunga *et al*., (2017); Wiley *et al*, 2009; Dror *et al*, 2011; De Beer, 2012; Miller *et al*, 2016). Few impact studies have considered the control group. This study will fill this gap in the literature. This study therefore, evaluates the impact of SDCP on household food security. The overall objective of this paper was to carry out an ex-ante impact assessment of Smallholder Dairy Commercialization Programme. The specific objective was to assess the impacts of smallholder dairy commercialization programme to the beneficiaries and the control group with respect to milk production, milk marketing and household dietary diversity. Figure 1 presents a conceptual model that describes the relationship between baseline information and impact on the control group in the middle. It is assumed that there is economic growth over time influencing both beneficiaries and non-beneficiaries. Therefore both the communities that receive treatment and the control show increasing values of the impact indicator e.g. income over time.

**Conceptual framework**

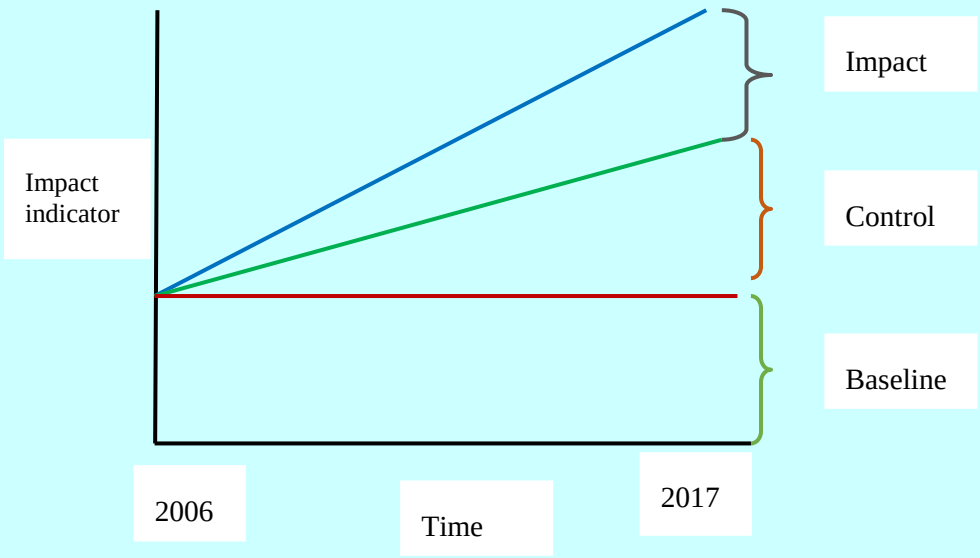


**Figure 1:** Conceptual Framework

**Methodology**

This study took place in Bomet, Nakuru, Lugari and Bungoma counties. The sites were selected since this is where the SDCP project has been implemented. The study involved gathering data from the people who were beneficiaries from the project and the non-beneficiaries. The list of SDCP sub-counties that were considered for the study and those included for comparison purposes are shown in Figure 2. Participants were drawn from all the three geographic clusters of where the programme is being implemented. A sample of 2,562 was split between 1,297 SDCP beneficiaries (from 95 dairy groups) and 1,265 matched comparison farmers (from 89 dairy groups) this was to ensure that the sample was representative.

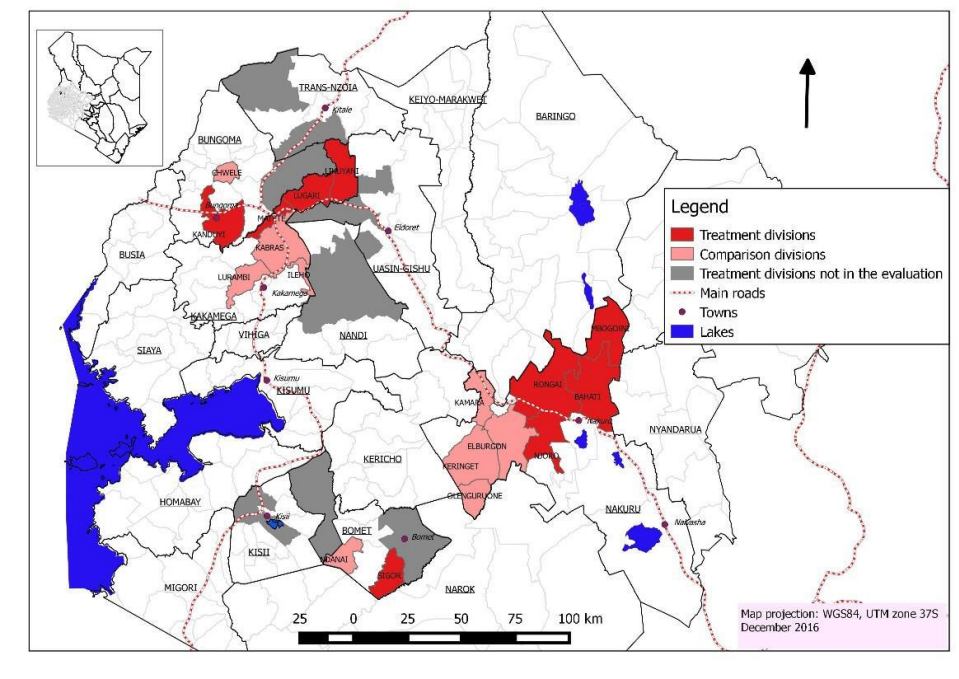


**Figure 2**: Study sites

Questionnaires and Focused Group Discussions (FGDs) were used for data collection. This paper utilizes the theory of change and the logic model, and quasi-experimental methods, in particular the propensity score matching. Calculating dietary diversity scores by summing the number of food groups consumed by anyone in the household over a reference period (last 7 days) is a proxy for food security, developed by the Food and Nutrition Technical Assistance Project (FANTA); greater values of FANTA measure indicate more food insecurity.

## Results and discussion

The results cover milk production and marketing, and household food security.

### Impact on milk production

The SDCP households had received information on all of the practices being promoted by SDCP versus control households, and they had adopted the practices indicated in (Table 1). In addition, SDCP households owned cross-bred cows, used AI services, and to had obtained a wider range of health services. Finally, many of them had adopt recommended management practices and investments, including practicing zero grazing, having concrete floors, and feeding concentrates. In fact, control households did not perform better on any measures of input use, management and investment. Overall, these improved input and management practices led to greater milk production for those who were in SDCP project.

**Table 1**: Impact on probability of receiving information from trainings

| Dependent variable | Impact estimate | Comparison mean | Treatment mean | |
|---|---|---|---|---|
| | (1) | (2) | (3) | N |
| Livestock best practices | 0.15*** (4.83) | 0.22 | 0.37 | 2558 |
| Managerial, bookkeeping, accounting, and finance | 0.04*** (3.58) | 0.03 | 0.07 | 2558 |
| Fodder Establishment | 0.07*** (4.31) | 0.05 | 0.13 | 2558 |
| Hay Making | 0.06*** (3.38) | 0.06 | 0.12 | 2558 |
| Silage Making | 0.04** (2.50) | 0.05 | 0.09 | 2558 |
| Use of chaff cutter | 0.05*** (4.46) | 0.01 | 0.05 | 2558 |
| Animal registration | 0.03*** (3.42) | 0.01 | 0.04 | 2558 |
| Fresh milk marketing | 0.07*** (5.34) | 0.02 | 0.09 | 2558 |
| Value addition marketing (e.g., mala, yoghurt) | 0.05*** (5.16) | 0.01 | 0.06 | 2558 |
| Group/Cooperative Milk Marketing | 0.02** (2.19) | 0.02 | 0.04 | 2558 |
| Market Information Searching | 0.02*** (2.64) | 0.01 | 0.02 | 2558 |

**Milk and input markets impact**

With respect to impact of the SDCP on marketing, both total milk production and milk sold is higher for SDCP (Table 2). The reason attributed to this is due to the fact that SDCP producers indicated that they had sold some milk before the day of the interview and after the interview sold both in the morning and the evening.

Thus, this evidence suggests that there were positive impact on milk marketing. Those farmers selling their milk to the market are able to sell at a price that is 31% higher than the selling price received by non-beneficiaries. Overall, the total value of milk sold, calculated as the product of quantity of milk sold and the price, observed by SDCP farmers is 43% higher than the value of the comparison group. One of the most successful initiatives to help farmers access input and output markets appears to be the expansion of access to credit, as primarily documented in the dairy group surveys and FGDs. SDCP dairy groups were more likely to access a wider range of finance sources, including micro-finance and commercial, but in particularly local savings and loan clubs.

**Table 2:** Impacts on milk production and total value impact

| Dependent Variable | Impact Estimate | Comparison Mean | Treatment Mean | N |
|---|---|---|---|---|
| | (1) | (2) | (3) | |
| Sold milk yesterday any time | 0.08** | 0.42 | 0.50 | 2558 |
| | (1.98) | | | |
| | (2.08) | | | |
| Total litres of milk sold in the morning (yesterday) | 0.12 | 0.86 | 0.98 | 2558 |
| | (1.16) | | | |
| | (1.58) | | | |
| Selling price of milk/litre (yesterday) | 0.31* | 1.81 | 2.13 | 2558 |
| | (1.74) | | | |
| Total value of milk sold | 0.43* | 2.47 | 2.90 | 2558 |
| | (1.71)G | | | |
| Total milk production at calving | 0.58*** | 1.33 | 1.92 | 2558 |
| | (4.72) | | | |
| Total milk production (yesterday) | 0.37*** | 1.13 | 1.50 | 2558 |
| | (3.25) | | | |

## Increased food security

The results in Table 3 shows that SDCP households are more likely to have a more diverse food basket, specially foods with larger levels of animal and vegetable proteins (red meats, milk products, and legumes such as beans, peas, lentils, and nuts), and lower levels of tuber and fruit consumption, which are nonetheless still quite common among SDCP farmers. In general the results provide some evidence that programme beneficiaries were able to exhibit higher levels of food diversification towards more nutritional food items.

Multiple FGD participants revealed that they had increased their income from their agricultural activities as a result of the SDCP which had enabled them to have variety of foods in their households. One farmer said that his family's general health had improved, while others said they now consistently have tea with milk in their house. Farmers' perception of increased food security may partially result from having good knowledge of better farming practices for instance the use of appropriate seeds in a given region, application of organic manure in their farms such as the use of cow dung. Theory of Change explains the process of change by outlining causal linkages in an initiative, i.e., its shorter-term, intermediate, and longer-term outcomes (Keystone, 2016). The identified changes were mapped, as the outcomes pathway, showing each outcome in logical relationship to all the others. The links between outcomes are explained by rationales or statements of why one outcome is thought to be a prerequisite for another. The interventions of Smallholder Dairy Commercialization Programme (SDCP) aimed at increasing milk production and productivity, and enhanced participation in milk markets with reduced seasonal fluctuations. The programme identified three main areas where impediments to improving dairy incomes operated: dairy group activities, household production, and market intermediaries. These three areas conform to three of the programme components.

**Table 3**: Impact on food categories consumed in last 7 days

| Dependent Variable | Impact Estimate | Comparison Mean | Treatment Mean | |
|---|---|---|---|---|
| | (1) | (2) | (3) | N |
| Cereals/grains | -0.00 | 0.99 | 0.98 | 2558 |
| Potatoes/yams/cassava | -0.14*** | 0.89 | 0.75 | 2558 |
| | (-412) | | | |
| Vegetables | 0.00 | 0.99 | 0.99 | 2558 |
| | (0.48) | | | |
| Fruits | -0.11*** | 0.89 | 0.78 | 2558 |
| | (-3.71) | | | |
| Beans/peas/lentils/nuts | 0.03* | 0.88 | 0.91 | 2558 |
| | (1.65) | | | |
| Red meats/other organ meats | 0.17*** | 0.36 | 0.54 | 2558 |
| | (4.82) | | | |
| Eggs | 0.02 | 0.60 | 0.62 | 2558 |
| | (0..46) | | | |
| Fresh/dried fish/shellfish | -0.02 | 0.37 | 0.35 | 2558 |
| | (-0.62) | | | |
| Milk/cheese/yogurt/ other milk product | 0.09*** | 0.80 | 0.89 | 2558 |
| | (3.04) | | | |
| Other (condiments, coffee, tea) | 0.06** | 0.89 | 0.95 | 2558 |
| | (2.41) | | | |
| Household dietary diversity score (HDDS) | 0.16 | 9.81 | 9.97 | 2558 |
| | (1.15) | | | |

Increasing dairy incomes for smallholders emanated from three primary channels: increased milk production, increased prices received from milk sold, and decreased costs of production and of milk marketing. Here we focus on the first three components, as these components address all of the channels to varying degrees. The primary impact is expected to be higher net milk incomes, through increased production and productivity per animal, reduced input costs, reduced transactions costs, and potentially higher farm gate milk prices. The outcomes clearly indicate that there was an impact. The second impact was improved household food security through higher incomes and consumption of milk and increased employment.

## Conclusion and Recommendations

The results of this study revealed that both total milk production and milk sold is higher for SDCP compared to the control group. Those farmers selling to the market are able to obtain selling price that is 31% higher than the selling price received by non-beneficiaries. In general, the total value of milk sold observed by SDCP farmers is 43% higher than the value of the control group. Thus, this evidence suggests that there were positive impacts on milk production and marketing. The results further revealed that the programme beneficiaries were able to exhibit higher levels of food diversification with more nutritional value as demonstrated by the impact estimate of 0.16 for household dietary diversity score. Therefore, SDCP beneficiaries had higher household food security levels compared to the control group.

The study findings revealed that smallholder dairy has been able to transform livelihoods of the beneficiaries in the counties where the project is being implemented. There for this study recommends that the technology needs to be up-scaled in other counties in Kenya.

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# Feeding and hygiene practices for higher production and lower milk postharvest losses among smallholder dairy farms in Kenya

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## Abstract

Postharvest losses in milk (PHL) occur as a result of altered milk quality during production process. This study synthesized the relationships between farm-level practices and milk yield and PHL using qualitative and quantitative data analysis methods. Feeding practices were dominated by zero-grazing in peri-urban and free grazing in rural farms, characterized by low concentrates intake and low quality basal forages that led to low milk production. Improving the practice through training increased knowledge levels and production. However higher milk producers were found to face higher milk PHL for which hygiene milking practices were major contributors. *Staphylococcus aureus* was the major mastitis pathogen contributing to increase in milk somatic cell count that was isolated and used as quality marker. Effects of practices on milk PHL were system specific. In rural herds not washing hands before milking (O.R.: 0.521), Calves not suckling before milking (O.R.: 0.283), use of aluminum containers (O.R.: 0.484) and milking in open field (O.R.: 0.277) had lower prevalence risk of *Staph. aureus*. In peri-urban farms, use of aluminum containers (O.R.: 1.733) for milk handling and milking in a cowshed (O.R.: 3.929) had higher prevalence risk of *Staph. aureus.* Analysis of practices in smallholder dairy systems showed that current feeding practices are not adequate to support higher milk production but it could be improved through training. However, the higher milk production, more farmers turn in the formal market where they experience higher milk PHL. Milking practices are major contributors to these losses but farmers show no incentives to applying good hygiene practices because of lack of strict quality control and uptake based on volume rather than quality.

**Key words:** policy implication, postharvest milk losses, *Staphylococcus aureus*

## Introduction

In Kenya, domestic milk is produced by smallholder dairy herds (75%) and by pastoral cattle and camel herds (24%). On average, smallholder dairy herds produce 10 kg of milk per herd per day from about 2 cows while pastoral camel herds produce 37 litres per day from 17 camels (Kashongwe *et al*, 2017a) of which over two thirds are marketed but predominantly through the informal market outlets. Compared to formal markets, the informal markets sell raw milk to low-to-middle income consumers, taking advantage of their preference for taste of raw milk sold at prices lower than those of pasteurized milk (Muriuki, 2001, Noor *et al*, 2013). However, selling raw milk in the informal market outlets impacts on the hygiene and shelf-life of milk. Kashongwe *et al* (2017b) demonstrated that about 19% of milk marketed in smallholder dairy cow herds is high in somatic cell counts (SCC). At the farm, this spoilage of milk is due to contamination with foreign substances and harmful microorganisms that pose public health risks to consumers (Wafula *et al*, 2016, Makau *et al*, 2016). Farm-level postharvest losses milk (PHL) is the proportion of milk with deteriorated value through spillage (as a result of accidental pouring) or spoilage (caused by proliferation of microorganisms). Poor hygiene of the cow udder, milking environment, milking person and milk storage containers contribute to physical and microbiological contamination of the milk, hence spoilage (Kashongwe *et al*, 2017b and Wafula *et al*, 2016). Mixing the evening and morning milk is another source of milk spoilage, where preservation of evening milk lacks cooling facilities (Younan, 2004 and Lore *et al*, 2006). Milk microbial load is increased and shelf life shortened where farmers do not practice pre- and post-milking disinfection of

the udders surface and equipment (Gleeson *et al*, 2009). Feeding practices play an important role because they affect milk production. The diversity of diets in smallholder and pastoral camel herds are associated with available feeds and influence milk yield, composition and quality (Kashongwe *et al*, 2017a). This study synthesized the hypotheses that milking, milk handling and feeding practices influence milk production, quality and post-harvest losses.

## Methodology

Data was obtained from representative smallholder dairy cow and pastoral camel herds from rural and peri-urban areas, which accounts for 80% and 12% respectively of the total domestic milk in Kenya (Muriuki, 2001; FAO, 2003). The herds were sampled in stratified cross-sectional surveys for data collection at the herd and animal levels. Complementary data was obtained in longitudinal action research. The design was made to foster innovation capacity of smallholder farmers in finding solutions to low production and quality milk which impacts on milk PHL and incomes.

## Results and discussion

### Feeding practices affect milk yield and could be improved through training

#### *Feeding practices in smallholder dairy herds*

There was a diversity of feeding practices in smallholder dairy herds. Cut-and-carry feeding (semi-zero and zero-grazing) was deployed in response to limited land for fodder production (Napier grass, oats) and was characterized by use of crop residues and off-farm feed resources (forages and concentrates). Free grazing was prominent in rural smallholder herds where cows are fed on natural pastures supplemented with Napier grass and concentrates (Table 1).

**Table 1:** Characteristics of smallholder peri-urban and rural farms

| Variables | Peri-urban | Rural |
|---|---|---|
| Dominant feeding practice | Zero-grazing | Free grazing |
| Land used for crop production (acres) | 0.88 | 3.12 |
| Land for fodder/ pastures (acres) | 0.12 | 2.08 |
| Total milk production (litre/per year) | 2704 | 6240 |
| Average milk price (USD/litre) | 0.33 | 0.31 |

The low average milk production in smallholder rural (6 kg) and peri-urban (5 kg) herds could be related to inadequate feeding in nutrient quality and quantity (Njarui *et al*, 2011). Regression modeling of the effects of these variables (basal forage, forage supplement and concentrates) on milk yield showed positive contribution of basal forage and concentrates (Table 2).

**Table 2:** Regression estimates of effects of feed quantities on milk yield in smallholder dairy farms

| Feeds | Estimate | Std Error | P-value |
|---|---|---|---|
| *Smallholder peri-urban* | | | |
| Basal forage | 1.434 | 0.369 | 0.0015 |
| Forage supplement | -0.854 | 0.537 | 0.1327 |
| Concentrate | 1.004 | 1.860 | 0.5971 |
| *Smallholder rural* | | | |
| Basal forage | 2.336 | 0.386 | <0.001 |
| Forage supplement | -1.111 | 0.545 | 0.046 |
| Concentrate | 3.512 | 1.133 | 0.0029 |

### Training to improve knowledge on recommended practices and production

An attempt to improve feeding practices was through training session in action research conducted in smallholder rural (Olenguruone) and peri-urban (Mukinduri) farms. The peri-urban farms chosen for the

intervention had already been exposed to improved farm practices through collaborative learning process (Restrepo et al., 2016). Improvement of feeding practice consisted of planting and managing forages in the field (planting); preserving forages and value addition through silage making and treatment of crop residues (preserving) and feed formulation (formulation). This resulted in increased milk production as reported in Kashongwe *et al*, (2017d). Assessment of knowledge level showed an increase in farmers' knowledge on forage management after training (Figure 1 and 1), though knowledge of cow feed requirements and formulation of feed ration remained relatively low. These findings are in agreement with Kiptot et al. (2015) who also reported lack of technical knowledge on silage/ hay making and feed formulation in smallholder farms in Kenya. Their recommendation on more training on feeding practices show the importance of training in improving farmer's knowledge since it creates a more receptive environment for application of better practices (Nampanya et al., 2012). This could be a more beneficial approach than only introducing new feeds and more effective than public awareness programmes (Nampanya *et al*., 2012).

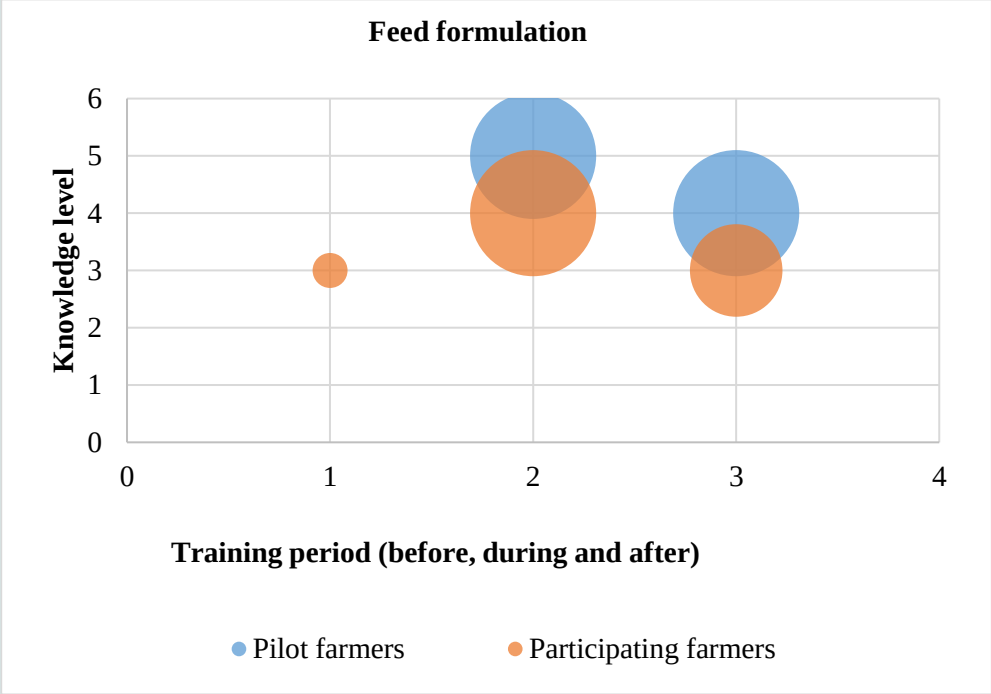
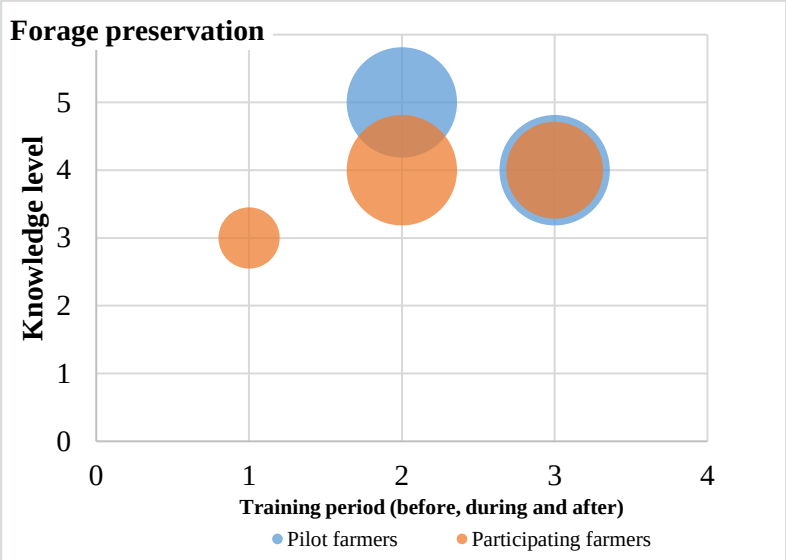



**Figure 1**: Knowledge level and proportion of participating farmers (size of the shape) with knowledge on training items in peri-urban farms for pilot and participating farmers.



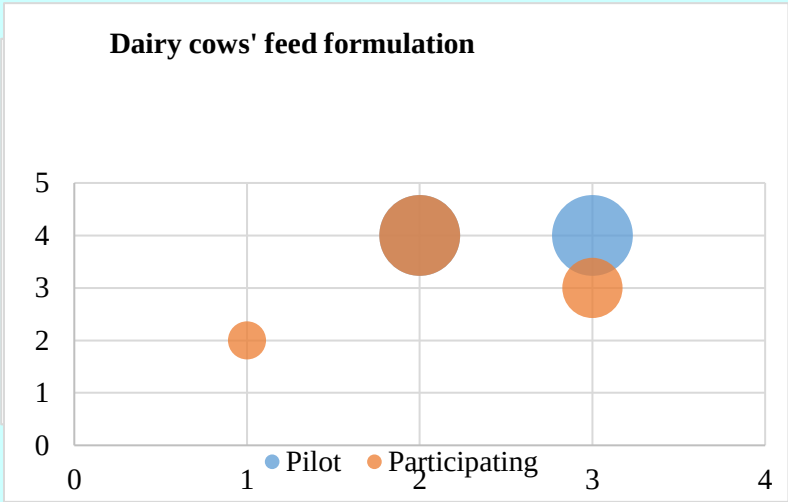




**Figure 1:** Knowledge level on feed management and rations formulation assessed before and after training in rural farms for pilot and participating farmers.

**Hygiene practices during milking, a risk of PHL that could be reduced through training**

**Risks of PHL due to milking practices in smallholder dairy herds**

Milking practices have influence on PHL through association with high prevalence of mastitis causing pathogens, especially *Staph. aureus*, which increased SCC level. In a previous study by Kashongwe et al (2017b), an estimated 19% PHL in smallholder dairy herds were associated with high SCC. The losses were a consequence of ineffective practices that varied with production system. The risk prevalence of *Staph. aureus* in smallholder rural herds was associated with hand washing, type of milk handling container, calves suckling prior to milking and presence of cowshed (Table 3). Not washing hands had half (Odds ratio 0.521) risk prevalence of the *Staph aureus* than those washing hands, because farmers were not following recommended procedure in pre-milking hand washing with use of sanitizers (Lore et al., 2005; Wanjala *et al*, 2016). The way it is practiced, hand washing is unable to remove pathogenic microorganisms even with use of detergent (Wafula *et al*, 2016). Risk prevalence of *Staph aureus* was lower when handling milk in aluminum containers than in plastic containers (Odds ratio 0.484) in smallholder rural farms. Despite milk regulator in Kenya (Kenya Dairy Board) banning use of non-food grade plastic containers commonly used for milk handling, both smallholder farmers and

pastoralists continue to use plastic containers. Though it is easier to clean aluminum containers, farmers and pastoralists find the non-food grade plastic containers cheaper, more convenient for transporting milk over poor roads in rural and pastoral areas (Wafula *et al*, 2016; Kashongwe *et al*, 2017c) and better fit to size for marketing small milk volumes.

In the peri-urban areas, milk transporters often pool milk from several farms in aluminum containers, which increases the risk of milk contamination (Odds ratio 1.733) with milk of poor quality from other farms (Kashongwe *et al*, 2017c). The risk prevalence of *Staph. aureus* was lower when calves were not suckling compared to when they were suckling (Odds ratio 0.283), which contrasts the results of Wagenaars and Smolders (2008) who found no effects of calves suckling on milk quality. But they are in agreement with Lore *et al.* (2005) who found an increased risk of mastitis pathogens due to calves suckling in conditions where other pre-milking preparation procedures are properly applied. However, in pastoral conditions without water for pre-milking preparation, calves suckling was associated with reduced risk prevalence of *Staph. aureus* (Odds ratio 0.175) (Table 3). This has implications on policy recommendation on calves suckling, that they should be specific to management practices deployed. While it may be beneficial in pastoral camel herds, it may not be recommended practice in smallholder dairy herds if other pre-milking practices are correctly applied.

Milking in the open field in smallholder rural herds had lower risk prevalence of *Staph. aureus* (Odds ratio 0.277) than in a cowshed, while the risk was nearly 4 times higher for those without a cowshed in smallholder peri-urban than those with. Kashongwe *et al* (2017b) explained that reduced accumulation and spread of pathogens from the environment to the cows occurs when milking in open field on the pastures as practiced in rural farms. In the peri-urban, milking is on bare grounds. Milking in such conditions should be in a cowshed with concrete floor for easy animal protection from contamination. Smallholders may achieve this with iron sheet roofing and concrete floor.

**Table 3:** Milking and handling practices associated with the presence of *Staphylococcus aureus* in milk from smallholder dairy cow rural and peri-urban and pastoral camel herds

| **Practices contributing to presence of *Staph aureus*** | **Risk prevalence of *Staph aureus* (Odds ratio)** | **Confidence Interval (95%)** |
|---|---|---|
| *Smallholder rural* | | |
| Hand washing (No vs Yes) | 0.521 | 0.020 – 13.376 |
| Container (Aluminum vs Plastic) | 0.484 | 0.056 – 4.207 |
| Calves suckling (No vs Yes) | 0.283 | 0.039 – 2.081 |
| Owning cowshed (No vs Yes) | 0.277 | 0.047 – 1.629 |
| *Smallholder peri-urban* | | |
| Container (Aluminum vs Plastic) | 1.733 | 0.347 – 8.652 |
| Owning cowshed (No vs Yes) | 3.929 | 0.301 – 51.256 |

## Conclusion

Analysis of practices in smallholder dairy systems showed that current feeding practices are not adequate to support higher milk production but it could be improved through training. With higher milk production, more farmers turn in the formal market where they experience higher milk postharvest losses. Milking practices are major contributors to these losses but farmers show no incentives to applying good hygiene practices because of lack of strict quality control and uptake based on volume rather than quality.

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# Performance of emerging dairy services agri-enterprises A case of youth-led service provider enterprises (SPEs)

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## Abstract

The growth of the Kenyan dairy sector has triggered an increase in smallholders' demand for various external inputs and services. As a result, many business opportunities have emerged along the dairy value chain related to extension, advisory services and inputs delivery. This paper presents a case study of the youth-led service provider enterprises (SPEs) that has emerged to offer commercial support services to entrepreneurial smallholders and medium scale farmers in the vibrant Kenyan dairy value chain. The study assessed sampled SPEs in relation to their technical (i.e. soundness, quality and effectiveness of service delivery) and entrepreneurial performance (i.e. management, marketing and income generation). Eight SPEs were purposively selected. Majority (53%) of active SPE members fell within the youth bracket (18 - 35 years) and 94% were male. In general SPE services have contributed positively to the dairy supply chain where they are operational. The eight SPEs made an estimated 11,268 tonnes of silage in 2016, mainly from maize. Farmers that sought SPE services reported some increase in productivity. The SPEs' income ranged between 5,300 and 46,500 average KES per month mostly from silage making. Equipment problems and limited financial capacity of farmers to pay for services are among the main challenges that affect SPEs' technical and entrepreneurial performance respectively. Beyond the technical aspect of the services, SPEs need to pay equal attention to the business/entrepreneurial dimension of their work in order to realise business opportunities and create viable enterprises.

## Introduction

The growth of the Kenyan dairy sector has triggered smallholders' demand for various external inputs and services in order to meet the increasing demand for more and better quality milk, delivered at low costs and with sustainable practices (van der Lee *et al.*, 2016). As a result, many business opportunities have emerged along the dairy value chain related to extension and advisory services and inputs delivery, attracting entrepreneurs. Increasingly, the youth that are seeking to venture into various agri-businesses either individually or as groups are pursuing these opportunities (Kilelu *et al.*, 2016; Linguli and Namusonge, 2015; MoALF, 2017). The Service Provider Enterprise (SPE) is an innovative youth-led business model in which young men and women form groups to offer commercial support services to entrepreneurial smallholders and medium scale farmers in the vibrant Kenyan dairy value chain.

**SPE Building Blocks**

| Sector Choice | Skills development | Branding | Evolution |
|---|---|---|---|
| - Vibrant economic sectors<br>- Target clients (farmers) willing to pay for services | - Targeted practical skills development<br>- Complementary (hands-on) & credible expertise | - Group enterprise<br>- Local (next-door) service provider<br>- Identity (brand) and standards | - Reskilling<br>- New service products<br>- Seek out new sectors<br>- Expand opportunities |

Summarises the main building blocks of the SPE model.

The value proposition for SPEs is to offer silage making services to dairy farmers, complimented with advisory support on feeding and dairy cow management, in order to improve productivity. The model was initiated as a pilot in 2010 with the support of SNV's core subsidy funded dairy program (SNV, 2013). Interested recruits received short-term practical training on technical aspects of silage making and some areas of dairy cow management. The pilot started with four SPEs located in Nyandarua, Nyeri and Embu Counties. These four SPEs later formed a limited company – SPEN (Service Provider Enterprise Networks) Ltd. The SPEs are linked to Dairy Farmer Co-operative Societies (DFCS) to provide services to their members and suppliers (Table 4). Since 2012, SNV's Kenya Market-led Dairy Program (KMDP) has facilitated formation of 29 SPEs spread across six Counties: 21 in Meru, 3 in Nyandarua; 2 in Baringo and 1 each in Nyeri; Nakuru and Uasin Gishu.

## Methodology

Eight SPEs were purposively selected for the study (Table 4). Data was collected using structured interviews with SPE representatives, focus group discussions (FGD) with sampled farmers and managers of DFCSs and the Meru Dairy Farmers Cooperative Union (MDFCU).

**Table 4**: Details of DFCSs linked to selected SPEs in the study

| County | SPE | | Related DFCS | |
|---|---|---|---|---|
| | Group name & active members | | Active DFCS members in 2016 | |
| Baringo | Bokimu | 3 | Mumberes | 1093 |
| | IDM | 4 | Kiplombe Farmers | 1500 |
| Meru | Drip | 6 | Nkuene | 1270 |
| | Bidii | 4 | Mbwinjeru Ariithi | 340 |
| | DASPE | 5 | Naari | 544 |
| Nyandarua | Intertech | 3 | Nyala | 8500 |
| | Ngorika | 4 | New Ngorika | 900 |
| Nyeri | Unique | 3 | Kiunyu | 80 |
| **Total** | **8** | **32** | **8** | **14227** |

## Results

### Characterization of selected SPEs

The age of the sampled SPE members ranged from 18 to 60, with the majority (53%) falling in the youth bracket (18 - 35 years). Majority (59%) had attained a secondary school education and about 38% had continued with post- secondary training. It was also noted that 94% of the active SPEs members were male.

### Types of services offered

Silage making was the initial value proposition for establishing SPEs. Most farmers in the study regions had not used silage before the SPEs and relied on traditional feeding practices. As **Figure 1** shows, most SPEs also offered a range of other services.

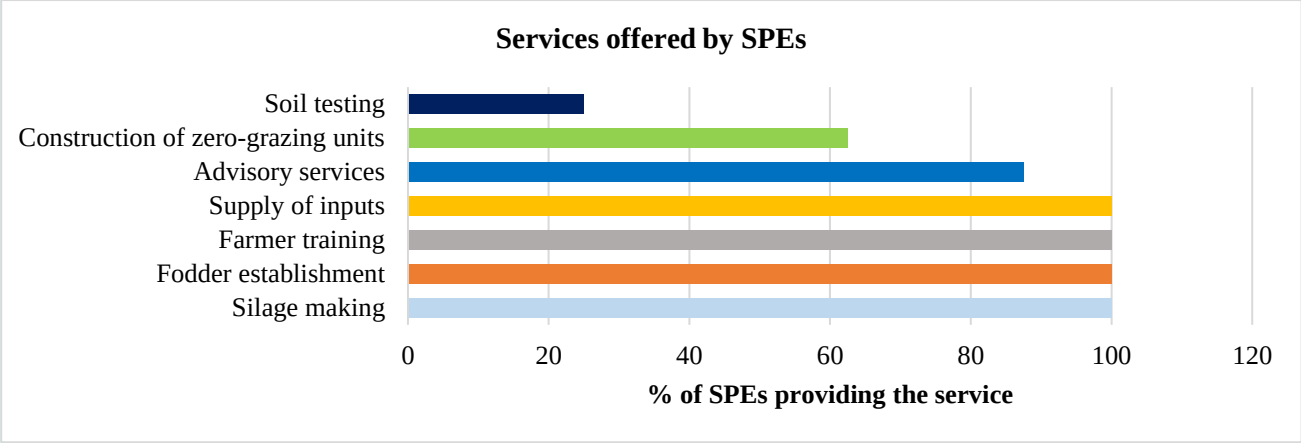


**Figure 1:** Service provision by SPEs (n = 8)

Other benefits of SPE services that farmers mentioned include improved dairy cow management; better animal health and weight gain, reduced costs of buying feed and time saved from collecting feed outside the homestead. Construction of zero-grazing units was noted to reduce wastage of manure.

### Assessing technical performance of SPEs

The eight SPEs made an estimated 11,268 tonnes of silage in 2016. As Figure 2 shows, two SPEs in Meru, i.e. Bidii and Drip SPEs, made the highest volumes of silage of about 3100 and 2900 tonnes respectively in 2016, most of which was maize silage. The SPEN groups, Unique and Intertech made between 1500 and 1700 tonnes of silage. On average, farmers conserved between 0.3 and 66.2 tonnes of silage annually. Generally, farmers were satisfied with the SPEs because they made quality silage.

### Effects of the SPE services on-farm and on the supply chain

#### Farm level outcomes - more milk, more money

Farmers who sought SPE services reported some increase in productivity. In Meru, where most silage was made, productivity was up to about 9.5 l/cow/day for Nkuene DFCS and 8 l/cow/day for Mbwinjeru Ariithi DFCS.

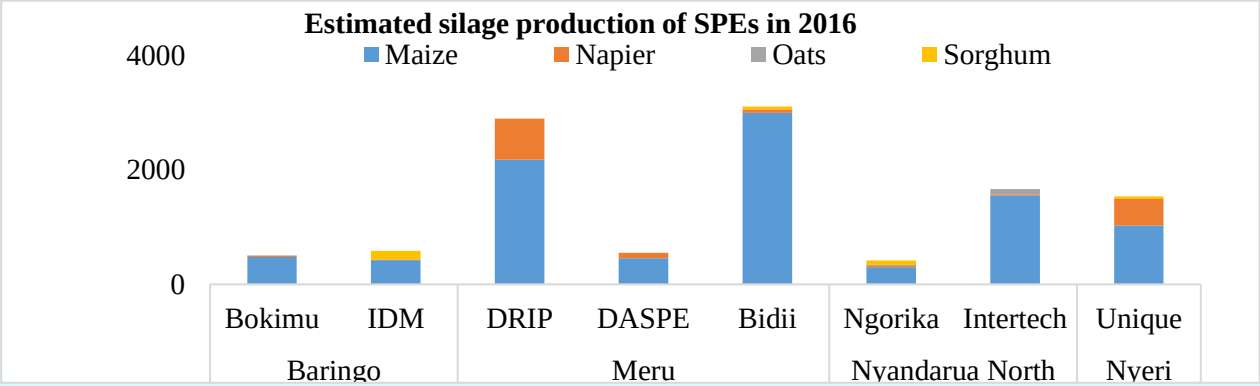


**Figure 2:** Silage production in 2016 by different SPEs

This is in comparison with the average productivity of 5/cow/day in dairy producing regions in the county (MoALF, 2010). Farmers also reported reduced fluctuations in their milk volumes during the dry season. Farmers noted that silage contributed to this nominal increase. More effort is needed to enable higher increases in productivity. Farmers in these two DFCSs also generated a higher average daily income from milk sales to the DFCSs as compared to those in other DFCSs (i.e. KES 1779 and KES 804 respectively). However, more analysis is needed to generate actual gross-margins.

## Effects of SPE support on the supply chain

Increased production at farm level resulted in an increase in the volume of milk collected by DFCSs. Where more silage was produced, e.g. Meru DFCSs, the managers also indicated that their daily milk collection was stabilising during all seasons. Furthermore, the volume of milk was within their set targeted range (**Error! Reference source not found.**). This was an indicator that SPE services had a positive effect along the dairy value chain.

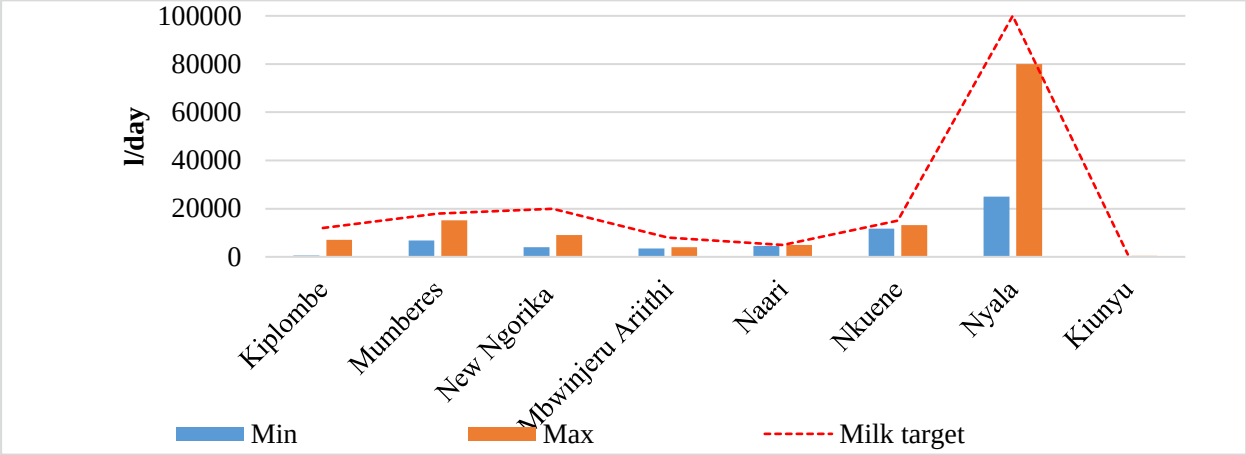


**Figure 3:** Average milk collected by DFCSs in 2016

Secondary data of the DFCS annual milk intake showed an overall increase in volumes collected across all DFCSs from 2012-2015 except Kiplombe DFCS. MDCU also reported a difference in the volume of milk collected from DFCSs that worked with SPEs. Whilst there may be many factors that contributed to more milk intake including increased membership and supplier loyalty, DFCS representatives pointed to the fact that SPE services contributed to the increase in their milk collection.

## Challenges limiting SPE technical performance

- Equipment problems (breakages, limited access and poor quality, e.g. for compacting)
- Poor quality of silage making material (e.g. polythene).
- Poor quality/inaccessible fodder seeds for forage establishment
- Farmers uncovering silage before it is ready
- Drought hence fewer silage making opportunities.

## Assessing the entrepreneurial performance of SPEs

## Client-reach and business operation

SPEs have been able to reach out to many farmers, although most of the interactions seemed to be for promotional and demonstration purpose. The sampled SPEs provided silage making services to about 950 farmers in 2016. This is equivalent to about 7 % of total active DFCS farmers, the main client base for the SPEs. This shows that SPEs have not saturated their market. In order to grow their client base, the SPEs marketed their services through various channels. However, SPEs mostly acquired new assignments through word-of-mouth referral. Most SPE members offered services individually rather than as a group, although they use the SPE name to acquire assignments.

## Income generation and investments of SPEs

Silage making services made up the larger portion of SPEs' income. SPE charged between KES 250 and KES 1,000 per tonne, depending on whether the SPEs paid for labour and provided choppers. DASPE

charged a daily rate of KES 2, 000 irrespective of the amount of silage made. Farmer training was mostly for promotional purposes without charge, or paid through a third party. The results show that Unique members made the highest monthly income from silage making in 2016 averaging about KES 46,500 and DRIP made the lowest: KES 5,300. SPEs also sold inputs, mainly fodder seeds. In 2016, Intertech SPE made the highest annual income (KES 176,500) as a group from sales of various types of fodder seeds. Some SPEs made various investments to enhance their business include the purchase of new and efficient silage chopping machinery. Others indicated that high cost of machinery prevented them from investing.

**Business challenges limiting SPE performance**

- Farmer refusal/delay in payment and limited financial capacity of farmers to pay for services
- Difficulty in determining appropriate costing or pricing of services
- Slow farmer adoption of promoted technologies and practices
- Poor planning by farmers when requesting for services resulting in waste of time/resources
- High costs of promoting and marketing services (e.g. doing many free demonstrations)
- Limited financing to acquire appropriate and quality machinery
- High work load and unavailability of casual labour, especially during peak season
- After practical exposure, farmers start making silage resulting in fewer repeat customers

**Discussion and conclusion**

**Enabling entry of youth into agribusiness**

The SPE model has enabled an entry of out-of-school youth into business and income generation activities in the agriculture sector. Through practical training, SPEs offered livelihood opportunities to rural youth who have completed high-school education. Such vocational training is argued to be important to enable fast entry for youth into agri-business (FAO and IFAD, 2014).

**Complementarity and viability of the SPE model**

SPEs offer complementary services to farmers with the potential to fill in gaps in the extension support and to enhance the cost-effectiveness and quality of services (Birner *et al.*, 2009). However, most SPEs have not attained the full potential performance, due to seasonality of business and low market penetration. Where SPEs work with DFCSs, their relations could be strengthened to stimulate business opportunities and contribute a robust dairy supply chain (Kilelu *et al.*, 2016). What remains to be seen is whether these bundles of services stimulate a sizeable market demand that enable the SPE to generate decent incomes over time (Poulton et al. 2010).

**SPE propagation and dynamics of entrepreneurship**

As observed in this study, the potential client base is largely untapped and the current numbers of SPEs are not able to cover this base. This raises the issue of how to propagate and scale the model. Attracting more service providers into the business can be a first step to scaling up the model. But rather than focusing on growing the numbers of service providers there is need to understand the "scaling readiness" (Sartas *et al.*, 2017) of this innovative service delivery model in light of the challenges that limit performance. Results suggest that SPEs lack adequate entrepreneurial skills to match their technical skills. The study also shows high attrition (57% drop out rate) and mobility that can be linked partly to seasonality of business for member. For success enterprise development policy support needs to approach SPEs as small and medium-scale enterprises (SME) that need a range of support services e.g. targeted financial services and business development support (BDS).

## SPEs as an inclusive model

By design, the SPE model in inclusive as it aims to attract youth to opportunities in agribusiness. However, the findings show that few (youth) women joined and even fewer remained active after recruitment i.e. a retention rate of 6% for sampled women. This points to the need for a gendered analysis and approach to the issue of youth and agriculture, paying attention to how best enable equitable participation and opportunities of young women in agri-business (Filmer and Fox, 2014; Heinrich-Böll-Stiftung, 2015). However promoting youth in agribusiness is not only about being inclusive, but also about enabling viable businesses that equally contribute to agri-food sector development. Finding a good fit between aspiration of youth and opportunity in agribusiness for a decent livelihood should guide program-led agri-entrepreneurial development. This also requires a broad look at the challenges facing youth in relation agricultural transformation and employment (Mgumia, 2017; Muiderman *et al.*, 2016).

## Performance of the SPEs as service agri-enterprises

The SPEs have contributed positive outcomes at farm and supply chain level in some regions. At farm level, farmers' knowledge and skills were enhanced and productivity improved. There was also closing of the seasonal fluctuation gap, which cascades to other supply chain actors. The entrepreneurial performance for most SPEs shows most have not reached full potential. This is due to seasonality of the business and low market penetration. While private service delivery can contribute to sustainable intensification and commercial orientation for smallholders, low demand makes it unsustainable for private sector actors to provide such services (Birner *et al.*, 2009; Poulton *et al.*, 2010; Bebe *et al.*, 2016; Kilelu *et al.*, 2016). There is need to understand how best to stimulate and sustain this demand.

## Evolution of the SPE model and some lessons learnt and recommendations

The SPEs started off by offering a specific service and evolved to offering more and sophisticated services. However, the evolution is not only about increasing the number of services offered, but also about ensuring that services are oriented toward offering a "best-fit", that is, to meet farmers needs to optimize their production and enterprise results (Birner *et al.*, 2009). Factors that need to be considered in strengthening the SPE model are: 1) Broad skill (beyond silage making) acquisition and their demand, 2) DFCSs support and SPE performance and 3) Personal attributes.

To further strengthen and scale the SPE model the following recommendations targeted at development and public agencies:

- **Broadening training**- There is a need to balance vocational, technical and entrepreneurial skills during recruitment and training.
- **Public investment is needed**- Such investment can play a role in facilitation of skill acquisition and deployment of SPEs
- **Strengthening business partnerships-** The DFCSs should consider to embed SPEs in their business development plans, as being complementary to or part of their extension system, to enhance fodder access of DFCS while facilitating assignments for SPEs.
- **Business model sustainability** – To increase the sustainability of the SPE model, development organizations and public agencies need to consider the pros and cons of having SPEs as independent businesses versus having the SPEs anchored on the support of DFCSs.
- **Inclusiveness** - To make the model more gender and youth inclusive, the needs of young women, who are the minority in the SPE model, as well as the broader aspirations of youth need to be factored. Inclusiveness is not an end in itself but should as factors that can contribute to sustainable agri-food sector development.

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# Value Chain Analysis of Kenyan Rabbit Industry. The case of Kiambu, Nakuru and Nyeri Counties

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## Abstract

Rabbit farming is increasingly being practiced in response to climate change, population increase, urbanization and changing consumption patterns. This is due to rabbit's unique features such as fast growth rate, high fecundity, feed conversion efficiency and early maturity. The purpose of the study was to map out the rabbit value chain in Nakuru, Kiambu and Nyeri Counties of Kenya, documenting producers' perspectives on rabbit's production and marketing, and the challenges they encounter. It was found out that majority of the farmers in the three study areas fed their rabbits on locally available materials. In addition, more than half of the studied households kept their rabbits with an aim of selling. However, it was noted that such farmers had a small market share which is a clear indication that the farmers are being exploited by traders. Diseases and parasites and lack of market were found to be among the challenges facing rabbit producers. There is need to strengthen the rabbit groups with a possibility of registering them as cooperatives for the purpose of collective bargaining for better prices and access to information.

**Key words:** Value chain analysis, rabbit, Kenya.

## Introduction

## Value Chain Mapping

The term value chain refers to all events which are carried out to change a product from conception, which involves various levels of production, distribution, ultimate consumption to discarding after use (Kaplinsky and Morris, 2002). Value chain analysis is rapidly applied as a tool to establish agricultural goods markets (Humphrey, 2005; USAID, 2006). Linkage to functional value chains comes with several benefits to farmers. According to McCormick and Schmitz (2001), enterprises with well-structured trading networks are always associated with increased trade thus high benefits for those involved. Value chain analysis helps to identify lead firms in various industries. Farmers that are connected to a lead firm in a value chain are found to increase production rapidly. This is because the presence of lead firms encourages the transmission of best practices and help in the provision of the required production advice such as good animal husbandry (Kaplinsky, 2000).

The global consumption of livestock products has rapidly increased in the past century owing to growth in income, population and urbanization (FAO, 2016; Bett *et al*., 2012). In order to meet the high demand for animal products, alternative sustainable sources of protein need to be exploited (Akinmutimi, 2007). Among the available options, rabbit (*Oryctolagus cuniculus*) has been identified as a suitable alternative (Mailafia *et al*., 2010; Hassan *et al*., 2012; Mailu *et al*., 2013) owing to its fast growth rate, high fecundity, feed conversion efficiency and early maturity. With good husbandry, rabbits can produce above 40 kids per annum compared to one calf per cow and up to two kids in goats (Kitavi *et al*., 2015). In addition, quick and high returns can be earned within a short time of approximately six months from the enterprise thus considered profitable.

Rabbit meat has also been found to be important for people in need of special diets, for example, patients suffering from heart-related diseases, diets meant for the aged, diets with low sodium, diets meant for

weight reduction, etc. Compared to other types of meats such as beef, pork, and chicken, rabbit meat has the highest protein (20.8%) and lowest fat (4.5%) , calorie (795 lb), and cholesterol contents (Van Heerden and Mentani, 2010) (Figure 1). The levels of obesity associated with chronic diseases and cancer have increased in both developing and developed countries thus affecting food security and nutrition (Neumann *et al*., 2010).

A study by Mailu *et al*. (2013) showed that Kiambu, Nyeri and Nakuru were some of the counties in Kenya where rabbit farming had increased tremendously over the last couple of years. This increase in investment in rabbit enterprise may be attributed to launching of an initiative in May 2011 by the government of Kenya to promote rabbit production as an enterprise which can promote food and nutrition security and poverty alleviation thus contribute to achievement of Kenya's Vision 2030 (Mutisya, 2014). Some of these counties have shown efforts in supporting rabbit enterprise. For example one of the priority areas in Nakuru County Intergrated Development Plan (2013-2017) is promoting and improving rabbit keeping.

Despite the high potential of rabbit farming in Kenya, the sector has not been fully exploited. Although past studies have shown that most farmers in Kenya have adopted rabbit farming as a commercial enterprise, there is limited information relating to the rabbit value chain in Kenya. The purpose of this study is therefore to map out the rabbit value chain in Nakuru, Kiambu and Nyeri Counties of Kenya, document producers' perspectives on rabbit production and marketing, and the challenges encountered by farmers. A thorough analysis of the rabbit value chain could facilitate further innovations in the production and marketing of this important food commodity.

## Objectives

The general objective is to analyze the Kenyan rabbit value chain. The specific objectives are as follows;

1. To characterize the Kenyan rabbit value chain,
2. To assess the constraints facing rabbit producers in Kenya.

## Methodology

The study employed a multistage sampling procedure. Three counties (Kiambu, Nakuru and Nyeri,) were purposively selected because of high number of farmers involved in rabbit keeping (Serem *et al*, 2013). The next step involved listing all the sub- counties in each of the three counties. One sub-county was selected from each county. The sub-counties were selected based on the number of rabbits in each. One ward with highest number of rabbits was selected from the selected sub-counties of each county. A list of all farmers who practiced rabbit farming was drawn with the help of community elders. The list formed sampling frame for the study. The respondents were then sampled from the two lists using probability proportionate to size sampling method. Based on the list, 230 rabbit farmers were sampled at population level in the three counties. The study also used focus group discussions (FGD) and key informant interviews so as to understand the current situation of rabbit farming in the study areas. A total of 80 traders were sampled in the three study areas.

## Results and Discussion

Figure 1, figure 2 and figure 3 provide detailed flow of rabbit and its products along the value chain in Nakuru, Kiambu and Nyeri Counties of Kenya.

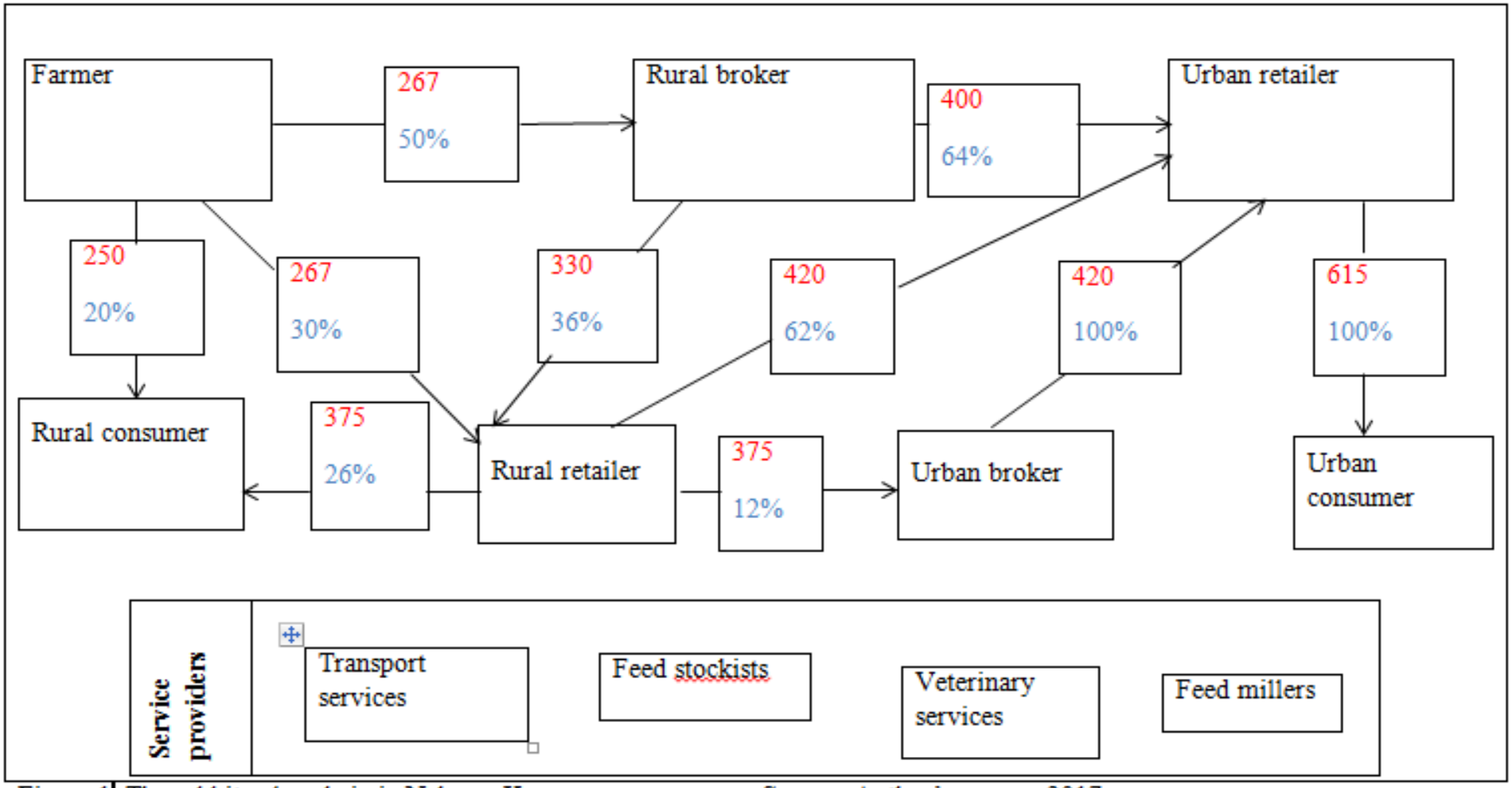


Figure 1: The rabbit value chain in Nakuru, Kenya Source: Author's survey, 2017

NB: Numbers highlighted in red are prices in Ksh per kg of rabbit traded

Numbers highlighted in blue are proportions of number of rabbits traded at each stage of the value chain

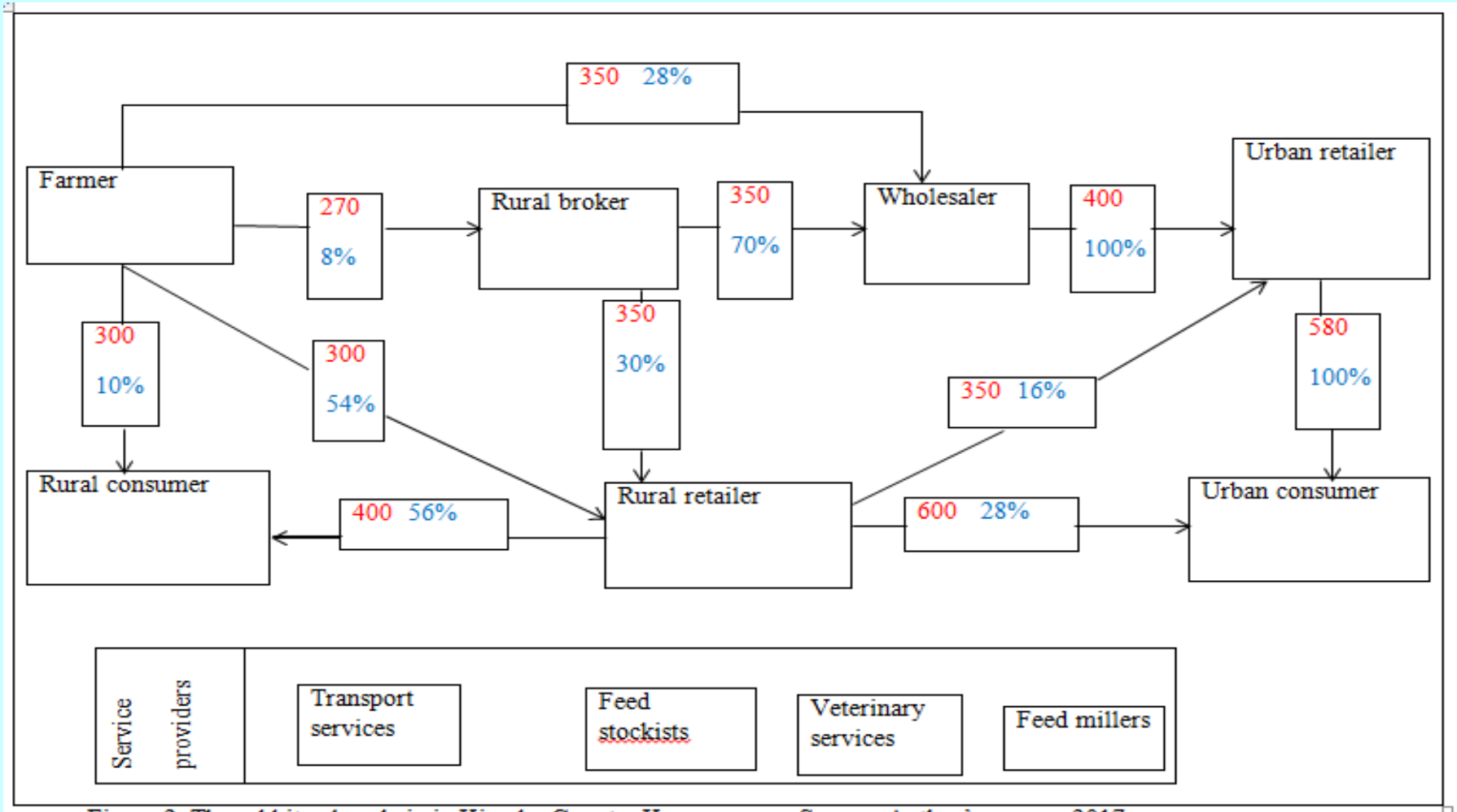


Figure 2: The rabbit value chain in Kiambu County, Kenya Source; Author's survey, 2017

NB: Numbers highlighted in red are prices in Kenyan shillings per kilogram of rabbit traded and those in blue proportions of number of rabbits traded at each stage

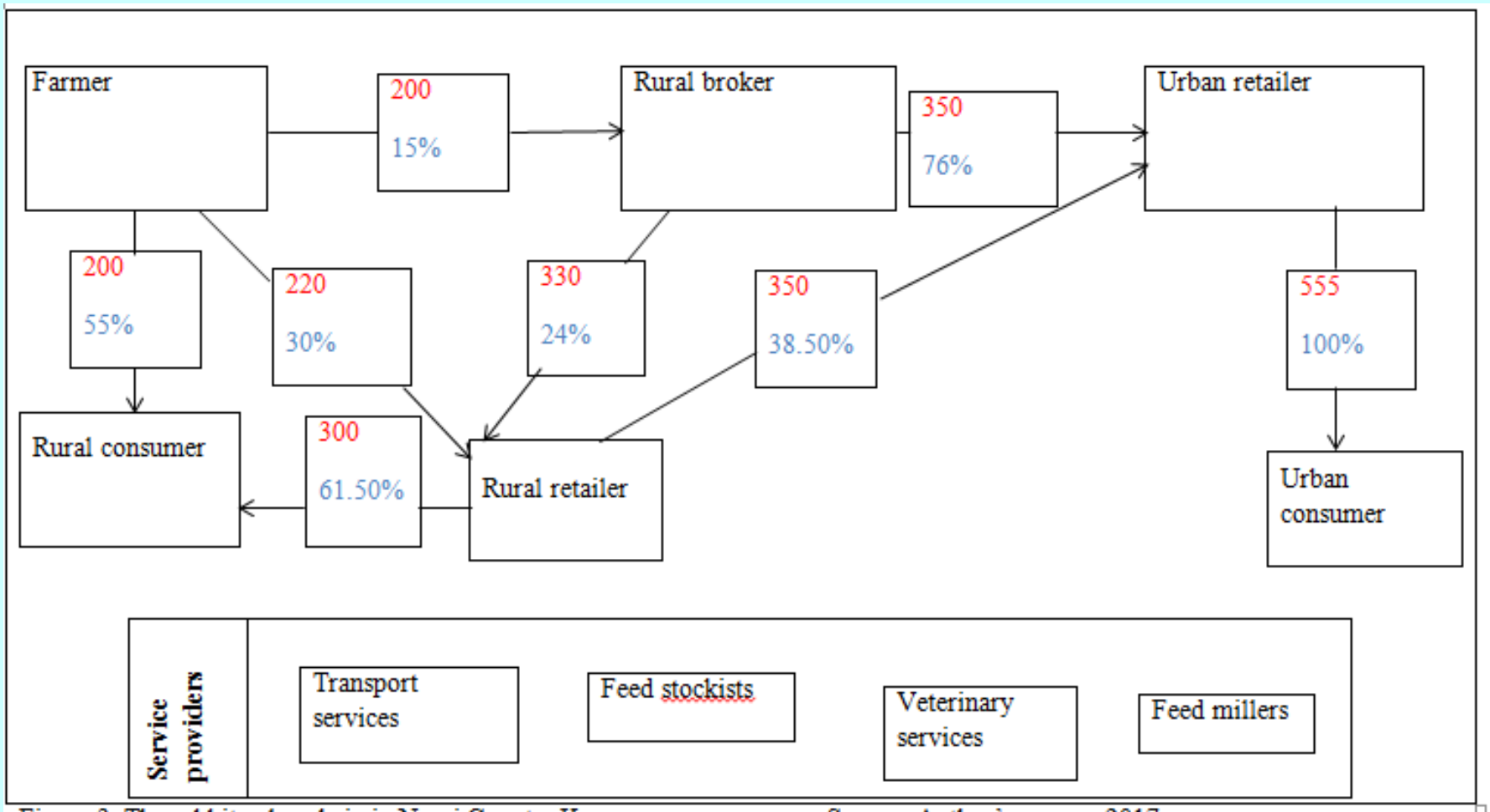


Figure 3: The rabbit value chain in Nyeri County, Kenya Source: Author's survey, 2017

NB: Numbers highlighted in red are prices in Kenyan shillings per kiloram of rabbit traded and those in blue proportions of number of rabbits traded at each stage

## Input source and Production

The findings of this study revealed that most of the rabbit producers are small-scale rabbit producers in the three study areas. More than 50 percent of farmers surveyed in the respective counties had less than 10 rabbits in their farms. This finding concurs with that of Hungu *et al*. (2013) and Wanyoike *et al.* (2013) who pointed out that majority of rabbit farmers in the three study areas practice small-scale rabbit farming. Majority (more than 60 percent) farmers in the three counties obtained their parent stock from neighbouring farmers. Out of the surveyed farmers in Nyeri County, only 5 percent purchased their parent stock from Wambugu multiplication station. The low proportion of farmers acquiring their stock from the station was attributed to high prices of the breeds. In Nakuru County, some farmers supported by county government's department of livestock had high quality rabbits breeds especially the New Zealand which they sold to other farmers in the area. Farmers purchased local breeds at an average of Ksh. 400 while they bought improved breeds at Ksh.1,250. Improved rabbit breeds in Kiambu County were reported to be purchased from Ngong Veterinary Farm and farmers.

Majority of the farmers in the three study areas fed their rabbits on locally available materials such as wild grasses (weeds, legumes), indigenous plants and herbs, cultivated forage (hay), farm crop residue (such as potato vines), agricultural by-products and kitchen waste. These materials were reported to be easily accessible by farmers from their own farms. Some farmers in all the study areas were reported to be mixing locally available feeds with purchased feeds from the shops. This was done to reduce the cost of solely depending on manufactured feeds which were viewed as expensive by majority of the farmers surveyed. One kilogram of rabbit pellets feed from the shops was sold at an average of Ksh. 50.

More than 50 percent of farmers in the three regions kept rabbits with the hope of selling with Nakuru having 52 percent, Kiambu 58 percent and Nyeri 51 percent anticipating to sell their rabbits. This finding agrees with that of Mailu *et al*. (2013) who found out that about 53 percent of farmers kept rabbits on a commercial basis. However, due to poor market linkages, about a third of the farmers interviewed ended up consuming their rabbits. The study showed that farmers in Nakuru sold a mature rabbit at an average of Ksh. 250 to 267 per kg to consumers, retailers and brokers respectively. As illustrated by Figure 1, 2 and 3 half of the rabbits produced in Nakuru were sold to the traders with the use of brokers who were connected to other market traders. In Kiambu, farmers sold their rabbits at an average of Ksh. 300 to 350 per kg to consumers, brokers, retailers and wholesalers respectively. Buying prices from producers were different in Nyeri where rabbits were bought at an average of Ksh. 200 to 220 to consumers, brokers and retailers respectively. Farmers from Kiambu County received higher prices due to establishment of a processor in the area by county government but managed by Rabbit Association of Kenya (RABAK) who offers higher prices compared to other traders.

## Marketing

### Selling Rabbits at whole sale prices.

As presented in figures 1, 2 and 3, it is clear that out of the three study areas, Kiambu Count was the only one where rabbit farmers had the opportunity to sell to wholesalers. The wholesalers in the area offered better prices than retailers and brokers. Farmers were paid an average of Ksh. 350 per kg of live rabbit. Payments to farmers were made on the same day and the transaction was done using *M-pesa* services. Wholesalers added value to their rabbits by processing them into meat and sausages which were then sold to retail outlets in nearby towns such as Thika and Nairobi. Each kilogram of meat was sold at an average price of Ksh. 400. Other by-products such as skin were not processed due to lack of tannery in the area. Skin were used as dog feeds or sometimes they were disposed.

## Retailing

Retailing is another important component of the rabbit value chain in the three study areas. It is through them that majority of the rabbits were able to get to the final actors who are consumers. Majority of the retailers were found in the markets which are scattered around the major towns and purchased the rabbits either directly from producers or from wholesalers at wholesale prices. The most common main retailers in the three counties were *Naivas* and *Tuskys* supermarkets and restaurants. The costs that were incurred by retailers included purchase of rabbits, transportation, market fees, county government levies and storage costs. Two groups of retailers were evident that is, urban and rural retailers. Rural retailers sold to rural consumers at an average price of Ksh. 375, 400 and 300 in Nakuru, Kiambu and Nyeri respectively. Rural retailers sometimes got rabbits using a broker probably who was not able to sell to urban retailer. Restaurants accounted for more than 60 percent of urban retailers in all the study areas. This is where more value was added to rabbit meat by cooking or roasting.

## Consumers

Demand for rabbit meat among consumers is very high because of its lower fat and higher protein contents compared to other forms of white and red meat. The demand for rabbit meat in the study areas can be divided into two major groups, urban and rural. It was noted that urban consumers paid higher prices as compared with rural counterparts with those in Nakuru paying the highest at an average of Ksh. 615 per kg of rabbit meat.

## Challenges faced by rabbit farmers

A summary of challenges facing rabbit producers in Nakuru, Kiambu and Nyeri. This study revealed that majority (more than half 58.4%) of farmers in the three counties reported diseases and parasites as a major production challenge as illustrated in Table 1 and Table 2.

**Table 1:** Production challenges facing rabbit producers

| Challenge | Nakuru (%) | Kiambu (%) | Nyeri (%) |
|---|---|---|---|
| Diseases and parasites | 58.42 | 74.36 | 81.25 |
| Expensive of feed | 50.50 | 20.41 | 75.0 |
| Lack of drugs for rabbits | 43.56 | 53.85 | 43.75 |
| Lack of extension services | 24.75 | 46.16 | 40.12 |
| Theft cases | 24.66 | 15.42 | 17.26 |
| Lack of quality breeding stock | 59.80 | 64.23 | 70.16 |

**Source:** Author's survey, 2017

**Table 2:** Marketing challenges

| Challenge | Nakuru (%) | Kiambu (%) | Nyeri (%) |
|---|---|---|---|
| Lack of market | 79.21 | 54.21 | 62.14 |
| Low prices | 65.35 | 47.64 | 26.84 |
| Lack of access to market information | 57.4 | 31.98 | 21.02 |

**Source:** Author's survey, 2017

This finding agrees with that of Serem *et al*. (2013) who found out that 71% of rabbit farmers in Kenya complained of diseases as a major challenge. This may be due to lack of well-trained rabbit practitioners such as veterinary and extension officers. Existence of expensive feeds was a serious challenge in Nyeri with about 75% of farmers citing it as a major problem. Kiambu County had the lowest proportion of farmers facing the challenge. This may be due to proximity of Kiambu farmers to feed manufacturing companies such as Chania feeds. Lack of market is a major challenge in the three study areas with Nakuru leading with about 79 percent of farmers facing the challenge as presented in Table 2. The results indicated that 54 percent and 62 percent of the households surveyed in Kiambu and Nyeri respectively

faced the challenge. Lack market in the three areas may be due to lack of access to information as cited by 57 percent, 32 percent and 21 percent of farmers in Nakuru, Kiambu and Nyeri respectively.

## Conclusion

The rabbit value chain was found to have actors who complemented each other. The chain was dominated by producers and retailers. It was found out that majority of the farmers in the three study areas fed their rabbits on locally available materials. In addition, more than half of the studied households kept their rabbits with an aim of selling. However, it was noted that such farmers were being exploited by brokers and other actors in the value chain. Diseases and parasites and lack of market were found to be among the challenges facing rabbit producers.

## Recommendations

Based on the findings from this study, more effort should be put in place to ensure that rabbit farmers form collective marketing groups or even strengthen the available rabbit groups for to ensure collective bargaining of better prices, accessing markets and reducing information asymmetry. In addition, resources should be provided to aid in training of extension officers and veterinary officers specialized in rabbits. Rabbit diseases and parasites need to be studied and suitable drugs manufactured to deal with related problems. The study also found out that farmers are offered different prices by different buyers. To address this issue, there is need for price regulation by different county governments so as to reduce exploitation of farmers by brokers and traders. There is need for rabbit farmers to adopt improved breeds to increase both production and productivity.

## Acknowledgement

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# Estimating the private and public costs & benefits of implementing a quality based milk payment system in Kenya

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## Abstract

The Kenyan dairy sector is facing persistent challenges in milk quality over the last decades fuelled by limited consumer awareness on quality, processor competition for milk volumes with neglect of quality, poor milk handling practices along the chain, and lack of enforcement of quality regulations. Quality based milk payment systems (QBMPS) have been successfully used in controlling and improving milk quality along the dairy chain in other countries, and this system is currently being piloted in a typical Kenyan dairy chain. The main objective of this study is to quantify the public and private costs and benefits implementing a QBMPS in Kenya. Data was collected from farmers, Collection and Bulking Enterprises (CBEs), processors, consumers, health workers, researchers and secondary sources. The costs and benefits of the QBMPS were estimated using various methods that were extensively discussed with peer researchers. Our findings show that in cash terms, the farmer is the greatest beneficiary from a good functioning QBMPS. His profit is about 2 KES per litre of milk, being the difference between his additional costs and benefits per kg of milk if he produces Grade A milk for the QBMPS. By participating in the QBMPS, the farmer also benefits from social inclusion, chain integration and productivity gains all contributing to business sustainability. On the other hand the CBEs and the milk processors both make a loss totalling to 2.5 KES per litre of milk, mainly driven by the huge costs for laboratory equipment, additional staffing and training of farmers. Regarding public health, we estimate an annual loss of 53,000 healthy life years (Disability Adjusted Life Years) translating to about 850 full lives annually in Kenya due to milk related infectious diseases. With a modest commitment of farmers, the QBMPS can generate health benefits of about 10 KES per litre of milk as avoided health costs from milk related illnesses. The enormous public health benefits could be used as a justification for public and donor investments to support the QBMPS, especially to subsidise and increasing the CBEs and processors who currently make a loss from the system, until the system can finance itself. Additionally, we recommend farmers to improve their commitment to the system in order to fully reap its benefits. Meanwhile, the government needs to strictly enforce milk quality standards and promote the growth of the formal sector in order to increase the benefits from the QBMPS.

**Key words;** Milk, KES, quality, litre

## Introduction

Milk quality assurance has been a persistent problem in the Kenyan dairy sector, caught between limited consumer awareness on quality, processor competition for milk volumes with neglect of quality, poor milk handling practices along the chain, and lack of enforcement of quality regulations. This has led to a situation in which safety of dairy products cannot be guaranteed. Milk quality is important to the consumer in terms of taste and flavour attributes and its potential impact on health (Bernadette, 2008). The per capita milk consumption in Kenya is increasing over the years and it is projected that Kenya's per capita consumption of milk will reach 220 litre/day by 2030 (DMP 2010), which increases the exposure of consumers to health risks due to milk quality.

Consumers could maintain or rehabilitate their health; and costs imposed on the health care system due to poor quality milk can be avoided. Milk quality is also important to processors and food companies due to it impacts on product yields, consistency and shelf life, thus affecting profit margins and market access (Caswell, 1998). Hence, increased attention is recently being paid on milk quality and safety of dairy products in Kenya. This is evidenced by the quality based milk payment systems (QBMPS) piloted by a few processors.

Consumption of poor quality milk is known to be hazardous in various ways for instance it may contain foodborne pathogens which can cause several diseases with various effects on humans (Tegegne and Tesfaye 2017; Fernandez et al 2017). For instance the high presence of aflatoxins in Kenyan milk, which originates mainly from maize and maize silage, has been shown to cause cancer and fertility problems in consumers (Mutiga et al., 2015; Peng and Chen, 2009). In addition abusive use of hydrogen peroxide, as milk preservative that is banned in Kenya, can cause irritation of the gastrointestinal and respiratory tracts showing various symptoms that could lead to a coma and even death (Watt et al., 2004).

Quality based milk payment systems have been successfully used in controlling and improving milk quality along the dairy chain (Pašić et al. 2016; Garcia Botaro et al, 2013). In order to achieve a safe quality of dairy products, all actors along the dairy chain have to play an important role; input providers have to comply with standards, such as producing aflatoxin-free feed; dairy producers need to source inputs from approved suppliers and improve animal husbandry and milk handling; cooperatives need to minimize collection time and install cooling facilities, build laboratory facilities for milk testing, and train milk graders; processors need to invest in laboratory facilities and staff as well as in trainings and extension, regulators need to enforce the respect of quality standards along the chain, just to name a few. This implies that there are many actors involved in a Quality Based Milk Payment System (QBMPS) chain. Each player incurs various costs and/or sustains various benefits, some of which are private (business) and others public in nature.

## Objectives of the study

The main objective of the study was to quantify the public and private costs and benefits of the implementation of a QBMPS in Kenya, as piloted by the processor Happy Cow.

Specific Objectives:

Calculating the costs and associated benefits of improving the quality of milk for the farmers, cooperatives and processors.

1. Assessing the public health benefits related to reduced incidence of milk related illnesses as a result of improved milk quality.
2. Providing recommendations on considerations needed in order to upscale the QBMPS.

## Description of the analysed QBMPS

Happy Cow, a dairy processor in Nakuru, Kenya has started applying a QBMPS for milk sourced mainly from smallholder dairy farmers through cooperative bulking centres. Next to the regular in-company costs related to integrating such a system, farmers and Collection and Bulking Enterprises (CBEs) are being convinced by Happy Cow about the benefits of quality milk, and are motivated to invest in quality assurance, with a bonus payment scheme as incentive. This study seeks to quantify the – public and private - costs and benefits of the major players (farmers, cooperatives, processors and consumers) of a QBMPS, so as to determine its prospects of being scaled up in Kenya.

**Box 1 - What is a Quality Based Milk Payment System?**

In a Quality Based Milk Payment System, payment for milk is not only based on volume, but also on a number of quality standards, be they microbial and/or physicochemical. The QBMPS as applied by Happy Cow gives smallholder farmers an opportunity to earn bonuses on top of the normal milk prices for milk that meets the set standards. Parameters used are: total plate count, presence of antibiotics residues, adulteration, and total solids (including fat & protein). Happy Cow works with milk Collection and Bulking Enterprises (CBE's) who collect milk from their smallholder members in Nakuru and Nyandarua Counties. Happy Cow developed its own standards, which were lower than the KEBS industry standards, but considered more realistic and attainable by smallholder farmers and CBEs, as shown in Table 1.

**Table 1**: QBMPS and KEBS Standards‡

| Test | Grade | QBMPS Standard‡ | KEBS Standards | Premium/penalty score[æ] |
|---|---|---|---|---|
| **Total plate count (units in cfu/ml)** | A | 0 - 2,000,000 | <200,000 | 50 |
| | B | 2,000,001 - 10,000,000 | 200,000 - 1,000,000 | 0 |
| | C | >10,000,001 | >2,000,000 | -50 |
| **Antibiotics residue** | All | Negative | Negative | 15* |
| **Freezing point** | All | -0.500- | -0.525 to -0.565 | 20# |
| **Total solids** | All | >11% | >11.75% | 15[#] |

*[æ] Premium or penalty score given to milk of the corresponding to the QBMPS standard (column 3);*

**positive milk is rejected; [#]otherwise a 0 score; ‡Source: Happy Cow.*

In the QBMPS, milk samples are collected and analysed daily for all the above mentioned parameters. In order to reduce the costs for testing, about 5 – 10 farmers are grouped such that their supplied volumes add up to fill a can of 50 kg. These farmers are maintained in the same groups to assure continuity and consistency in the payment system. Sampling is done randomly to assure that each can is tested twice a month for the above mentioned parameters. Results are employed in the following payment module (**Table 2**).

**Table 2**: Payment modules employed

| Grade | Total score * | Payment | Amount (KES) |
|---|---|---|---|
| **A** | 70-100 | Premium | +2 |
| **B** | 40-69 | Standard | +1 |
| **C** | <40 | Penalty | 0 |

* Calculated by summing the scores from Table 1.

### Overview of the costs and benefits of the QBMPS

Data was collected from farmers, CBEs, processors, consumers, health workers and researchers. This was complemented with secondary data, combined with interviews. The costs and benefits of the QBMPS were estimated using various methods that were extensively discussed with peer researchers.

### Private costs and benefits

The private costs & benefits include the costs and benefits for farmers, CBEs and processors as relevant business entities.

### Costs and benefits to farmers

In analysing the costs and benefits, it was assumed that different farmers would make dissimilar levels of investments into the QBMPS, which would also reflect in their benefits. Four milk quality levels were considered with three targeting Grade A, B and C milk, and one targeting milk of a mix of levels A, B and C. The additional costs (investments) and benefits to farmers are shown in Table 3.

**Table 3:** Additional costs and benefits for various farmer categories using the QBMPS

| | Unit | Additional costs and revenue per litre for different milk grades | | | | Per farm per day for |
|---|---|---|---|---|---|---|
| | | Grade A | Grade B | Grade C | Mixed | Grade A |
| Milk quantity considered | Litre | 1 | 1 | 1 | 1 | 10.71 |
| QBMPS payment | KES | 2 | 1 | 0 | 0.5 | 21.42 |
| Revenue from forgone milk rejection # | KES | 1.86 | 1.09 | 0 | 0.6 | 19.87 |
| ADDITIONAL REVENUE | KES | 3.86 | 2.09 | 0 | 1.1 | 41.29 |
| Additional feed costs | KES | 0.15 | 0.15 | 0 | 0.07 | 1.56 |
| Milk equipment costs | KES | 0.08 | 0.08 | 0.08 | 0.08 | 0.85 |
| Water costs | KES | 0.17 | 0.08 | 0.08 | 0.08 | 1.8 |
| Housing costs | KES | 0.53 | 0.53 | 0 | 0.35 | 5.71 |
| Additional time for cleaning and attending trainings | KES | 0.62 | 0.33 | 0.04 | 0.25 | 6.64 |
| ADDITIONAL COST | KES | 1.55 | 1.17 | 0.20 | 0.83 | 16.56 |
| Additional profit/loss | KES | 2.31 | 0.92 | -0.20 | 0.27 | 24.73 |

* Mixed milk was a scenario made to illustrate the situation of hesitating farmers who are about 50% committed and who venture into but never really commit to implementing the changes required by the QBMPS.

# The revenue from forgone milk rejection considers farmer benefits due to reduced rejection of milk by the processor. It is estimated that farmers targeting Grade A milk can reduce milk rejection rates to 0.5% compared to a rejection of 5.8% for those in Grade C category. If this is applied to the average daily sales of 10.71 litre, the farmer can make an additional income of 19.87 KES per day from the forgone revenue loss due to poor milk quality.

### Key benefits per farmer category

- At the current market price (of 35 KES), an average farmer incurs an additional costs of 1.55 KES per litre of milk in order to continuously meet the standards for a premium payment of +2 KES (grade A milk). The same farmer also gets an additional 1.86 KES as revenue from forgone milk rejection, giving him a profit of 2.31 KES per litre of milk.
- A farmer who continuously meets the standard for Grade B milk incurs an additional cost of 1.25 KES and gets a benefit of 2.09 KES, which comes from 1 KES for quality payment and 1.86 KES made by a forgone loss of income due to milk rejection. This gives him a net profit of 0.92 KES per litre of milk.
- Because there is no extra payment for farmers with Grade C milk, they make a loss of -0.20 KES per litre of milk due to inevitable costs they incur in order to be paid following the QBMPS scheme. Therefore, being part of a QBMPS without having a full commitment would lead to a loss.
- Most farmers are not consistent with their investments to the QBMPS and have a fluctuating milk quality that ranges from grade A to grade C, represented by a "Mixed" quality in Table 4. They tend to limit their investments in the QBMPS and as such do not always get the premium price. Such farmers have a net profit of 0.27 KES per litre of milk, which is less attractive than the profits made by farmers constantly supplying Grade A and Grade B milk. Because this amount is small, it might not be noticed by such farmers and could lead to dissatisfaction with the system.
- The higher the investments by farmers, showing their level of commitment, the higher their profits. In order to attract more benefits from the QBMPS, it is advisable for farmers to be more committed by being optimal and consistent in their investments.

### Additional benefits

- **Social/business inclusion**: Another benefit of this form of the QBMPS - designed for smallholders - is the ability to enhance their inclusion into higher value dairy supply chains. Due to their small quantities and their quality issues, they are likely to be excluded from a formal dairy chain. The QBMPS gives the smallholder farmers a chance to sell their milk at a competitive price through a reliable market channel.
- **Chain integration:** The QBMPS encourages grouping of farmers and the organisation of the system strengthens both horizontal and vertical integration along the dairy chain, making it more robust. This also gives them an advantage of becoming more trustful business partners attractive to other actors such as input suppliers, financial institutions etc.
- Productivity gains: Farmers practicing the QBMPS receive a lot of training, including animal husbandry and feeding. These good practices will contribute to improved milk quality, and might well lead to higher production volumes. Costs and benefits to the CBEs and processor

### Costs of the CBEs and processor

Figure 1 shows the costs per kg of milk for various investments of the processor and the CBEs in the QBMPS. The annual depreciation was used as a cost for fixed investments. All annual costs were divided by an average daily milk intake of 9,000 kg milk (actual levels) to get the cost per litre. The processor spends an average of 3.05 KES per litre and the CBE about 0.56 KES per litre of milk that goes through the QBMPS.

Looking at the processor's costs, about 40% of the total costs were used for consumables in the laboratory, while 20% of the costs were used for hardware and about 15% each for training of farmers and benefits for project staff. Interestingly, only 8% of the total costs was used in bonus payments to farmers. For the CBEs, 90% of costs were on staffing, while the other 10% was almost equally distributed between laboratory consumables and software development. These figures show that in terms of costs, in the Kenyan context involving smallholders, building a QBMPS is a lot more about equipping laboratories, paying for lab consumables, training farmers and paying staff, rather than about paying bonuses to farmers.

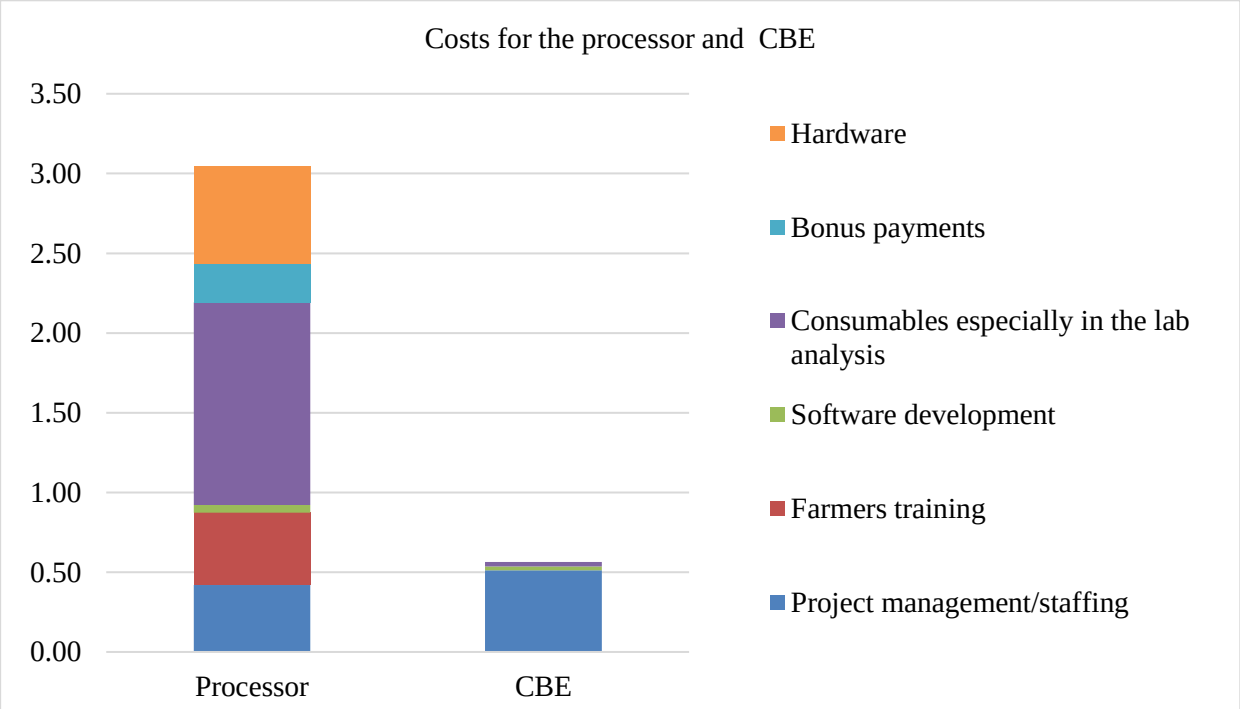


**Figure 1:** Costs for processors and CBEs

*Benefits to the Collection & Bulking Enterprises*

An average of 41 KES is paid to the CBEs by the processor per kg of (bulk) milk collected. It should be noted that the bulk milk will be a mixture of Grades A – C milk and that the CBE receives a fixed add-up of 6 KES to the farmers milk price, which is independent of the milk quality.

Based on discussions with the CBEs, it was evident that the QBMPS brought about huge reductions in the proportion of milk that was rejected by the processor. Milk rejected by the processor is not paid for, leading to a loss of 35 KES to the farmer and 6 KES to the CBE per litre of rejected milk. Meanwhile, milk that is rejected at the CBE is returned to the farmer. The milk rejection levels for different grades of milk were estimated using information from the CBEs. **Table 4** shows the losses which the CBE would make, assuming that all the daily milk collected were of a target grade (for example Grade A), in comparison to a situation where all the daily milk were Grade C. If the CBE's farmers only provide Grade A milk instead of Grade C milk, the CBE would make an extra benefit of 0.32 KES per litre of milk. In the same way, the CBE will make a benefit of 0.19 KES/litre if all farmers deliver Grade B milk and 0.10 KES/litre for Mixed milk.

As is the case with farmers, the increased milk production from productivity gains will also be translated into higher milk intake by the CBE leading to a higher total daily margin to the CBE.

**Table 4:** Costs and Benefits to the CBE and processor due to reduced milk rejection

| | Grade A | Grade B | Grade C | Mixed |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **CBE** | | | | |
| Total CBE cost per kg of milk | 0.56 | 0.56 | 0.56 | 0.56 |
| CBE benefit per kg of milk as forgone milk rejection (compared to Grade C milk) (KES) | 0.32 | 0.19 | 0.00 | 0.10 |
| Profit/loss of CBE | -0.24 | -0.37 | -0.56 | -0.46 |
| **Processor** | | | | |
| Total processor cost per kg of milk | 3.05 | 3.05 | 3.05 | 3.05 |
| Processor benefit per kg of milk as forgone mis-production and milk returns* (KES) | 0.93 | 0.74 | 0.00 | 0.52 |
| Profit/loss of processor | -2.12 | -2.31 | -3.05 | -2.53 |

*Calculated as additional revenue from sales of finished products which the processor will get due to forgone product returns and under production when using the target Grade of milk compared to Grade C milk

When poor quality milk is processed, the chances of losing batches of the product are higher than when good quality milk is used. For example, the fermentation of yogurt and cheese may be hindered by the presence of antibiotics in milk. Also, products from milk of poor quality might get spoilt before their envisaged shelf life and as a result the milk is usually returned to the processor. The QBMPS has the potential to reduce such occurrences, thus giving the processor an average benefit of 0.93 KES per litre of received milk (**Table 4**).

## Public health costs and benefits

### DALYs

To determine the burden of various milk-borne diseases on public health, Disability Adjusted Life Years (DALYs) were calculated**. Table 6** indicates the incidences of milk related infectious diseases per year. These incidences are based on the current population of 48,46 million (Kenya Dairy Board, 2017; World Bank, 2017) and on an estimation of the cases of infectious diseases that are caused by poor milk quality.

**Table 5:** Incidences and DALYs of milk related infectious diseases in Kenya

| | ***Incidence (cases/year)** | **#DALY (years)** |
|---|---|---|
| Tuberculosis | 3,392 | 16,045 |
| Brucellosis | 28,107 | 19,259 |
| Listeriosis | 8,238 | 3,521 |
| Salmonellosis | 26,653 | 563 |
| E.coli infections | 23,745 | 2,089 |
| Campylobacter infections | 2,423 | 10,694 |
| Coxiella burnetti | 1,890 | 922 |
| **Total** | | 53,093 |

*Source: KDB, #Source: Own calculation. NB: These incidences are based on an estimation of incidences of infectious diseases caused by poor milk quality. However, since proper microbiological research on the cause of infectious diseases is often lacking, it cannot be said with certainty that all these incidences are indeed caused by poor milk quality.

The table shows that the impact of brucellosis is substantial. This is mainly because brucellosis is transmitted to a large extent of the population at the same time and because the duration of the illness is relatively long. The DALY for brucellosis is 19,259, which means that each year in the total population 19,259 healthy life years are lost due to brucellosis. On the contrary, although salmonellosis occurs more frequently, because of the low mortality rate and the short duration of the illness, only 563 healthy life years are lost each year. Campylobacter has a high DALY primarily because young children are vulnerable to this illness and the mortality rate is high. Tuberculosis also occurs frequently and has a relatively high DALY, particularly due to the higher severity for HIV positive patients.

In total, as estimated 53,093 healthy life years are lost annually in Kenya due to milk related infectious diseases. Considering an average lifespan of 62.13, this gives us an average loss of 855 full lives per year due to milk related infectious diseases. It should be noted that due to lack of reliable information on the losses due to use of antibiotics, mycotoxins and harmful preservatives like hydrogen peroxide, they have not been considered in the above calculations.

## Direct and indirect public health costs

Direct costs are all costs related to diagnosis and treatment of a particular illness. For antibiotics residues, aflatoxins it is more difficult to estimate the direct costs, as these residues can cause various effects, hence it is are discussed separately.

***Costs due to diseases***

**Table 6** shows the direct costs per case, the total direct costs and the total indirect costs per year.

| Illness | *Cost per case | Total direct costs | Total indirect costs | Total costs |
|---|---|---|---|---|
| Tuberculosis | 0.02 | 76.36 | 2,381.85 | 2,458.21 |
| Brucellosis | 1.21 | 33,945.69 | 2,858.92 | 36,804.61 |
| Listeriosis | 43.02 | 354,384.74 | 522.67 | 354,907.40 |
| Salmonellosis | 0.44 | 11,609.13 | 83.59 | 11,692.72 |
| E.coli infections | 1.00 | 23,767.21 | 310.17 | 24,077.38 |
| Campylo-bacter | 0.16 | 397.69 | 1,587.54 | 1,985.23 |
| Coxiella burnetti | 0.001 | 1.95 | 136.86 | 138.82 |
| Antibiotics | - | 4,346.51 | - | 4,346.51 |
| Aflatoxins | - | 272.72 | 77.85 | 350.57 |
| Total | | 428,802.00 | 7,959.45 | 436,761.44 |

**Exchange rate:** 1 USD = 102 KES

***Source:** KDB, 2017 Exchange rate: 1 USD = 102 KES

The variation in the direct costs (**Table 6**) is mainly due to the different medicines needed to treat the illness and different durations of treatment. Treatment of brucellosis and listeria is especially expensive, as they require the use of expensive antibiotics for a prolonged time period.

### *Costs due to antibiotic resistance*

As discussed before, antibiotics residues in milk may cause antibiotics resistance. In case bacteria become resistant, treatment becomes more difficult. Antibiotics are often used to treat diseases common in developing countries such as tuberculosis, malaria, HIV/AIDS, food poisoning, pneumonia, sexually transmitted diseases, etc. In case the standard antibiotics do not work anymore in treating these illnesses, doctors have to prescribe 'last-resort' medicines, which have more adverse side effects, more costly and are often not easily available in low income countries. Sometimes the bacteria could become resistant to the 'last-resort' medicines, leaving the patient with no other treatment possibility. Although it is hard to estimate the costs related to antibiotic resistance, it is certain that it causes economic losses, due to higher rates of illness, increased duration, decreased productivity and higher costs of treatment (Cosgrove & Carmeli, 2003; Levy & Marshall, 2004; Okeke et al., 2005; World Bank, 2016; World Health Organization, 2015). The Kenya Dairy Board has made an attempt to quantify the costs caused by antibiotics drugs which are resistance and are linked are estimated at the costs of 42,6 million USD each year (Kenya Dairy Board, 2017).

### *Costs due to aflatoxins*

The costs of aflatoxins are equally difficult to estimate, as their effects are not yet fully understood. Research done mainly focuses on the market-related costs of aflatoxin exposure, such as lost harvest. Aflatoxin can have four major effects on human health: acute poisoning, stunting, immunosuppression and increased risk of liver cancer. Because Kenyans consume more milk than the average African population, they have a higher risk to consume aflatoxin-contaminated milk (Karaimu, 2014). Although causality is not yet confirmed, it is widely assumed that aflatoxin exposure has an effect on stunting in children, which can cause adverse health outcomes beyond childhood (Wu, 2013). The link between aflatoxin and immunosuppression is shown in several studies, however the exact impact of immunosuppression on health is not yet studied (Wu, 2013). More is known about the relation between aflatoxin and liver cancer. Wu (2015) estimated that 23% of all liver cancer cases can be attributed to aflatoxins. Applying this to Kenyan milk gives the results shown in **Table 6**.

Although liver cancer is the third-leading cause of cancer deaths worldwide and mortality follows in most cases within three months, the DALY is not that high because people are most vulnerable around the age of 60 (Wu, 2013). This means that relatively few healthy years of life are lost. Treatment of liver

cancer is expensive, indicated by the total direct costs. However, treatment costs heavily depend on the case and stage of the cancer.

**Table 6** also shows the indirect costs and the total (direct and indirect) costs per year due to milk related health hazards. These total costs are estimated at 437 billion KES. However, actual costs may even be higher, because of the missing costs due to hydrogen peroxide adulteration.

Cost reduction scenarios

The QBMPS is introduced to improve the quality of milk and in this way to reduce health risks and costs, and enhance business benefits for various dairy supply chain actors. However, the system is not yet working optimally and the quality is not yet substantially improved. If the system works optimally and the quality of the milk improves further, this will mean a reduction in the incidence of milk related health hazards and therefore in the related health costs. Previous studies estimated that incidences would reduce by 50% every year in case interventions are introduced (Government of New Zealand, 2010; Kenya Dairy Board, 2017). This rate of reduction seems however unlikely with the current status of the QBMPS. The implementation of the system is still being improved to meet its optimal potential, and we estimate that the current efforts have generated milk of "Mixed" average quality level describe in Table 3. Therefore, in **Table 9**, different rates of reduction for incidences are applied. The reduction rates of 10%, 20% and 50% are used to reflect improving effectiveness of application of the QBMPS.

We estimate that if all Kenyan milk were Grade A, then we would attain 50% reduction. Meanwhile, with mixed milk, we are only likely to attain 10% reduction of the incidences of milk related illnesses.

**Table 9:** Cost reduction scenarios (1,000,000 KES)

| | **Current** | **10% reduction** | **20% reduction** | **50% reduction** |
|---|---|---|---|---|
| Total direct costs | 428,802.00 | 382,009.94 | 339,564.39 | 212,227.75 |
| Total indirect costs | 7,959.45 | 7,163.48 | 6,367.51 | 4,011.39 |
| Total costs | 436,761.44 | 389,173.42 | 345,931.91 | 216,239.14 |
| Total avoided costs | - | 47,588.02 | 90,829.54 | 220,522.30 |
| Avoided costs per kg milk | | 9.52 | 18.17 | 44.10 |

**Table 9** shows the different costs for these different scenarios. It appears that costs per year will decrease rapidly in case a reduction in incidence cases is accomplished, to a reduction of 220 trillion KES per year in case of 50% reduction of incidences. When calculated per kg of milk, this scenario will result in 44 KES in avoided costs per kg of milk.

## Conclusions

Sustainable development of the dairy sector in Kenya is important to meet the growing consumer demand. It is projected that Kenya's per capita consumption of milk will reach 220 Litre/day by 2030. The dominance of an informal sector coupled with weak enforcement of quality regulations has raised concerns on milk quality in the country. The current payment structure of milk emphasizes quantity rather than quality in both the formal and informal sectors. In this structure, actors do not have the incentive to improve on milk quality - they get the same payment, regardless of the investments made to improve milk quality.

A functional QBMPS gives incentives to all players along the dairy chain to improve the quality of milk. Based on the pilot program implemented by Happy Cow, farmers delivering Grade A milk would earn an additional KES 3.86 for every litre of milk delivered to the CBE. This would require that the farmer acquires the right milking equipment, practice hygienic milking, observe withdrawal periods for antibiotics, separate morning and evening milk and attend regular trainings. The costs incurred by the

farmer amount to 1.55 KES/litre, resulting in a profit of 2.31 KES/litre. The CBEs would incur a cost of 0.56 KES per litre of milk and have a benefit of 0.32 KES/litre, leaving them with a net loss of -0.24 KES/litre. For the processor, the system requires equipping a laboratory, employing quality control personnel, acquiring a good software, etc., at the cost of 3.05 KES/litre and accruing benefits of 0.93 KES/litre leading to a loss of -2.12 KES per litre of milk. Next to the private benefits to the value chain actors (farmers, CBEs and processor), these actions would result in public health benefits amounting to 44.1 KES/litre for grade A milk, 18.17 KES/litre for Grade B milk and 9.52 KES/litre for mixed milk. These are quite huge benefits which should justify public investments into the QBMPS.

Based on the information collected, the QBMPS is a step in the right direction towards improvement of milk quality in Kenya. The processor and CBEs incurred huge costs in setting up the system and both made cash losses. From the cost-benefit analysis it is evident that the QBMPS is not yet viable to auto-finance itself in the current Kenyan situation. Since this was a pilot phase, some funding was received from the Embassy of the Kingdom of the Netherlands in Kenya to cover part of the processor and CBE costs, which compensated for the loss.

First of all, for the business of the processors and CBEs to be sustainable, it is advisable that their investments in QBMPS are supported financially either by the government or by other public parties. This support can be progressively decreased until the system can stand on its own. Secondly, once the system runs effectively, it is expected that the processor costs per kg will significantly reduce due to lower expenses in capacity building. Thirdly, if consumers are duly informed on the difference in quality of milk which goes through the QBMPS, they might accept a higher price for products generated from it, which could (partly or entirely) compensate the costs made by the processor. Finally, the QBMPS has a huge potential to improve public health by cutting down on the enormous health losses of 53,073 life years lost annually nationwide, with public health costs amounting to a total (direct and indirect) cost of 4,4 billon KES/year. This indicates that implementing a QBMPS gives an undoubtable potential to address milk quality issues leading to reduced health risks of consumers and at the same time improve farmers revenues and multiple benefits for various dairy chain actors in Kenya.

In order to fully integrate and replicate the system, the study put forth the following recommendations for improvements in the QBMPS pilot.

**Farm level:** Recommendations at farm level include full implementation of proper hygiene, adoption of aluminium cans, separation of morning and evening milk and timely delivery of milk to the milk collection points.

**Cooperative (CBE):** The CBEs should be stringent in checking the quality of milk that is delivered, either at the milk collection point or at the CBE for farmers who deliver to the CBE directly. This means that all employees involved in handling the milk must be trained on hygiene practices. This calls for development and enforcement of strict standard operating procedures. As much as its main objective is finding a market for its members' produce, the CBE must be willing to reject poor quality milk to ensure quality of milk supplied. A further study might be needed to find out the feasibility and sustainability of collecting milk twice a day. As the CBEs incur losses that are likely to influence their commitment, we recommend that they get support from the government or other donors in order to compensate their losses and keep their commitment. This could be either through a percentage coverage of their costs or providing a top up per litre of milk, considering their cost of 0.56 KES per litre of milk.

**Processors:** Just like the CBE, the processor must not accept poor quality milk. It should strictly and continuously monitor the milk collection process of the CBEs. Similar to the CBEs, processors also incur losses at this stage and we recommend that they also get support during the first years of implementation of the QBMPS until it can refinance itself.

**Government/regulatory:** The regulatory authority should ban the use of plastic cans completely. It should streamline the dairy sector towards a formal sector, since a QBMPS can only be implemented in such a system. It should also invest in quality control staff who will enforce quality regulations in all the counties. Part of the investments currently done by the processors and CBEs could be done by the government. For example training of farmers, which costed the processor 0.45 KES per litre of milk.

Also due to the huge public health benefit, it is advisable for the government to allocate funds to support the dairy sector in building up a sustainable QBMPS.

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# Gender differentials in extension advisory service access among smallholder dairy farmers in Mosop sub-County, Nandi County.

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## Abstract

This study examined the gender access to extension advisory services among smallholder dairy farmers in Mosop sub-County, Nandi County. Using questionnaires, data was collected from 70 smallholder dairy farmers selected purposively. The results indicated that, 34% had accessed information from field days, 11% from newspapers, 30% radio, 5% had attended dairy cooperative training. A majority of the respondents (99%) indicated that men are likely to attend trainings and technical meetings on dairy production. All women respondents indicated long distance and household responsibilities as major limitations in attending the extension advisory activities. Male respondents highlighted inadequate livestock extension officers and travelling cost to the venues of the extension activities as being major challenges in participating in extension activities. It is evident from the results that there are gender gaps in accessing extension advisory services in the study area. The study recommends that, to benefit both women and men, extension advisory services should be designed to address the gender differential needs and capacities.

**Key Words**: Gender gaps; extension, service, dairy, smallholder.

## Introduction

In Kenya, 70% to 80% of agricultural work is done by women. However, women have limited access to land, agricultural materials, agricultural techniques, information and markets (Kathotya, 2017). Consequently, their productivity is lowered by about 20% to 30% compared to that of male farmers (Nalep,2006).Women are responsible for most housework and child rearing in addition to agricultural productive activities and the heavy burden results in their lower agricultural productivity. The strong demand for dairy products occasioned by increasing urbanization and income growth is a strong case for the development of smallholder dairy farming (Kathotya, 2017). To develop dairy enterprises and dairy participating households to be able to double incomes from their dairy enterprises, improved production and productivity and access to gainful markets are very key objectives. To achieve this, access to relevant education, training and scientific and technological innovations in animal breeding, feeding, health care, milk quality handling and markets by the farming families are key interventions. The mandate of delivering the aforementioned services entirely lies on the livestock extension and advisory service providers.

In Kenya, several organizations, both international and national, including the Ministry of Agriculture and non-governmental organizations have developed and promoted the use of improved dairy technologies to help increase dairy productivity and smallholder income. However, FAO-ILRI (2013) indicates that many extension service providers including governments have failed in their obligations to ensure that services are delivered effectively to disadvantaged groups and particularly to rural women. It has been reported that pluralistic extension services have hardly targeted women farmers as many advisory service programs tend to be mostly concentrated on productive activities dominated by rural men farmers (Ochora, 2002). Many systems have put a greater emphasis on promoting various agricultural extension projects without understanding the practical and cultural obstacles that prevent women from accessing the most needed services. Particular attention needs to be paid to how effectively gender differences are addressed with regard to the accessibility of such services by men and women smallholder farmers.

Agricultural extension service plays a vital role in creating effective linkages among producers, agricultural research and other sources of information and input providers (Converson, 1995). In return, it performs an important function in enhancing agricultural production and productivity (Rubin et al.,2009).The standard guidelines and regulations established at national level to help promote participation of rural women in agricultural extension services has not been cascaded to lower structures (NALEP, 2006). For instance, most extension programmes give a direction to implementers that 30% of the extension beneficiaries shall be women. In spite of this provision, the reality is that the extension services are not accessible to most of the rural women. Women in male headed households especially have almost been neglected from the services. Oniang'o (1999) indicated that women have limited access to extension services mainly due to men's' strong position as heads of households and greater off-farm mobility. They further argued that training and extension should be directed towards those people who do the actual work and in the case of smallholder dairy production, women do the bulk of the work yet extension is directed to men and is assumed that the information will trickle down to the women.

The extension system employs several types of approaches that are believed to enhance the transfer of knowledge, skills and technologies for the farming community. The common types of extension services in operation includes trainings and consultations, practical demonstrations, experience sharing visits, field days and regular advisory services. The other extension approaches being used includes electronic and print media. However, there are gender based constraints to some of the approaches hence it is critical for extension service providers to analyze each delivery approach. Farnsworth and Colverson (2015) identified issues relating to the roles and decision making power between men and women in agriculture in the pilot areas. The result revealed that, for example, women had very limited opportunities to attend various types of training despite the fact that they were engaged in farming activities. This is due to the reproductive and productive roles of women. In addition, customary rules and traditions can also limit women's mobility and freedom to leave the house. As a consequence, they can face challenges in systematically participating in extension meetings or group training activities on subjects such as husbandry and veterinary practices, marketing skills and credit systems as well as accessing labor-saving technologies.

Though women in Mosop and elsewhere play an important role in small holder dairy farming, there is little information available on influence of gender relations on access of dairy extension and advisory services. Research has not been done to assess how gender relations impact on the access to the existing dairy extension services, particularly in Mosop Sub County. This present study has been carried out to assess gender access to livestock extension services by smallholder dairy farmers in Mosop.

The overall objective of this study was to analyze the influence of gender relations on extension service access and how this impact on adoption of dairy technologies among the smallholder dairy farmers.

## Materials and methods

The study was conducted in Mosop sub-county in Nandi County**.** The reasons for selecting Mosop Sub County for the study include: widespread and long history in dairying; high potential for dairying; the presence of: households engaged in dairying activities as a main income source, formal dairy value chains (DVCs), multiple marketing channels for milk, dairy cooperatives.

The sub-county covers 601 square kilometers and is located in the Upper Highland agro-ecological zone with an annual rainfall of 1800-2200 mm. The rainfall is bimodal with dry spells experienced between December and March. The distribution of rainfall is affected by topography and the south-westerly winds from Lake Victoria (CIDP, Nandi County 2014). The sub-county has a mean population density of 216 persons per $km^2$ with a population growth rate of 2.9% per annum (CIDP, 2014). The Sub-county has a well-developed supportive infrastructure including dairy hubs, milk chilling plants and a number of dairy cooperatives. Dairying is based on natural pastures supplemented with improved pastures of Rhodes grass and Nandi Setaria (Kathotya, 2017). The inhabitants of Mosop region practice mixed farming with both crops and livestock. The system of dairy production in the area can be classified broadly as Small scale. The cattle are reared under free extensive grazing, semi-zero grazing or zero

grazing systems and depend on natural pastures/forage, fodder crops and agricultural by-products as their main feed source.

Despite the fact that the region is endowed with land and plenty of rains, dairy productivity in Sub County is generally low, averaging 6 l/cow/day (County directors report, 2016). Different dairy technology packages have been promoted by various dairy stakeholders in the various wards of the sub county. For instance, the Smallholder Dairy commercialization programme, Kabiyet dairies, Tanykina dairies and ASDSP through the cow milk value chain. Various input suppliers have spearheaded dairy extension packages such as fodder and pasture establishment, utilization and conservation, milk quality and hygiene, herd health management, breeds and breeding, calf rearing etc. This affirms that government and non-government bodies have been working in dairy extension in order to improve dairy production and productivity through improved dairy technologies. These extension programmes are aimed at increased dairy productivity and rural incomes by bridging the gap between new technical knowledge and farmers' practices but the achievement have been below the expectation.

## Research design

A cross sectional study design was used. To obtain the representative sample for the study, simple random sampling technique was used to select farmers for the study. Farmers were selected from Chepterwai, Kurugung-Surungai, Ndalat and Kipkaren wards.

## Data collection

The study was carried out in May to July 2017. Data were collected by use of structured questionnaires on gender participation in dairy farming activities and gender access to dairy extension and advisory activities. The questionnaires were used to collect information from the farmers at the household level. Secondary data were also collected from published reports, journal articles from libraries and internet.

## Data analysis

Data was analyzed by use of descriptive statistics. Tables and percentages were used in report presentation.

## Results

## Characteristics of the sample used in the study

A total of 70 respondents out of the expected 70 completed the questionnaires. This represented response rate of 100% comprising 52 males and 18 females. The age of the farmers in the sample ranged between 21 to 74 years. The findings from the study revealed that majority of the respondents (37.9%) were aged 56-65, 31% between 46-55 and 5.2% between18-35.years old.

Majority of the respondents ( 22.4%) attended primary school, 19.0%, 12.1%, 6.9% and 1.7% having attended secondary school, college certificate/diploma, did not attend school, and university degree, respectively.

## Dairy farming system

With respect to system of dairy production, 92% of the respondents practice extensive grazing with supplementation, 6% extensive grazing and 2% zero grazing. Table 1 gives a summary of the outcome

**Table 1**: Dairy production sytems

| Production system | % |
|---|---|
| Extensive grazing | **92** |
| Grazing with supplementation | **6** |
| Zero grazing | **2** |

## Gender roles in dairy farming

Results on household labor input contributed to the main dairy farming activities in the study area is as presented in the table below. women participate mainly in milking, feeding and in delivering milk to the cooler whereas men major in grazing/herding, disease control and collection of milk payment.

**Table 2:** Roles in dairy farming activities by gender.

| Activity | Men (%) | Women (%) |
|---|---|---|
| Grazing/herding | 96 | 4 |
| milking | 3 | 97 |
| Fodder and pasture establishment | 66 | 34 |
| Cutting and carrying fodder and pasture | 42 | 58 |
| Delivering milk to the cooler | 48 | 52 |
| Milk payment collection | 98 | 2 |
| Dipping and deworming | 83 | 17 |

## Source of dairy production information

Access to agricultural extension services was generally low across all the selected villages. Only 38% of the respondents had accessed dairy related extension advisory from government and private extension service providers for a period of one year. The respondents were asked to indicate the source of dairy farming related information and skills. Thirty four (34%) had accessed information from field days, 11% from newspapers, 30% radio, 5% had attended dairy cooperative training.

**Table 3:** Sources of dairy production information

| Source of dairy production information | percentage |
|---|---|
| Field days | 34% |
| Farm visit | 3% |
| Demonstrations | 18% |
| Dairy cooperative training | 5% |
| Radio | 30% |
| Newspaper | 9% |
| Mobile phone | 11% |
| Internet | 2% - total = 112%; need to adjust to 100% |

## Access to extension advisory services by gender

There was a large variation in gender access to extension advisory services. A majority of the respondents (99%) indicated that men are likely to attend trainings and technical meetings on dairy production. These findings are in agreement with a study by Ragasa et al. (2013) conducted in Ethiopia

which showed that female-headed households and women plot managers are less likely to receive extension services through various channels than their male counterparts. Male heads are more likely to be visited, to attend community meetings and to visit demonstration plots and research centers.

Table 4: Gender access to extension advisory services

| Extension approach | Men | Women |
|---|---|---|
| Field days | 76% | 34% |
| Radio | 42% | 58% |
| Demonstrations near the farms | 42% | 58% |
| Group non-residential trainings | 67% | 33% |
| Exchange tours | 74% | 26% |

## Major constraints hindering access to extension advisory services by gender

The respondents cited various factors that limit the participation of men and women in accessing extension services. All women respondents indicated long distance and household responsibilities as major limitations in attending the extension activities. Men respondents highlighted inadequate livestock extension officers and travelling cost to the venues of the extension activities as being major challenges in participating in extension activities. The major reasons given by the respondents were that men have time to attend the activities, men are usually informed of when and where the meeting will be held through their social networks and that their mobility is not limited. Women are constrained by household reproductive roles and limited mobility.

There are two aspects to gendered inaccessibility of extension advisory services: First, extension services are often not made available to women; on the other hand, even when extension services are available, women do not have equal access as compared to men (FAO, IFAD and World Bank, 2009). The World Bank (2001) reported that many institutions continue to operate under the perception that "women" are not farmers. As a result, women are underserved as clients of extension services in their own right, often seen to be only helping. Alternatively, they are targeted for agricultural information related to home economics in the assumption that their role in agriculture is linked to their household responsibilities.

## Discussion

Women face restrictions in accessing extension services mainly because of workload and mobility constraints. In many societies, local gender norms discourage women from attending public meetings since these opportunities are perceived as suitable for men. As a consequence, women mostly rely on their husbands to acquire technical information. The other obstacle which limit women from having extension services is as a result of extension officer not being conscious when women would be available for meetings to schedule training at those times. The location of training may also be a constraint for women if the training is scheduled to take place far from the locality women might not have funds to pay for transport and lunches unless they are supported by the training organizers. This being the case it is important to hold training in areas where women could have access.

## Conclusions and Recommendations

It is evident from the results that there are gender gaps in accessing extension advisory services in the study area. To benefit both women and men, extension advisory services should be designed to address the gender differential needs and capacities. There is a need to implement extension approaches and tools that consider the specific interests and opportunities of female household heads and spouses. The growing trend of out-migration of men for longer periods, has resulted in the feminization of agro-based livelihood strategies including dairy farming. This reality must be reflected in the selection of the extension advisory service approach and methodology of implementing dairy development programmes. It is also imperative to use extension approaches adapted to the socio-cultural context of a given locality.

This implies that in Mosop sub-county, extension interventions must be adapted to overcome some cultural constraints that may restrict women's participation in extension activities. Women dairy farmers in the study area experience constrained mobility, therefore extension officers is to introduce activities which is gender friendly.

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# Emerging Dairy Processing in Arid and Semi-Arid Lands of Kenya: Current Status and Opportunities for Future Development

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## Abstract

Kenya ASALs currently holds 84% of Kenya livestock herd with average annual milk output of 689,982,764 litres of milk worth KES 24 Billion. The products produced are largely based on traditional recipes and include smoked fresh milk, fermented milk, and limited production of clarified butter (Ghee). Market potential for these products is yet to be tangibly realized because of a number of challenges bedeviling the dairy value chain in the area. Yield from traditionally processed product is low coupled and with poor quality with only 12% of the products reaching end markets in Kenya. Current attempts to modernize processing technologies in ASALs of Kenya has yielded a meagre 1% of the milk market share with focus mainly on camel milk value chain. Other specialized products such as Ultra High Heat Treatment (UHT) milk is yet to work out in camel milk which is the most economically viable priority area for ASAL dairying. Although the sector faces enormous challenges such as poor infrastructure, lack of inputs, disjointed collection system in the absence of cooling facilities, there still exist greater opportunities for development. This include but not limited to bridging the production gap which currently stands at 75%. A number of Lactic Acid Bacteria of probiotic significance have already been identified in traditionally processed milk products, there is need to conduct more research with a view to isolating, purifying the LAB bacteria so as to produce starter cultures for local use in ASALs.

**Key words:** ASAL, milk, Processing, technologies, pastoralists

## Introduction

Livestock sub-sector in Kenya contributes about 14% of agricultural gross domestic product (GDP) and 3.5% of total GDP (Wambugu *et al*., 2011) accounting for 30% of the farm gate value of agricultural commodities (GoK, 2013). According to the Kenya National Bureau of statistics (KNBS, 2010), Kenya is home to a herd of 3.5 million exotic cattle, 14.1million indigenous cattle, 27.7 million goats, and 2.9 million camels with gross milk off take of about 5 billion litres of liquid milk (GoK, 2013) for household consumption and marketing. Livestock production therefore is a major economic and social activity for the communities that live in the high rainfall areas for Intensive livestock dairy production and in the arid and semi-arid land (ASALS).

About 80% of Kenya land mass is arid to semi-arid (ASAL) and supports about 36% of the Kenya population, 70% of the national livestock herd and 90% of the wild game that supports the country's tourism industry (KNBS, 2010, GoK 2010). Arid and semi-arid lands are characterized by aridity with low and poorly distributed rainfall in arid areas ranging between 150mm and 550mm per year, and in semi-arid between 550mm and 850mm per year. Temperatures in arid areas are high throughout the year (24°C to over 30°C) with high rates of evapotranspiration (Herlocker *et al*., 1995; GoK 2010). Large part of ASALs in Kenya is domiciled in Northern part of the country which include counties such as Mandera, Garissa, Wajir, Isiolo, Marsabit, Turkana, Samburu, Baringo and Tana River. The main economic activities of the inhabitants of these counties is livestock keeping under pastoral production system where large herds of livestock are kept in free range system. Main livestock species kept include camels, cattle (mainly zebu), sheep and goats with livestock and livestock products, and notably camel milk, significantly contribute to household food and income needs, especially among poorer households (Elhadi, 201; Adongo *et al*., 2013; Behnke and Muthami, 2011).

Milk surplus is usually experienced during the last months of the rainy season and directly after the rains and is consumed in fresh or fermented form or as ingredients such as tea. With increasing sedentarization among pastoralists, quest for non-livestock based commodities and need to access social amenities such as hospital, education among others is on the rise (Fratkin, 1999). The result is increased need for cash

income for pastoral households giving rise to commercialization of livestock and livestock products in ASALs. The emergence of commoditization of livestock products in local markets has ushered in the need to introduce standard protocols for improving livestock products in order to insure consumers from risks associated with consumption on unhygienic dairy products and also to maximize on better income from processing of healthy dairy products. Since the year 2000, research institutions such as Kenya Agricultural and Livestock Research organization (KALRO) initiated community based participatory processes of value addition of pastoral dairy products in northern Kenya in collaboration with partners. This process has grown and up-scaled in a number of areas beyond test sites and with mixed outcomes thus prompting the need to review its status in terms of research, development and market penetration. The objective of this paper therefore is to appraise advances in development of the pastoral ASAL dairy sector in Kenya and explore opportunities available for the emerging dairy phenomenon in Kenya.

## Methodology

This paper reviews literature on dairy processing initiatives being undertaken in Kenya ASALs. It presents achievements and challenges bedeviling the realization of stable dairy activities in the areas. It further provides insights into alternative option that may assist in improving the performance of the industry in ASALs. Information has been sourced from existing documents which include journal papers on milk hygiene and handling, technical project reports on milk production and value addition in ASALs and relevant Government policy documents. The author has also given personal opinion based on over 15 years of personal experiences with the development of dairy projects among pastoral communities of northern Kenya. The Agricultural Product value chain (APVC) approach has been adopted in this review and has focused on priority value chains based on priority setting in ASAL counties agriculture sector coordination.

## Findings

### ASAL livestock population and estimated potential for milk output

Table 1 gives summary of pastoral ASAL livestock population according to the 2009 national census in Kenya and how they compare with the national livestock herd population. Eighty four percent of national livestock are found in ASAL of Kenya where over 75% are sheep and goats, 52% cattle with nearly all camels in Kenya being in the ASAL and more in the arid Northern Kenya.

**Table 1:** Livestock population in arid and semi-arid pastoral areas in Kenya

| Species | Arid areas | Semi-Arid[1] | Total pastoral | National Total | % of National herd |
|---|---|---|---|---|---|
| Cattle | 6,281,354.00 | 2,704,786.00 | 8,986,140.00 | 17,167,774.00 | 52.34 |
| Sheep | 10,246,527.00 | 3,170,220.00 | 13,416,747.00 | 17,129,606.00 | 78.32 |
| Goats | 18,230,633.00 | 2,627,347.00 | 20,857,980.00 | 27,740,153.00 | 75.19 |
| Camels | 2,924,742.00 | 35,625.00 | 2,960,367.00 | 2,971,111.00 | 99.64 |
| Total | 37,683,256.00 | 8,537,978.00 | 46,221,234.00 | 54,759,212.00 | 84.41 |

[1] Semi-arid pastoral counties include; West Pokot, Elgeyo/Marakwet, Baringo, Laikipia, Narok and Kajiado (source: KNBS 2010)

Table 2, gives gross estimates of milk off take from all livestock species from the ministry of Agriculture. Currently, gross milk output in ASAL estimate at 690 million litres (15%) compared to national output of 4.5Billion litres translating into KES 24billion (MoA&LDF, 2016). However, the figures do not show production per livestock species hence making it difficult to show contribution per livestock species for purposes of priority setting within the pastoral dairy production.

**Table 2:** Current milk production from all livestock species in ASALs and value in KES

| Arid Pastoral | Semi-Arid Pastoral |
|---|---|

| County | Milk Volume (L) | Price (KES) | Value (KES) | County | Milk Volumes (L) | Price (KES) | Value (KES) |
|---|---|---|---|---|---|---|---|
| Turkana | 43,012,658 | 60 | 2,580,759,498 | West Pokot | 85,587,870 | 50 | 4,279,393,500 |
| Marsabit | 130,661,720 | 70 | 9,146,320,400 | Baringo | 34,617,428 | 50 | 1,730,871,409 |
| Mandera | 11,855,000 | 70 | 829,850,000 | Elgeyo/Marakwet | 49,148,118 | 40 | 1,965,924,720 |
| Garissa | 14,564,946 | 70 | 1,019,546,220 | Kajiado | 67,105,262 | 60 | 4,026,315,705 |
| Wajir | 83,330,262 | 70 | 5,833,118,340 | Narok | 82,944,000 | 30 | 2,488,320,000 |
| Isiolo | 6,800,000 | 60 | 408,000,000 | Laikipia | 64,723,326 | 40 | 2,588,933,040 |
| Tana River | 12,004,524 | 70 | 840,316,680 | **Total** | **384,126,004** | **45** | **4,279,393,500** |
| Samburu | 3,627,650 | 60 | 217,659,000 | | | | |
| **Total** | **305,856,760** | **66** | **20,263,010,370** | **Total ASAL** | **689,982,764** | | **24,542,403,870** |

**Source**: (MoAL&FD, state department of livestock, 2016)

To assess the potential milk production in ASAL, various formulae have been used by different researchers to quantity amount of milk produced by various livestock species. These methods factored in the percent of lactating cows in the herd, the proportion of those cows that lactate per year, output per lactation, the level of extraction for human (Behnke *et al*., 2011). Premised on this framework, Rege *et al*. (2001) observed that a farmer can extract 378 litres of milk per cow per year and with approximately 28.75% of cows in lactation giving unweighted mean of 108.6 litres/head/year. This is high compared to 59 l/head /year in arid zone Marsabit (McPeak and Doss 2004) and 81 l/head at 22% of herd lactating in Turkana (McCabe 1987).

Estimation of camel milk production has been reported in a number of studies. Musinga *et al*., (2008), found 1.5litres per lactating dam per day and with total lactating herd at 34% hence the total annual output was estimated at 186 litres per head or 18615 litres per 100 heads of lactating dam in Isiolo. Comparatively Aloo *et al*. (2003) reported daily mean yield of 1.56 l per lactating dam with 15200 l/100 head/year or 152 l/head/year in Rendille camels, lower than figures found in Isiolo. However, variation within each community may be attributed to the availability of forage and breed type among other management practices. Similarly, Simpkin (1998) estimated mean daily output per dam among Rendille herd at 1.9 l giving annual output of 693 l per dam. With 25% of dam lactating, the annual output per head translated to 17325 l per 100 dams or 173.25 litres per head/year. Other similar studies included Bollig (1992) with estimated annual output of 600 l per dam and with 24.2 % of lactating herd, the annual output per 100 head of lactating dam was 14520 litres or 145.2 litres/head/year. This gives camel milk value chain higher net value in terms of production compared to cattle milk in the same area.

The high number of goats in ASALs also has implications on food and nutrition security among households. Currently most communities produce milk mostly for household consumption but some quantities are sold in the nearby urban centres for cash income. Estimation Milk production in goats in ASALs face some challenges due to high numbers kept over extensive free range and mobile grazing system. The task is further complicated by short lactation period coupled with very small quantities extracted from the ewe, furthermore most pastoralists let the lactating goats to stay with their kids. Attempts have been made to estimate pastoral goat milk output especially in northern Kenya (Field, 1985), Tanzania (Safari *et al*., 2008) and Ethiopia (Baars, 2000). Estimates by Field (1985) indicate average daily milk yield among Rendille goats is 0.35 l of milk per ewe thus giving annual output of 128 litres. Hence at 40% of lactating herd goats in Marsabit produce 51.2 l per head per year (Benhke and Muthami, 2011). A study conducted by Safari *et al.* (2008) in Tanzania in different location using different breeds gave varying figures. At 42% lactating herd of local small east African goat, an awe(ewe) produced a mean total annual output of 223litres within a lactation period of 8 months (240 days), whereas in a mixed system, the ewes gave an output of 220 litres within similar lactation.

For purpose of relevance to the geographical area of focus for this review, this paper adopts the formula used by Rege et al (2001) and McPeak and Doss (2004) for cattle semi-arid and arid areas respectively. Although many studies have postulated a number of estimates in camel milk output, this study adopts the latest formula by Musinga *et al* (2008) for calculation of camel milk output in ASALs. Several authors (Field 1985, Semeye, 1989, Safari *et al* 2008) have provided various estimates of sheep and goat milk output in varying agro-ecological zones in East Africa. This paper adopts the formula by Field (1985) since it was conducted in arid zones of northern Kenya where Galla goat is the dominant breed being kept for dual purposes (both for meat and milk). Based on these formulae and following the method of Benhke and Muthami (2011), the annual milk output of various species can be provided and has been calculated and summarized in table 3.

**Table 3**: Calculated potential milk output in ASAL pastoral areas of Kenya (Litres)

| Species | Arid areas | Semi-Arid pastoral | Total pastoral | % of total |
|---|---|---|---|---|
| Cattle | 370,599,886.00 | 294,010,238.20 | 664,610,124.20 | 23.64 |
| Sheep | 524,622,182.40 | 3,170,220.00 | 527,792,402.40 | 18.77 |
| Goats | 933,408,409.60 | 134,520,166.40 | 1,067,928,576.00 | 37.98 |
| Camels | 544,586,960.40 | 6,633,375.00 | 551,220,335.40 | 19.61 |
| **Total** | **2,373,217,438.40** | **438,333,999.60** | **2,811,551,438.00** | **100.00** |

Based on the formulae used elsewhere in this paper, the current gross value of ASAL milk production and justification for value addition and commercial orientation can be drawn. Table 4 gives calculated value of milk from various livestock species using the of formulae of Field (1985) goat/sheep milk, Musinga *et al*. (2008) camels, Rege *et al*. (2001) and McPeak and Doss (2004) for semi-arid and arid cattle respectively. Using KES 50 (0.5USD) as the mean farm gate price for raw milk in table 3 above, the net value of pastoral dairy sector can be calculated as summarized in table 4. Therefore the net value of pastoral dairy should range from KES 24.5 billion to KES140 billion from 0.69 to 2.8 billion litres of milk.

**Table 4:** Potential estimated monetary value of the pastoral milk sector (KES)

| Species | Arid areas | Semi-Arid pastoral | Total pastoral | % of total |
|---|---|---|---|---|
| Cattle | 18,529,994,300 | 14,700,511,910 | 33,230,506,210 | 23.64 |
| Sheep | 26,231,109,120 | 158,511,000 | 26,389,620,120 | 18.77 |
| Goats | 46,670,420,480 | 6,726,008,320 | 53,396,428,800 | 37.98 |
| Camels | 27,229,348,020 | 331,668,750 | 27,561,016,770 | 19.61 |
| **Total** | **118,660,871,920** | **21,916,699,980** | **140,577,571,900** | **100.00** |

**Dairy Processing technologies in ASALs**

**Indigenous processing and preservation technologies**

Milk surplus in ASAL is normally experienced immediately after rainy season. Traditionally, this milk has been utilized by pastoral household where it originally constituted 80% of the household diet (Scheider, 1984; Field, 2000) and consumed either in raw or fermented form (Omar *et al.*, 2007) since fermentation and fumigation are the most used methods of improving shelf life of milk in ASALs areas ( Shalo, 1987;Yagil, 1992; Wanjala *et al.*, 2017 ). Below are some of the traditional dairy processing technologies used by pastoralists.

**Smoking treatment of fresh milk containers**

Table 5 gives examples of tree species preferred by pastoralists in fumigation of containers. Dry trees and shrubs for smoking is done in the evening when women have gone to fetch firewood. The wood material is split into small pieces and set on fire in the evening. One of the splints is then removed from

the fire and the flame is blown off. The splint with bellowing smoke is inserted into the milking container and any other storage container. The container is then shaken to allow for spread of smoke evenly on the inner walls of the container. This is done until the hands feel warm when touched on the outside of the treated gourd/Plastic jerican (normally the splint is reintroduced three times). Butter, which is used to protect the gourds, starts to melt when the treatment is said to be complete. 'A *musuti* (Samburu) or *soso* (*Boran)*, which is a special cloth, is then used to wipe out excess soot from inside the milk container. Some people ignore this important step and supply milk with a lot of ashes. Originally this cloth was not supposed to be washed, as the Samburus believed that this would result into death of the lactating animals. The containers once treated are hanged around cattle homestead ready for the milker. The milker would then washes it with cold water before milking. However in *fora* herds where water is a problem this is normally skipped. And the water used is always almost of poor hygienic quality.

According pastoralists, smoking milk containers imparts special taste and flavour to the milk, and disinfected the containers, thus reducing the numbers of micro organisms and thereby extending the shelf life of milk (Kaufmann, 1998; Wayua *et al.*, 2009). This also agrees with findings of Wanjala *et al*. (2017) who found that smoking inhibits development of gram negative bacteria that are very stubborn to sanitation using detergents. However, smoking has been associated with low performance of mesophilic starter cultures compared to non-smoked milk (Ashenafi, 1996) and also affects market reach of pastoral milk especially from non-pastoral consumer base (Wayua, 2011).

**Table 5:** Plants used in smoking of containers in milk preservation & storage

| Community | Local name | Scientific name | Reference |
|---|---|---|---|
| Borana | *Ejarse* | *Olea africana* | ICRAF.1992 |
| Gabra | *Burquqe* | *Acacia elatior* | ICRAF-1992 |
| Samburu | *Sokotu* | *Salvadora persica* | ICRAF-1992 |
| Rendille | *Akhai* | *Salvadora persica* | Maundu *et al*. (1999) |
| | *Mad'eer* | *Cordia sinensis* | Maundu *et al*. (1999) |
| Samburu | *Loirien* | - | Kyalo (1987) |
| Somali | | *Acacia horrida benadirensis* | Mohamed (1993) |

**Fermentation technologies for liquid milk**

Traditionally fermented milk is known as *kule naoto* (Samburu), *kalbao/ititu* (Borana), *mursik* (Kalenjin) and *suusa* (Somali─camel milk). It is made by putting raw milk in a clean and fumigated container, sometimes wrapped with a piece of cloth and then kept in warm place (ambient temperature) for about 12-24 hours to allow spontaneous fermentation (Wayua, 2011). The milk becomes sour either from inherent microbes of milk when it is not boiled, or from the bacteria growing on the walls of the milk vessel. The ambient temperature can range between 25 and 35°C. According to Steinkraus (1995), fermentation process can be caused by bacteria, yeast, and mold with common microbes being *Lactobacilli* (*L. acidophilu*s and *L. bulgaris*), *Lactococci* species *(L. cremoni, and L. lactis*), *Streptococcus thermophilus, Leuconostoc* species, and *Saccharomyces* species, each giving the product a characteristic flavor (Steinkraus, 1995; Muliro, 2017, Mwangi *et al*, 2017; Muigei *et al.*, 2013). Hence traditionally fermented products vary in taste and consistency.

**Hard fermented milk curd (*Ititu*)**

This product (*Ititu*) is prepared by the Borana tribes, pastoralists in southern Ethiopia and northern Kenya for use during the dry season. Raw milk (from goats, sheep, cows) is naturally fermented followed by daily removal of whey and addition of fresh milk until the vessel is filled with hard curd. When milk is soured and reaches an acidity of about 1 per cent lactic acid, fermentation ceases and two layers - curd and whey - are formed. The curd floats on the whey and the whey is removed by a wooden pipette introduced into the vessel. This type of product may be used for up to 90 days (Bekele and Kassaye, 1987).

**Ghee (Clarified butter)**

Traditionally, clarified butter is prepared from whole raw milk is allowed to ferment spontaneously overnight. The fermented milk is then churned to obtain butter. Once the quantity of butter produced is sufficient, butter is poured into a large open pan and heated to boiling point (110–120°C) to evaporate the water. At first, the melted butter froths up and scum and sediments appear. The scum consists mainly of proteins and impurities and the sediment of solids-non-fat (SNF). Frothing stop with expulsion of nearly all water. Once the residue has settled down during cooling, the clear fat is filtered through muslin and put into an earthenware pot, metal or glass container. Shelf life depends on the moisture content in the product. It can keep for up to one year when the humidity content is less than 1%. This technology does not work with camel milk. The weakness with this technology is that the producers have to accumulate a lot of milk overtime in order to acquire a substantial amount that warrant profitable commoditization against a backdrop of high seasonality.

**Emerging Technologies**

Lifestyle changes among pastoralists is drifting to a commercial orientation where livestock products especially milk is sold for cash income to help defray expenses incurred in other needy social amenities (Fratkin, 1999). The realization of full potential of commercialization of pastoral milk in the current century may not wholly depend on traditional technologies given their limitation in terms of products yield and hygiene related issues along the value chain (Farah *et al*., 2004; Matofari *et al*., 2007; Matofari *et al*., 2013;). Studies conducted by Field (2000; N.D) recommend testing and adaptation of alternative technologies and recipes appropriate for dairy processing, preservation and marketing in Kenyan ASAL communities as a way of reducing high incidence of poverty (over 70% compared to national levels of 56% (KNBS, 2010). In 2001, scientists from KARI (currently KALRO) and with financial support from European Union through Agricultural Research Support Programme phase two (ARSP II) initiated community based low cost and appropriate technology experiments with camel milk to test suitability of cultures and recipes under arid conditions (Recke *et al*., 2004). These experiments focused majorly on camel milk because camel produces more milk for longer period than other livestock species in ASAL (Hashim *et al*., 2009; Farah, 2004). Recipes were adapted and new ones developed. In the field, camel butter milk (plain / strawberry flavour), camel milk ghee, dried dissolvable camel cheese and a cheese based spiced toffee were produced according to local preferences (Brunste *et al*., 2015; Bruntse, 2013). Table 5 gives summary of other camel milk products which have been tested and others that still require further scrutiny.

**Table 5**: Other studies on product development both in Kenya and outside

| Milk Product | Recipe/Product type | Country | Source | Conclusion/Remarks |
|---|---|---|---|---|
| UHT | Ultra High Temperature (UHT) treated, direct (150°C/ 2 sec, the product is heated by direct contact with steam)<br>indirect (138°C/ 8-10 sec, medium and product are not in direct contact)<br>Homogenized, cooled and stored in sterile bottles at 5 °C and 25°C in dark room. | Kenya | Farah & Wangoh, 2010 | •Camel milk cannot be UHT treated following the same procedures as cow milk.<br>•Camel milk caseins heat sensitivity can be reduced by stabilization of the proteins with selected thickening agents and specific additives. |
| Fermented milk (*Mala*) | • Pasteurise (batch) at 82°C for 5 seconds. Then cool to 25°C. Inoculate the milk with 2% (w/w) mesophilic starter culture, i.e. i.e. 4-5 granules of culture (Flori Danica, CHN22 Chris Hansen Laboratories). [Or if using propagated culture, 1 litre of prepared starter culture to ferment 50 litres of milk overnight].<br>• Incubate the milk at room temperature overnight.<br>• The following day, the thickened product is stirred and packed.<br>• *Mala* can be flavoured with any available flavour including fresh fruit, orange flavour and strawberry, among others.<br>• Shelf life of this product is 5-10 days at ambient temperature (about 5 days in hot weather like in ASAL). | Kenya and other countries | Brunste 2013, | Widely adopted in ASALs |
| Cheese | Soft cheese, Dry cheese, Hard cheese (ripened). Refer to literature for specific recipes. | Kenya | Brunste (2013, 2015). Ramet *et al*., 2001 | Uses coagulant (FAR-M®) developed by CHR Hansen A/S. Can work with PH of 6.0 as compared to PH 5.5 previous reported by Farah and Brunste (2004). The development and field trials of camel cheese was done but yet to be commercialized in Kenya. |
| Tea toffee/sweets | • 1 kg fresh cheese is mixed with 3 kg sugar and according to preference spices such as cinnamon, cardamom or ginger are added and cooked over very slow heat until it turns caramel brown. This can take 45-60 minutes and stirring during the process is essential to prevent burning.<br>• Pour on greased plate to cool<br>• Cut in suitable pieces for sale or consumption.<br>• When properly dry, this product lasts for months and is very popular with children. | Kenya | Brunste 2013 | This product can be packed in small jars after cooling. To use it in tea, a spoonful can be dissolved in hot black tea, which will then turn milky and sweet. Tea toffee made from camel milk dissolves completely in hot water, and does not curdle the tea. It has only a slight tangy taste left from the fermentation of the milk.<br><br>Yet to be adopted for commercial purposes. |

| Milk Product | Recipe/Product type | Country | Source | Conclusion/Remarks |
|---|---|---|---|---|
| Condensed camel milk | mix 1 part of sugar with 4 parts of milk and boil over an open fire until the mixture is reduced to half its original Volume. The milk can last for 6 months or more without refrigeration. | Kenya | FARM Africa, 2002 | Project supported production of about 2000 kg of condensed milk for demonstration And sale. However, people have been slow to take up the technology due to lack of fuel wood and high sugar required. |
| Ghee (clarified butter) | Using sterile containers, heat milk to $60^0$C for 30 minutes (camel milk) or $45^0$ C (cows, goat's milk) for 30 minutes. Pour the milk into a manual cream separator to separate cream from skim milk and non-fat. Heat the cream till a clear golden brown liquid appears. For fermented flavour, boil the cream and let cool to room temperature. Then add mesophilic starter culture available from any dairy product shop. Let stay overnight. Cook fermented cream over low heat till all particles turn brown. Sieve the ghee using dry sterile cotton cloth. (The cotton cloth is sterilised by boiling in clean drinking water.). Before complete cooling, pack ghee in suitable clean containers depending on purpose and targeted market. | Kenya | Adongo A.O, 2004 | Works very well with camel milk. And milk from other species. |

**Adaptation of processing practices (mini dairies)**

Initial trials on viability of processing milk in Kenya ASALs was first conducted in Marsabit county with establishment of three mini dairies in different community based set up. Three community based groups supported by KARI (currently KALRO) with financial support from European union included Salato women group in Ngurunit, Karare women group in Karare location at the foothills of mount Marsabit and Pastoralist Resource Marketing cooperative (PRMCO) in Moyale town. Using participatory methods for capacity building recipes on conventional milk processing were first assessed for community acceptance among Samburu women in a remote area of Ngurunit in Marsabit County. The recipes adapted for commercial piloting included products such as *Mala* (fermented milk), ghee and fresh pasteurized milk initially developed in Ngurunit. Although Empson and Bachmann (1990) recommend starting a mini dairy with as little as less than 1000 litres of raw milk, these pilot dairies barely operated beyond 300 Litres on daily basis given the pastoral nature of milk production system. Available records indicate that fresh pasteurized fresh milk was highly demanded throughout the seasons compared to fermented products such as mala and ghee (Adongo *et al.*, 2002). A mini dairy with financial stability at the time was PARMCO which received a net monthly profit of KES 1,000 during the lowest production period and KES 11,500 during the highest peak so far reached. This translated into an average monthly income of about KES 6,200 from an average daily supply of 62 litres. With success stories from the initial trials, a number of development agencies and common interest groups have widened the scope of dairy processing in Northern Kenya. A Dutch development agency (SNV) in collaboration with VSF Suisse supported bulking of camel milk in Isiolo. This has been done through Anolei camel milk cooperative which currently holds 5000 litres of fresh raw camel milk at a depot in Isiolo town before transport to wholesalers and retailers in Nairobi (Siloma, 2011). The cooperative has been supported with a 5000 litre capacity electric operated cooler and packaging facility and several metal cans for transportation of milk. In north eastern part of Kenya, daily traded volume of liquid camel milk for both primary and secondary milk collectors in Garissa county is estimated at 9000 litres with an average of 20 litres per trader (SITE, 2009) with Garissa town being the major source of market for

that milk. Several actors were trained on hygienic handling and processing of camel milk. Currently, conventional processed milk especially camel milk accounts for 1% of the market share of total traded milk in ASALs and is mostly processed by one factory, the Vital Camel Milk Limited (VCML) in Nanyuki even though camel milk accounts for 13% of total national milk output (Nassiuma and Nyoike, 2013).

**Current challenges facing development pastoral ASAL dairy development**

Challenges affecting dairy processing in Kenya ASALs are not restricted to the processing alone but may be a net effect of constraints within the value chain of most prominent livestock product species being traded in the market which in this case is the camel.

- Milk production in ASALs is highly seasonal given the short and erratic rainfall which in most cases is poorly distributed in time and space. Long dry season experienced in ASALs causes land degradation and poor vegetation growth thus resulting into feed shortage. As a result there is high mobility of lactating animals to distant places which in turn present with high logistical requirements against poor road infrastructure to access milk for market. Low milk yield per animal requires well developed system of aggregating milk from several animals which are spatially distributed over expansive grazing land. Additionally, the practice of milking two teats and allowing calf to suckle others may be contributing to low milk output due to inefficient extraction by herders.
- Input supply is one of the major challenges facing producers, milk traders as well as other chain actors. Currently, most livestock producers and milk traders source inputs from Nairobi. Starter cultures, mastitis testing kits, aluminium milk cans, lactometer among others can only be sourced in major towns far from pastoralists in ASALs.
- Although organizational structures for milk collection are beginning to show up in grazing areas near peri-urban centres, the system is still constrained by poor means of transport and road infrastructure. Cold chain facilities are beginning to exist at the bulking centre in town where there is electricity. A number of bulkers have received support from development agencies to acquire chilling plants however, they barely operate within the optimal capacity thus incurring a lot of expenses in running the cold chain facilities given. For example, Anolei milk cooperative have a 5000 litres chilling tank but can manage 3000 litres of camel milk on daily basis. Similar experience exist in Loitokitok Dairy Cooperative Society in Kajiado County as well as in several other groups that operate fridges in Garissa town.
- There is limited processing facilities coupled with limited range of processed products in Kenya market. Currently about 95% of milk is sold in boiled form and in some cases in raw form. Product diversification is only possible with entry of the vital camel milk factory in Nanyuki, but the performance of this facility has been put to test due both social and technical bottlenecks. Despite formulation of standards for camel milk, there is limited regulatory implementation framework in place to enforce adherence to quality control requirements in ASALs. Both the Kenya Dairy Board (KDB), Kenya Bureau of Standards (KEBS) are yet to establish offices in ASALs.
- There is weak linkage among sector players as most milk trade is socially driven rather than market dynamics hence production is localized away from the main consuming regions resulting in narrow customer range.

**Opportunities for future development of diary sector in Pastoral ASALs**

- There is a huge potential for milk extraction in ASALs. As reported earlier milk optimum production is estimated at 2.8 Billion litres (Field, 1985; Rege *et al*., 2001 McPeak and Doss, 2004, and Musinga *et al*.,2008;) compared current figures of 0.69 billion litres (GoK 2016). The production gap of about 75% can be bridged if producers are enabled to access adequate water and pasture, access to stable market for raw milk. Collection systems supported by effective chilling facilities, processing with interconnected end market players.

- Most studies have reported a number of processed camel milk products such as fermented liquid milk (Mala) using starter cultures, cheese (both soft and ripened), sweets among others. But these products are yet to be adapted for full scale marketing in Kenya. Furthermore, milk markets for pastoral dairy products are still restricted to customers of pastoral background given the smoked nature of milk from pastoralists. Expanding this customer base presents an opportunity in research and development in product development and establishing a more aggregated marketing system to help penetrate milk market. Promotion of camel milk which is the most dominantly traded milk commodity in ASALs especially in more arid areas should take advantage of the nutritional and therapeutic value of camel milk (Yagil, 1992).
- There is need for more research to help understand the phytochemical and microbial properties of tree species used by pastoralists in sterilizing milk containers in ASALs. The research can also encompass the inherent properties of camel milk to withstand longer time before degradation compared to milk from other livestock species.

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# EMERGING LIVESTOCK FEEDS

# Diamond V Original XPC™ Alleviates *Salmonella* Antimicrobial Resistance in Layer Chicken Production

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## Abstract

Antimicrobial resistance (AMR) is one of the greatest setbacks to global health and food security. An estimated 700, 000 people die each year from antimicrobial resistant infections (WHO, 2017). Over 80% of important medical antibiotics in animal sector are used for prophylaxis or growth promotion in healthy animals, with 70% of the administered drugs being secreted as residues in animal products. Antimicrobial resistance occurs naturally, although, is accelerated by either misuse or overuse of antibiotics together with poor infection prevention of diseases in humans and animals. Impacts of AMR include: Prolonged hospitalization, higher medical costs, allergies and increased mortality. This provide the need to implement sustainable agricultural practices that prioritize infection prevention for healthier animals therefore reducing need for antimicrobial treatments. This require technologies, such as feed additives that promote animal immunity and health. Diamond V XPC™ [Yeast Culture (AFCO - 96.8)] is a *Saccharomyces cerevisiae* fermentation derived product with potent metabolites that, when incorporated into chicken diet at the rate of 1.25kg/MT of feed, positively impact their health by promoting gut microbiota, healthy intestinal morphology and balancing immunity enabling birds to be resistant to diseases such as salmonellosis, significant to both the producers and consumers. This is evidenced by the fact that Diamond V XPC™ reduces Salmonella incidence by up to 60% in layers, reduces shedding, virulence and enhances reversal of AMR in salmonella indicated by a 45% reduction of *hil*A gene in AMR pathogens thus potentiating antimicrobial stewardship.

**Key Words:** Antimicrobial Stewardship, Food Safety, Functional Metabolites, Yeast Culture.

# Bovine Imunity: Balanced for Health and Performance

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## Abstract

Dairy cow's immunity is underexploited in the optimization of animal's performance to ensure adequate contribution to global food security. After feeding, the ingested feed is usually digested followed by nutrient absorption, partitioning and assimilation to meet the animal physiological needs. Unchecked nutritional demands of an activated immune system in a cow diverts nutrients which would have otherwise be directed towards milk production. For optimal performance of these dairy animals, it is important to ensure that immune responses are only elicited when absolutely needed by the body. This can be achieved by ensuring optimal nutritional balance which attained by introduction of yeast culture (YC) - *Saccharomyces cerevisiae* fermentation based immune support product (Diamond V Mills Cedar Rapids, Iowa) in dairy feed. This is fundamental especially in the transition cow (21 days pre and post calving) due to the high immune response initiated by the pre and post calving processes. This was proven by feeding three categories of cows; control - fed on a basal diet only, while the second and third groups of animals were fed 56g and 112g of Yeast Culture respectively in addition to the basal diet. Serological analysis showed that plasma levels of Serum Amyloid A (an acute phase protein) increased significantly pre-calving in the control group, an indication of un checked immune response compared to animals on the YC product whose immune system was only recruited when needed during healing process post calving. This therefore shows the positive role of YC in ensuring a balanced immune response that spare the nutrients for performance in dairy production.

**Key Words:** Dairy production, Immunology, Nutrient partitioning, Transition cow, Yeast Culture.

# Animal Feeds and Feeding: The Importance of Animal Feeding and Feed Inventories for Kenya

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Feed is financially the single most important element of animal production and its costs can account for upto 70% of the total cost of production. High feed costs can wipe out a livestock rearing operations and livelihoods. Availability of animal feeds is currently affected by feed-fuel competition, food-feed competition, land use and water use change. Animal product quality is also affected by chemical substances found in feeds: saponins (meat shelf life), Phenols (antioxidation potential of milk), tannins (meat colour). Toxic agent can be introduced into foods of animal origin through feeds: Industrial & environmental toxins: dioxin, dibenzofurans, dioxin-like polychlorinated biphenyls, melamine, heavy metals, pesticides, radionuclides. Grass-based diets also contain conjugated linoleicacid (CLA) isomers, trans vaccenic acid (TVA) which is a precursor of omega-3 fatty acids and precursors for Vitamin A and E, as well as cancer fighting antioxidants.

The national feed inventory documents the available feed resources and the amount. The feed balance estimates the requirements (demand) and the amount of available utilizable feed (supply). Advantages of National Feed Inventory include: setting of environmentally sustainable stocking rates & better handling of emergencies, designing a sustainable development pathway for the livestock sector –based on feed resource availability and identifying investment strategies on efficient use of biomass – development of agro-based industries. A feed balance enables: assessment of shortage/surplus of feed resources for current levels of production, estimation of potential shortages in feed resources to meet a targeted level of animal products and identification of types of feeds that might be required where shortfalls are identified.

Information required to conduct a feed inventory include feed system characterization: which feedstuffs, in what proportion, in which period of the year (e.g. season), in which region ( e.g. agro-climatic zone or livestock production system (extensive, mixed extensive, mixed crop-livestock, intensive).

In conclusion, animal nutrition impacts almost all sectors & services of the livestock operation and generation of sound feed-related data is imperative for sustainable development of the livestock sector in Kenya.

FAO and Ministry of Agriculture and Irrigation have taken a lead to generate National and County Feed Inventories and Balances, and to develop a National Feed Strategy.

# Heterogeneous treatment effect of maize ensiling on production stability among smallholder dairy cow producers in Meru County, Kenya

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## Abstract

This study provides empirical evidence on determinants of adoption of maize silage and heterogeneous treatment effects of maize ensiling on milk production stability among smallholder dairy producers in Meru County, Kenya. A multi-stage sampling technique was used to select 349 respondents. Data was collected using a semi structured questionnaire through face-to-face interviews. The stratification multilevel and matching-smoothing approach of treatment effects was used to determine the heterogeneous treatment effects of maize ensiling in smallholder production system. Adoption of maize silage was enhanced by higher level of education of the household head, more frequent contacts with extension service providers and training on fodder production. Further, larger herd size and higher dairy related assets enhanced adoption of maize ensiling. Producers with high socioeconomic and institutional characteristics benefited most maize ensiling. To such program, planners implied assumption of homogenous treatment effect of organic certification does not always hold.

**Key words:** Maize silage, adoption, dairy cow, heterogeneous treatment effect, smallholder producers, Kenya

## Introduction

Seasonal variability in feed supply and availability is a major challenge to increasing dairy production under smallholder systems in Kenya The variability could be addressed through adoption of appropriate feed management techniques, such as silage or hay making, which is increasingly being demanded in commercial dairy production (de Haan, 2014). Conserving forage as silage is an option to alleviate seasonal feed shortages and maintain animal productivity during dry periods. Maize (*Zea mays*) silage is one of the solutions that is being considered to deal with deficit of feed for dairy cows in Kenya, especially due to the persistent dry spells.. Maize can be used as an energy and fiber source for cattle, mainly for dairy cows (Bernardes and Do Rêgo, 2014).

The advantage of maize silage is that it can be produced in regions suitable for silage crop production and the surplus transported and sold in areas facing feed shortages or where land size is limited (Campbell, 2013; Mugabe et al., 2017). Despite maize crop being the most dominant food crop in Kenya, few producers engage in ensiling the crop to provide steady supply of feed to cattle among smallholder producers. Maize ensiling technology has a potential to provide the much needed feed supply stability which could translate to milk yield stability for smallholder cattle households (Reiber et al., 2010; Rademaker et al., 2015). However, despite numerous research and development efforts, adoption of silage technologies has been low in the tropics and subtropics, especially under commercially oriented smallholder production system. Due to the quest to provide a balance between livestock feed production and food supply for the households of smallholder producers, silage production from maize is a great challenge. The erratic supply has led to milk production fluctuations in dry and wet seasons affecting the farmer profit margins. . However, the drivers and the impact of adoption on stability of milk

production in terms of season of maize silage among smallholder dairy cow producers is not well documented.

Consequently, this study aims to fill the knowledge gap with an exploratory study among smallholder dairy producers in Meru County, Kenya. Therefore, the objective of the study was to provide micro level empirical evidence on factors that influence smallholder producer's adoption of maize ensiling and its impact on stability of milk. The study contribution to literature is two fold. First, it seeks to determine the drivers of adoption of maize ensiling in smallholder dairy cow production system and link the same on production stability between the dry and wet seasons. Secondly to demonstrate the heterogeneous treatment effects of technology adoption that is widely missing in empirical literature (Xie et al., 2012); with a view to revealing key beneficiaries from technology adoption. The innovative stratification multilevel and matching-smoothing approaches of estimating heterogeneous treatment effects proposed by Xie et al. (2012) were used.

Findings are expected to assist policy makers and stakeholders in ensuring stability in milk production in smallholder production systems, which accounts for about 70 percent of milk produced in Kenya. For maize ensiling program planners, understanding heterogeneity in treatment effects is imperative in giving insights on whether producers are benefiting from the technology and for program planners to get maximum impact, which group should they target acknowledging the heterogeneity in target population.

## Material and methods

### Study area

The study was conducted in Meru County in Kenya. Meru county lies within 0˚6' North and 0˚ 1'S and latitude 37˚ West and 28˚ West with a land size of about 6, 936 Km$^2$. with a population of 162,712 and an area of 627.20 square (MCIDP, 2013). Meru County was purposively chosen because maize silage concept has been promoted by Netherlands Development Organization - SNV, Producer organisations, government extension officers and other organisations as feed for dairy cows. The "lead producer" approach" was employed in trainings and demonstrations. Data was collected from 349 smallholder dairy farmers, where about 52 percent were involved in maize ensiling. Multi-stage sampling approach was used to select the sampled households in September 2017.

### Analytical framework

Unevenness across population has received recognition in empirical literature in response to impact evaluation (Xie et al., 2012). Maize ensiling is the treatment (denoted by C) where $C_i = 1$ if the $i^{th}$ producer is involved in maize ensiling while $C_i = 0$, if otherwise. Consequently, $Y_{1i}$ and $Y_{0i}$ represent stability in cow milk for producers that use maize silage and the non-users, respectively. In case maize silage technology is random, Average Treatment Effect (ATE) using propensity score matching of users and non-users of maize silage is presented as;

$$ATE = E(Y_1 - Y_0) \quad (1)$$

Consequently, if the effect of maize ensiling is homogenous across smallholder dairy cow producers, ATE, TT and TUT would be identical, but if diverse it is a signal of heterogeneity effect of maize ensiling. The ATE, TT and TUT statistics "ignores' the heterogeneity within group among producers (Xie et al., 2012) and hence the need to create categories/groups in order to establish the impact.

Stratification multilevel approach of estimating heterogeneous treatment effects involves an estimation of Probit regression model and there after propensity scores are predicted conditional on socio-economic and institutional characteristics. Dairy cow producers are grouped separately into balanced score strata at 1% significant level before estimating the effect of maize ensiling to the balanced propensity score strata's (Level-1 slope) generated using ordinary least square regression model. Using, variance-weighted least square regression of each strata certification effect, a linear trend is then generated for dairy cow producers (Level-2 slope). In matching-smoothing approach of estimating heterogeneous

treatment effects, matching is conducted by propensity score of participants and non-participants of maize ensiling before data is transformed into participants-nonparticipants comparisons for dairy cow producers. Nonparametric smoothing device is then used to generate graphs of maize ensiling effect as a function of propensity score.

## Results and discussion

### Determinants of participation in maize silage usage

The maximum likelihood estimates of Probit model regression results used in predicting individual propensity scores and to determine farm and producers socio-economic characteristics that influence participation in maize silage usage are presented in Table 1. Better educated producers were more likely to participate in maize silage usage. Formal education is a platform for knowledge acquisition and forms a basis for skill development. As search, education plays an important role in empowering people and changing their perceptions and their self-drive towards being innovative in their future business investments and stability. Producers with large farms were more likely to adopt maize ensilage. as the land was enough to grow maize which could be used for silage making and home consumption. Producers with larger herd sizes were more likely to adopt maize silage usage. The herd size implies the commitment to dairy as a source of income therefore, larger herd sizes makes a producer more committed to the sector. The commitment in turn implies that a producer would try to maintain a stability level in the business by adopting technologies that aid or contribute toward such stabilization.

Similarly, the higher the dairy asset value, the more likely a producer was to adopt maize silage usage. This may be because the dairy asset investment implies commitment on the dairy business. Higher frequency of extension services increased the likelihood of producers' participation in maize silage usage. Extension services are means of producer gathering information on new technologies but most importantly, the higher the frequency of the services implies support of the producer in their activities. Number of training contacts on dairy cow production in the last two years had a positive influence on adoption of maize silage. This may be because, training build confidence in the producers ability to produce quality silage. Further, it also gives an opportunity for producers to learn and ask questions clearing their doubts on usage of new technologies.

**Table 5:** Determinants of participation in maize silage usage (probit estimates)

| Maize silage | Coefficient | Standard Error |
|---|---|---|
| Age of the household head | 0.004 | 0.008 |
| Gender of household head | -0.239 | 0.181 |
| Education level of the household head | 0.167* | 0.097 |
| Household dependency | -0.006 | 0.062 |
| Total used land size | 0.058* | 0.035 |
| Dairy herd size | 0.804*** | 0.183 |
| Dairy assets value | 0.193*** | 0.033 |
| Log income from other sources | -0.011 | 0.020 |
| Share of dairy sector in income | 0.005 | 0.004 |
| Risk perception score | 0.039 | 0.089 |
| Trust perception score | 0.013 | 0.086 |
| Number of extension visits | 0.036** | 0.016 |
| Ownership of title deed | -0.056 | 0.193 |
| Training frequency | 0.059* | 0.030 |
| Group diversity | 0.017 | 0.072 |
| Cooperative dummy (Uruku dairy) | 0.248 | 0.216 |
| Cooperative dummy (Naari dairy) | 0.466** | 0.215 |
| Constant | -4.674*** | 0.878 |

| Maize silage | Coefficient | Standard Error |
|---|---|---|
| LRchi2 | 158.080*** | |
| Pseudo R2 | 0.346 | |
| Log Likelihood | -149.208 | |
| Number of observations | 349 | |

Note: *, **, ***=significant at 10%, 5% and 1% level, respectively.

**Heterogeneous maize silage effects on household dairy production stability**

To determine the heterogeneity in the effects of maize silage usage on production stability, stratification multilevel and matching smoothing approaches of estimating heterogeneous treatment were used (Xie *et al.*, 2012). First, the stratification multilevel methodology was used in estimating heterogeneous maize silage effects on production stability using propensity scores approach. It starts by constructing balanced propensity score strata before estimating the average maize silage effect within each stratum. Using the variance weighted least squares regression, a linear trend is displayed graphically. Results of level 1 and level 2 slope are plotted in Figure 1.

Level 1 slope (Figure1) are point estimates of stratum specific effects of maize silage usage on dairy production stability (which are plotted in Figure 1). Producers with middle and higher propensity scores to usage of maize silage (in strata 3 and 5) significantly benefit most across the stratum.

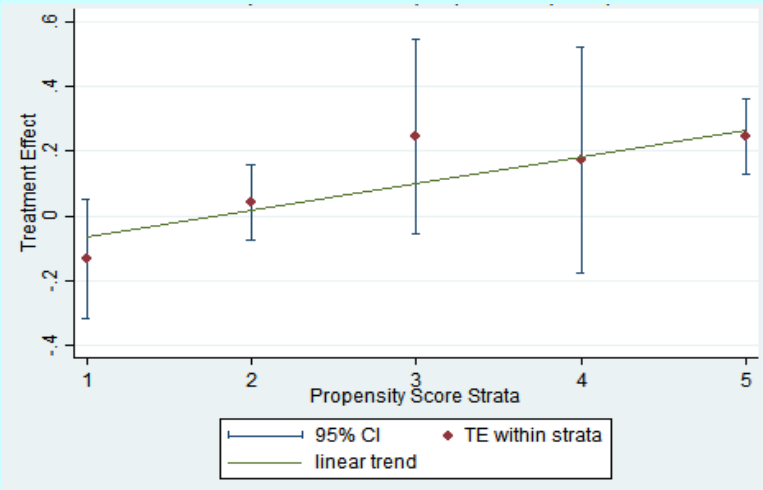


**Figure 4:** Stratified maize silage effect on dairy production stability

A unit change in stratum rank was associated with about 15% increase in dairy production stability of a household. This implies that households with higher propensity to use maize silage experience higher production stability which was statistically significant at 1%. These findings demonstrate heterogeneous effects of maize silage usage on household's dairy.

There was an increase in eduaction level, total used land size, number of extension visits, training frequency, natural logarithms of herd size and dairy asset values as propensity scores increases. This confirms the earlier results on determinants of participation in maize silage usage among dairy producers. The matching-smoothing method of estimating heterogeneous treatment effects was estimated to overcome the limitations of stratified multilevel approach of estimating heterogeneous treatment effects.

Figure 2 shows the results of matching smoothing approach for maize silage usage. The local polynomial regression was used as smoothing device (Epanechnikov kernel, degree 2, bandwidth 0.1) and the shaded region represents 95% confidence interval.

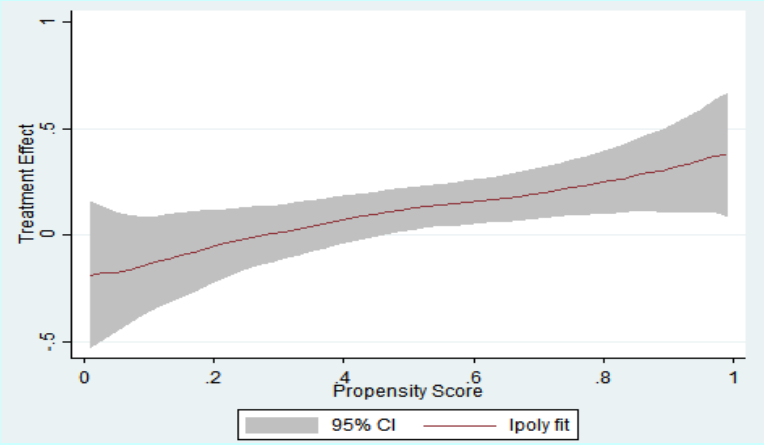


**Figure 5:** Matched differences in maize silage effect on dairy stability

The results complement findings of stratified multilevel approach. Though producers experience an increase in production stability through use of maize silage as propensity score increases, the producers who benefit the most are the ones on the higher stratums as compared to those on the lower stratums. However, the likelihood of a producer who participated in maize silage usage to have benefited from the venture was consistent throughout the stratums at 95% confidence levels.

## Conclusion

The study shows that the training frequency, number of extension visits, asset value and herd size are some of the factors that influence the usage of maize silage in the small holder dairy farms. This implies that policies promoting producer trainings and adequate access to extension services would be encouraged to increase adoption of maize silage. The findings of stratification multilevel and matching smoothing methods of estimating heterogeneous treatment revealed that producers at higher propensity score strata benefited more from maize silage usage than those in the lower strata. Thus, it is incorrect to assume that the impact of maize silage usage would be uniformly felt across all producers. There is some level of heterogeneity in effects on production stability among producers as a result of adoption of maize silage technology in smallholder production system. The findings show that the assumption on homogeneity of effects of maize silage usage by policy analysts and program planners would be misleading.

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# Utilization of termites as an alternative livestock feed resource: A review

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## Abstract

Out of concern for environmental resilience researchers are now looking into alternative food and feed resources that are friendly to the environment. With the projected increase in demand for milk and meat by the year 2050, a corresponding increase in demand for animal feeds is expected. A quest for novel feed resources is a must. Insect rearing could be one of the ways to enhance food and feed security. Insects grow and reproduce easily, have high feed conversion efficiency and can be reared on bio-waste streams, transforming waste biomass into high value food and feed resource. It is technically feasible to produce insects on a large scale and to use them as alternative sustainable protein rich ingredient in pig and poultry diets, particularly if they are reared on substrates of bio-waste and organic side streams. Termites constitute 10% of all animal biomass in the tropics. Forty-five termite species belonging to four families are used by human populations, with 43 species used in the human diet or for livestock feeding and nine species used as a therapeutic resource. Of the 29 countries that use termites, 19 are in Africa. Termites are harvested from the wilds. However, methods of termite farming are still in the experimental stages. They are rich in nutrients. One species of termites (*Macrotermes falciger)* contained 23% crude protein, 46.5% crude fat, 591 kcal/100 g Energy (591kcal/100g), 81 mg/100 g Calcium, 5.3 mg/100 g zinc, 132mg/100g magnesium, 147.5 mg/100 g manganese, 22.2 mg/100 g selenium, 81 mg/100g phosphorous. The total fatty acid content was 45.3g/100g. The high fat content of the termite was made up 60.3% unsaturated fatty acids. The potential for using termites as food and feed is good.

**Key words:** Termites; feed; food

## Introduction

The number of termite species in the world is more than 2500, of which more than 1000 are in Africa. The family Termitidae contains builders of great mounds of up to 5 m high. Colonies are composed of casts: a queen, a king, soldiers and workers. Termites constitute 10% of all animal biomass in the tropics. One survey in the rice-growing plains of Laos (South East Asia), recorded eleven different species of Termitidae (Miyagawa et al., 2011). Termites are generally known as destructive household pests. Their ecological role as mediators of plant organic matter decomposition and influence on the formation of soils, energy and nutrient flows, and human and livestock nutrition are often ignored (Vasconcellos and Moura, 2010). In a global review, de Figueiredo et al. (2015) recorded a total of 45 termite species belonging to four families as being used by human populations, with 43 species used in the human diet or for livestock feeding and nine species used as a therapeutic resource. Seven of the species could be used for food, feed and medicinal purposes. Families reported in the studies were Hodotermitidae (4%), Kalotermitidae (4%), Rhinotermitidae (6%) and Termitidae (87%). The species most frequently recorded in the studies reviewed (de Figueiredo et al. 2015) were *Macrotermes bellicosus* (Smeathman, 1781) [n = 22 studies], *Macrotermes subhyalinus* (Rambur, 1842) [n = 20 studies], *Nasutitermes microcephalus* (Silvestri, 1903) [n = 10 studies] and *Pseudacanthotermes spiniger* (Sjoestedt, 1900) [n = 10 studies]. It should be noted that termite species richness used by humans exceeds the number studied here. Many studies identified termites only by their common name, or their identification was only to genera (de Figueiredo et al., 2015).

Among the species used in human and/or livestock diet, the species *Macrotermes bellicosus* stood out, with a record of usage in several countries, especially in Africa. In addition, four species are used in the human diet and for livestock feeding. Furthermore, five species had only one registered use, including *Macrotermes herus* (Sjoestedt, 1914), *Macrotermes lilljeborgi* (Sjoestedt, 1896) and *Macrotermes*

*muelleri* (Sjoestedt, 1898), which are used only for livestock feeding (de Figueiredo et al., 2015). For medicinal purposes, the use of ten species of termites was recorded. The species *Nasutitermes microcephalus* was the most frequently recorded, and it is widely used in Brazil as a therapeutic resource for the treatment of asthma, hoarseness and sinusitis, among other diseases. Another example is *Macrotermes nigeriensis*, which is used in Nigeria in the treatment of wounds and sickness of pregnant women (de Figueiredo et al., 2015).

## Termite farming

Termite farming methods are still in experimental stages. It is clear that, because of their distractive nature, termites have to be farmed under controlled situations. The author finds the method described by Wells (2005) to be the most promising. Their major dietary requirement is cellulose which can be provided in the form of rotting plant debris, wood, paper products and cloth such as rayon and other natural fibres. Another key requirement is adequate humidity to avoid desiccation of their soft bodies. The temperature requirements range from 45 degrees to the low 80's F. Damp, rainy conditions are perfect for termites. During hot dry weather it is difficult to farm them. According to Wells (2005) requirements for termite farming are:

1. Several 4-5 inch diameter PVC pipe sections each 15 to 18 inches long, drilled with ½ inch holes around.
2. Plastic cap to place on one end of the pipe to keep the interior damp and protected from light.
3. Non-dyed corrugated carton packing paper used in packing fragile things, a size close to the length of the PVC pipe sections. Alternatives to this are old cotton or any other natural fibre clothes.
4. A small tool for digging holes without disturbing the soil too much. A good fence post digger will work well but there is need to be very careful not to make the hole too big.
5. Some type of ground insulation in hot dry weather, such as old boards, leaves or other natural forms of cellulose. Any material that creates a cooler damper area under it will work.

A place that has active colonies of sub-terrainean termites is located. This is done usually after rains have dampened the soil enough to enable the termites to come to the surface and to construct mud tunnels up walls and wooden surfaces. Breaking into these tunnels will show whether they are occupied or not. Occupied colonies should be teeming with termites. If no termites are seen coming out of the broken tunnels the farmer can watch later for signs of sealing these breaks in the tunnels. Sometimes termites are not active in every tunnel all the time.

Good localities to look for termite activity are near gardens where a lot of organic manures are used in the soil. Other places to look are near debris such as old cardboard boxes, boards, firewood stacks, etc.

Once active termite colonies are located, dig a vertical hole as close to the diameter of your pipe section as is possible and almost as deep. One hole is dug for each pipe. The holes are spaced 60 cm apart. While digging the hole for the pipe installation, it is important to disturb the ground around the pipe as little as possible so as not to destroy existing tunnels that most likely are there but not seen. The pipe section is then pushed into the hole, leaving the top protruding so that a cap can easily be placed on top of the pipe.

The pipe is then tightly packed into the ground, making sure no gaps are present around the outside diameter. Cardboard packing paper is cut to fit the pipe length, rolled tightly and dampened using a hose or spray bottle till it is wet but not soggy. It is then put into the pipe, then the cap is placed on the pipe and left in place usually for ten to fourteen days. When the cap is removed after fourteen days, termite damage on the paper will be obvious. The paper can then be pulled out, gently unrolled and shaken. Usually large amounts of termites are collected into a sealable plastic container. They can then be fed to livestock directly, refrigerated for storage. Weaker colonies need more time before harvesting. This time will allow for more chemical trails to be laid down to direct more termites to the farms. Patience is very important during this initial stage. Each pipe will produce large amounts of termites as long as the basic requirements are met.

The ground around the pipes should be kept damp at all times. The paper rolls should be replaced as needed, and should be kept damp but not soggy.

***Challenges in termite farming:***

1. Robust colonies diminish, sometimes overnight for unknown reasons.
2. Generally some colonies disappear when the weather conditions are too dry, hot or cold. Other causes are unknown but populations usually come back in a few weeks or months.
3. Termites can be attacked by pests. Small ants attack termites and feed on them. These ants can be controlled by poisoning them at the source. It is important to note that termites are easily killed by insecticides, so treatment close to the termite farm should be avoided.
4. Termites produce substantial amounts of methane.

## Harvesting wild termites

The harvesting methods have been documented by van Huis, (2017)

***Alates***

Usually termite mounds are not owned and therefore are harvested by anybody. There are many different ways of harvesting winged termites (alates) depending on the termite species and the time that they emerge (Dounias 2016). During expected emergence of the alates, mounds are checked for appearance of emergence holes. For those that emerge during the night, the most common way to collect them is to place a lamp above a bowl of water. They are attracted by the light and fall into the water from which they are scooped. A hole can be dug near the termite mound or a trench around it, and a light placed nearby to attract the termites. The attracted termites are then swept into the hole or trench. In Sudan and Cameroon the chamber inside the termite mound near the periphery of the nest where alates group themselves is dug up. In Burundi, Cameroon, Kenya, Tanzania, Uganda and Zimbabwe, a tent made from leaves of Andropogon grass, banana leaves, bamboo, raffia or straw, with few exit holes can be put up over the termite mound. A hole is placed at an exit. The soil is often covered with banana leaves for ease of collection of the termites (Gelfland et al., 1985).

In Kenya and Cameroon alates are stimulated to emerge by pounding rhythmically on the soil with stones and sticks to simulate heavy rainfall and simultaneously pouring water over the mound to raise humidity (Ogutu, 1986). This may be accompanied by songs. In Uganda and Kenya, alternative methods to stimulate emergence include tapping on an inverted calabash or pounding a stone on a bigger one

placed on the ground. When they are to be used for food, termites are boiled in salty water or steamed, then dried in the sun or in a pan over fire. Winnowing is then done to get rid of the wings. The termites can be stored for 3 to 7 days. For long storage, termites are re-dried in the sun periodically. Dry termites can be crushed to make flour that can then be used in cooking.

***Soldiers***

Soldiers of termites are eaten by few ethnic groups in Africa (Seignobos 2012). The most common way of collecting them is to break a part of the termite mound, insert a grass stem, such as *Panicum maximum* or *Cylindrica impericum* or reeds from the river, into the hole of the mound. The soldiers that bite in the stem are stripped into a container with water. The heads of the soldiers are pounded into a cake. They can also be salted and fried then cooked with a paste of groundnut (peanut butter). The abdomen is said to be bitter.

***The Queen***

It is difficult to get to the queen and often a whole termite mound has to be demolished in order to reach the queen chamber. Usually the queen is not eaten. However, it can be given to ill persons or malnourished children (De Colombel, 2003). The content of the queen is sometimes applied to the skin to make it shine.

***The mounts***

A survey in the rice-growing plains of Laos found that the villagers use termite mounds as fertilizer for growing rice, vegetable beds and as charcoal kilns (Miyagawa et al., 2011). In Africa mounds and soil of termites have numerous functions: for geochemical prospecting, making bricks, plastering houses, making pots, and for storage. Termite soil is often used as fertilizer (van Huis, 2017). The act of eating soil (geophagy) especially by pregnant women, is practised all over Africa (van Huis, 2017).

***Food/feed***

Roasted *Macrotermes falciger* contained moisture (6.0 % ± 0.02), crude protein, (23.1% ± 0.00), crude fat (46.5% ± 0.01), Energy (591kcal/100g), Calcium (81 ± 0.03mg/100g) zinc (5.3mg/100g), magnesium (132mg/100g), manganese (147.5, ± 0.01 mg/100g), selenium (22.2mg/100g), phosphorous (81mg/100g). The total fatty acid content was 45.3g/100g. The high fat content of the termite was made up mainly of unsaturated fatty acids (60.3%). These values suggest that the winged termite, *Macrotermis falciger* has nutritional and pharmaceutical potential (Chulu, 2015).

Kinyuru *et al*. (2013) looked at the nutrient composition of *Macrotermes subhylanus*, *Pseudacanthotermes militaris*, *Macrotermes bellicosus* and *Pseudacanthotermes spiniger* termite species consumed in western Kenya. The fat content was 44.82–47.31 g/100 g, protein 33.51–39.74 g/100 g, available carbohydrate 0.72–8.73 g/100 g, iron 53.33–115.97 mg/100 g and zinc 7.10–12.86 mg/100 g. The level of unsaturated fatty acids was 50.54–67.83%, while n-6:n-3 ratio ranged between 5.80:1.00 and 57.70:1.00, signifying potential nutritional and public health significance.

In the rice growing plains of Laos, the villagers collected termites for food and as feed for breeding fish (Miyagawa et al., 2011). A study in Sub-Saharan Africa revealed that swarming reproductive females, soldiers and queens are collected as food (van Huis, 2017). Termites can also be used as feed for poultry or as bait to catch birds and fish (van Huis, 2017). The mushrooms that grow each year from the fungus gardens on the termite mounds are eaten (van Huis, 2017).

### *Medicine*

Termites are also used in the treatment of various diseases that affect humans, such as influenza, asthma, bronchitis, whooping cough, sinusitis, tonsillitis and hoarseness (Alves, 2009). The soldiers, the fungus gardens and the soil of termite mounds are used for multiple medicinal purposes (van Huis, 2017). Soldiers are used to suture wounds. The mandibles of the soldiers are applied to the edges of the skin which are drawn together over the wound. When the soldiers bite, their bodies are snipped off. The row of mandibles is left in place until the wound heals. Soil from the mound is used as a paste to treat skin diseases, swelling of the feet, to cure abscesses or as plaster on fractures. It is also said to cure angina, parotitis, tonsillitis or swollen udders of cows. It is used when a child has fever. In Nigeria soup of the termite *M. nigeriense* is used for pregnant women to assure a safe delivery of the baby (Lawal and Banjo, 2007). The termite soil can serve as a carrier in medicinal preparations. A concoction of parts of the fungus garden with the fruit of the plant *Lecaniodiscus cupanioides* is used as a cure for fever, burns, liver abscesses, jaundice, cough, malaria; or as a purgative or aphrodisiac (Olowokudejo et al., 2008). In Cameroon, the soil of mounds from two termite species is used as medicine: 1) *Nasutitermes* sp. - the vapour from boiled soil to treat eye problems; and 2). *Bellicositermes* sp. - a water mixture of soil and cola (*Cola acuminate*) nut against bleeding during pregnancy or a paste for the baby skull at birth in case of congenital hydrocephalus (van Huis, 2017).

### Conclusion

Termites are used by humans for a variety of purposes including food, feed and medicine. As food or feed, termites are rich in nutrients. The major limitation to large scale use of termites is the high levels of methane production. There is need to explore farming and harvesting methods that will ensure that large quantities are produced, while minimizing or tapping the methane produced for alternative uses.

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# Rumen degradation and *in vitro* digestibility of *Chloris gayana*, *Acacia tortilis* pods and cotton seedcake

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## Abstract

There are feed sources available in the arid and semi-arid lands (ASAL) which can be used to supplement the low-quality grasses. These include *Acacia tortilis* pods. Other supplements can also be transported and used in these areas. The nutritive value of these supplements needs to be determined in terms of nutrient composition, rumen degradability and in vitro gas production. This will facilitate feed ration formulation for finishing ruminant livestock in these arid areas destined for the market. Therefore, the objective of this study was to determine and compare the rumen degradability and *in vitro* gas production of Boma Rhodes, *Acacia tortilis* pods and cotton seedcake. Rumen degradability and gas production for these feeds were measured at 0, 4, 8, 16, 24, 48, 72 and 96h incubation period. The results showed that *Acacia tortilis* pods had the highest degradability with boma rhodes having the least. The same scenario was also observed in the *in vitro* gas production. In spite of the high crude protein content of the cotton seedcake, its degradability and gas production were less than that of *Acacia tortilis* pods. This was an indication that cotton seedcake has higher rumen bypass protein.

**Key words**: Boma Rhodes, *Acacia tortilis* pods, cotton seedcake, rumen degradability, *In vitro* gas production.

## Introduction

In the ASALs, feed may be abundant during the wet season followed by scarcity during the dry season. Grass is the cheapest source of livestock feed in Kenya (Pratt and Gwynne 1977) but is of low quality due to low in crude protein, high fibre and has low t digestibility. According to work done by Woie (1984), stem dry matter digestibility of *Digitaria macroplephara* and Guinea grass (*Panicum maximum*) were 51.6% and 59.4%, respectively. Perennial grasses production was estimated to be 406.5kg/ha and 280.7kg/ha in March and July, respectively according to Musimba (1986).

Most livestock keepers, especially from the agro-pastoral communities supplement pasture using crop residues and locally available leguminous fodder (Ndikumana *et al* 2000). However, guidelines for such supplementation are inadequate leading to improper use of the supplements. There is also need to identify crude protein rich supplements which are available in the ASALs to be used to supplement the low-quality pastures.

*In vivo* nylon bag technique is a method used to estimate the rate and extent of degradation of feedstuffs to facilitate utilization by ruminants. Near infrared reflectance spectroscopy (NIRS) was used by Ohlsson *et al* (2007) to study degradability of perennial ryegrass and orchard grass but accuracy was different for rumen soluble and non-soluble fractions. In the nylon bag technique, disappearance values are fitted into a model to determine the characteristic of the feeds. However, it is necessary to consider other variables that determine the productive performance such as dry matter (DM) intake and rumen fermentation products (Juan Pablo Keim *et al* 2013). *In vitro* gas production is also a technique used to study degradability of feeds by ruminants and complements the nylon bag or *in sacco* techniques. The objectives of the study were to determine and compare the degradability of *Acacia tortilis* pods and cotton seedcake used as supplements of poor quality Boma Rhodes hay.

## Materials and methods

*Acacia tortilis* pods were collected from agro-pastoralists farms in Makueni County. The pods were collected by the farmers from their own farms. To accelerate dropping, farmers shake the trees then collect the pods from the ground. The pods were then further dried to avoid spoilage during storage. Cotton seedcake was obtained from a feed outlet in Nairobi whereas Boma Rhodes hay was obtained from a farm in Naivasha. The three feed sources were sampled for proximate analysis according to the procedure as outlined by Abdulrazak and Fujihara (1999). Sampling of the feeds was also done for rumen degradability and *in vitro* digestibility tests. These tests were done following the procedure as described by Abdulrazak and Fujihara (1999). Fistulated Friesian steers were used for this study and were fed shredded Boma Rhodes hay with water and mineral lick given *ad libitum*. *In vitro* gas production and *in sacco* measurements were taken at 0, 4, 8, 16, 24, 48, 72 and 96h after incubation of the tubes.

## Results

Nutrient composition of the feeds are shown in Table 1.

**Table 1**: Chemical composition (%DM) of the feeds

| | | | Ingredients | |
|---|---|---|---|---|
| | Parameter | Rhodes gras hay | CSC | ATP |
| DM | 94.2 | 92.1 | 89 | |
| Ash | | 97.6 | 57.7 | 6.9 |
| CP | | 6.3 | 40.8 | 15.4 |
| EE | | 2.9 | 10.9 | 1.0 |
| NDF | | 72.2 | 18.5 | 34.5 |
| ADF | | 40.3 | 14.8 | |
| ADL | | 6.2 | 5.1 | 8.2 |

**CSC = Cottonseed cake; ATP = *Acacia tortilis* pods; DM = Dry matter; CP = Crude protein; EE = Ether extract; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; ADL = Acid detergent lignin.**

The rumen degradation of the different feeds is shown in Table 2 and Fig 1.

**Table 2:** Rumen DM degradability of the feeds

| | Incubation time (h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Feed sample | 0 | 4 | 8 | 16 | 24 | 48 | 72 | 96 |
| Hay | 13.04 | 10.66 | 13.68 | 16.69 | 20.00 | 30.41 | 36.81 | 40.54 |
| CSC | 31.19 | 33.8 | 38.23 | 45.52 | 57.17 | 72.94 | 76.42 | 81.08 |
| ATP | 43.33 | 33.8 | 51.78 | 63.20 | 63.29 | 76.77 | 78.72 | 82.60 |

**CSC =** cotton seedcake; **ATP** = *Acacia tortilis* pods.

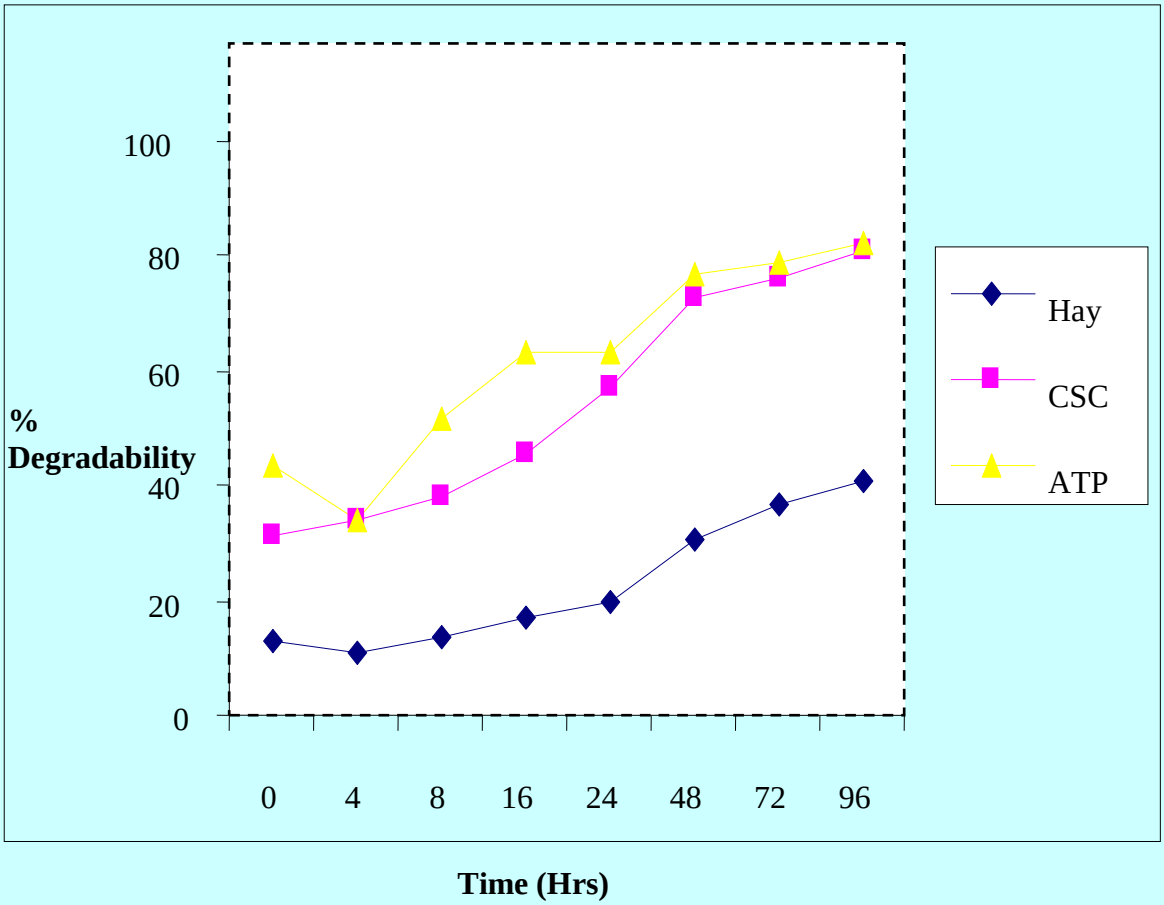


**Figure 1**: Rumen DM degradability curves for various feeds

*In vitro* gas production results are presented in Table 3 and illustrated in Figure 2.

**Table 3**: *In vitro* Gas Production for hay, cottonseed cake and *Acacia tortilis* pods

| Incubation time (h) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Feed sample | 0 | 4 | 8 | 16 | 24 | 48 | 72 | 96 |
| HAY | 0 | 1.05 | 11.57 | 11.57 | 18.94 | 30.52 | 38.94 | 44.74 |
| CSC | 0.54 | 8.63 | 26.96 | 26.95 | 32.35 | 40.97 | 46.36 | 49.60 |
| ATP | 0 | 8.94 | 31.29 | 31.29 | 41.34 | 50.28 | 54.75 | 56.98 |

**CSC** = Cotton Seedcake; **ATP** = *Acacia tortilis* pods.

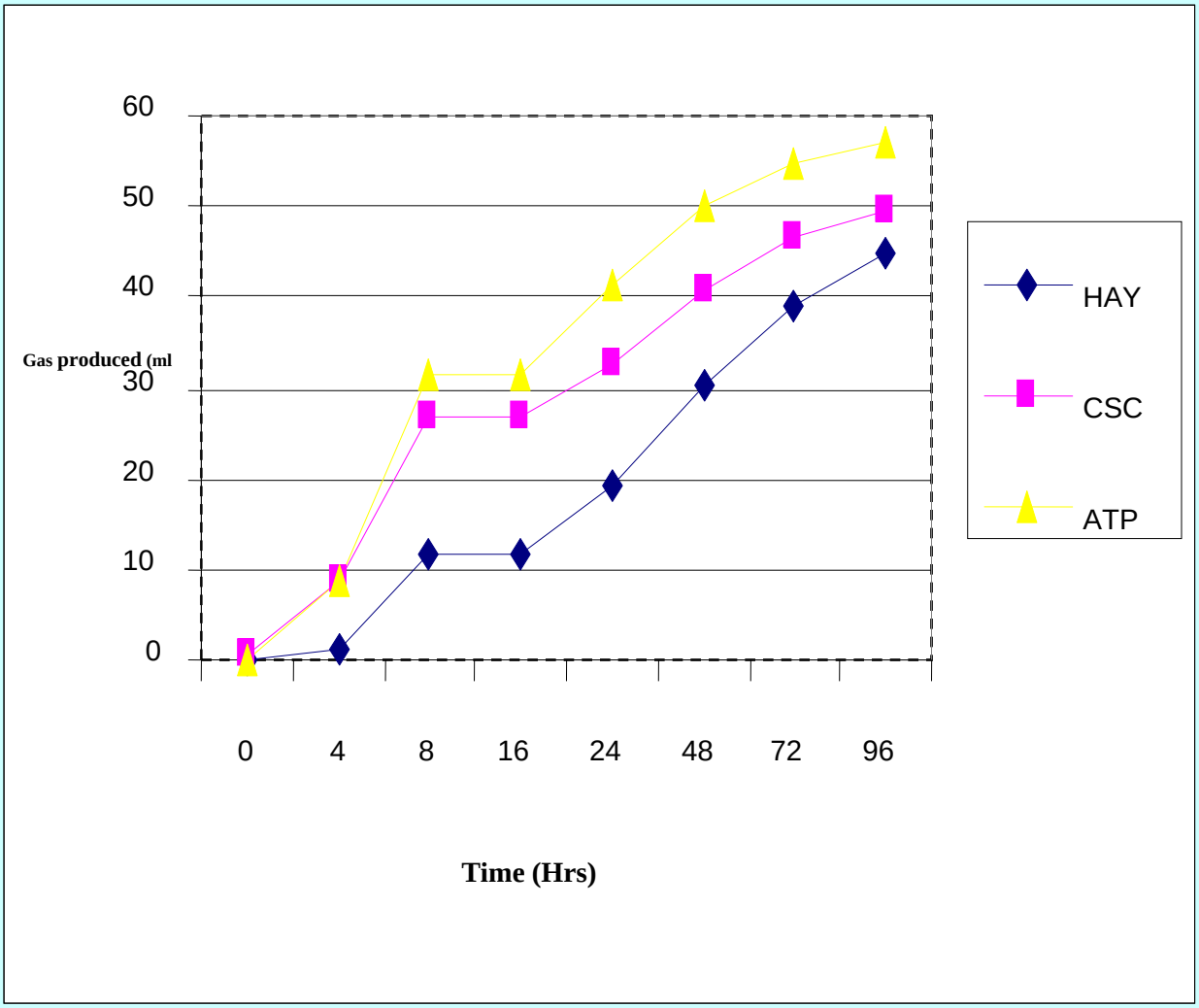


**Figure 2:** *In vitro* gas production of feed ingredients used in experiment one.

## Discussion

The crude protein content of Rhodes hay, which was 6.3% (Table 3), was close to 7.9% reported by Waweru *et al* (2004). Both supplements had higher CP content than the Rhodes hay but DM, Ash, NDF and ADF were higher for the hay than the supplements. Crude protein (CP) content of the cotton seedcake (40.8%) was similar to 40.31%. recorded by Bonsi *et al*. (1995).DM content of the pods was comparable to that of *Acacia albida* at 94.9% (Hashim, 1994). Similarly, the 16.5% CP content of *Acacia albida* was very similar to the *Acacia tortilis* pods in this study but the seeds of the *Acacia albida* pods had been removed (Hashim, 1994). Das (1999) reported 14.1% CP *in Acacia tortilis* pods. According to Krishnamurthi (1970), cotton seed meal had 31.65% CP and 12.62% EE but Shirley (1986) reported that, cottonseed meal had 44.8%CP. The variation in CP content of cotton seedcake may be attributed to location differences and varied agronomic practices such as fertilizer rates of application. The high NDF and ADF and also the low CP level of hay are some of the factors which characterized its low feed value.

The rumen degradability results for Rhodes grass hay, cotton seedcake and *Acacia tortilis* pods are presented in Table 2. Hay had the lowest degradability percentage (40.5) at 96 h while *A. tortilis* pods and cotton seedcake were almost similar (82.6 and 81.1, respectively). This could be attributed to the low fibre content of the supplements relative to the hay. The degradability of ATP was higher initially than that of CSC but they tended to be closer towards 96h period. This shows that ATP is more rumen degradablethan CSC. However, the potential rumen degradability of CSC was highest at 86.55. The *In vivo* nylon bag analysis on hay DM degradability demonstrated a linear relationship between time of

incubation and degradation percentage. The regression for CSC degradability demonstrated faster degradation at the beginning then stabilized with time. The regression for pods showed that degradation was faster at the beginning then stabilizes but at a higher percentage than CSC or hay.

There was more gas produced by *A. tortilis* pods than the other feeds. The *In vitro* gas production pattern of the pods and CSC) shows some similarity with the findings of Lanyasunya *et al* (2007) on *Sorghum almum*, *Commelina benghalensis* and *Vicia villosa*. The more gas produced by the pods may be attributed to better availability of protein to the rumen microbes as compared to CSC despite having more CP. This shows that CSC might be having higher rumen bypass properties than the pods. Anti-nutritive factors in ATP such as tannins might be responsible for low passage rate and therefore more action by the microbes resulting in increased gas production. The low CP level of the hay is presumably the reason it produced the lowest amount of gas.

## Conclusions and Recommendations

Boma Rhodes had low degradability of in the rumen with resultant slow release of nutrients for body functions. This requires supplementation using high CP feeds. Cotton seedcake had lower degradability than *Acacia tortilis* pods in spite of the high CP. The same case was observed forfor gas production where less gas was released by cotton seedcake. Cotton seedcake therefore is a more valuable feed than *Acacia tortilis* pods. These supplements could best be utilized in combination because rumen microbes benefit from ammonia from acacia pods and the ruminant will benefit from cotton seedcake which bypasses rumen degradation.

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# Managing Climate Change Risks through Better Livestock Feed Technologies and Innovations: The Case of Urea-Molasses Mineral Blocks (UMMBs) Production and Commercialization at KALRO Buchuma

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## Abstract

In the recent past, a unique role for Urea-Molasses Mineral Blocks (UMMBs) as a supplementary package to the basal diets of livestock during the severe droughts in Kenya has emerged. This has reduced the number of deaths in cattle and small ruminants. The blocks have also prevented deaths during the drought periods. During drought periods, only crop residues and other lignified fibrous materials are available for livestock feed. Through blocks, the supply of nitrogen, minerals and vitamins to rumen microbes enhances the availability of energy supply to the animal from poor fibrous feed materials. The simplicity of the method of block production and the compact nature of the blocks, and hence their fast production and ease in transport from non-emergency to emergency areas are some of the advantages of this technology in disaster situations which have been exacerbated by climate change.

## Introduction

Nutrient deficiencies and imbalances are among the principal constraints that severely inhibit the improvement of ruminant productivity in rangelands (Karangiya *et al*, 2016). Much of the pasture herbage available throughout the country does not completely satisfy all of the nutrient requirements of grazing animals. Under extensive management systems, grazing ruminants normally have access to native grass and crop residues, which have low crude protein (CP) content (<6%), high fibre content (>25%), low in digestibility (<45%) and are deficient in many minerals and vitamins. Poor body conformation, low growth rates and low fertility are some of the symptoms associated with under-nutrition (Singh *et al*, 2012). Production losses are aggravated when under-nutrition is associated with gastro-intestinal nematodes. Strategic supplementation with energy, protein and minerals offers an important approach to ensure animal performance is not reduced, especially during critical periods of feed shortage. The supplements can provide ruminal microbes with the nutrients that may be deficient in basal diets, thus stimulating digestion and intake. Improvements in feed intake, body weight gain and reproductive efficiency of ruminants associated with feeding urea-molasses mineral blocks (UMMBs) have been reported (Walli, 2011). UMMBs technology also has the potential to provide complete feed to livestock under emergency situations created by natural calamities such as climate change. However, manufacture and commercialization of UMMBs as an innovative technology to supply balanced feeds for livestock in Kenya is not widely adopted by farmers. There is a need for farmer participation in UMMBs research and technology transfer in Kenya. The current paper highlights the current status of production and commercialization efforts in UMMBs in KALRO Buchuma, constraints and opportunities.

### What are Feed blocks?

Urea Molasses Mineral Blocks (UMMBs) are a balanced feed supplement for ruminant livestock and are very rich in protein (20%), minerals and energy.

### Advantages of feeding UMMB licks to animals

- Increases feed intake by livestock (Choubey and Wadhwa, 2014).
- Increased milk production by up to 39% (Neelmani *et al*, 2017)
- Increases lactation length (Neelmani *et al*, 2017).
- Maintains health and reproductive functions (Haili *et al*, 2014).

- Improves growth rate of animals ( Syomiti *et al*, 2015)
- Increased growth rate in young animals ( Syomiti *et al*, 2015)
- Reduced worm infection ( Syomiti *et al*, 2015)
- An effective drought survival strategy for livestock (Muralidharan *et al*, 2012)
- Entrepreneurship potential for vulnerable groups

The typical chemical composition of UMMBs is shown in Table 1.

**Table 1:** Typical Chemical Composition of UMMBs (10% Urea) manufactured at KALRO Buchuma

| Nutrient | Content |
|---|---|
| Crude protein | 20.4% |
| Phosphorus | 0.247% |
| Calcium | 4.45% |
| Magnesium | 0.069% |
| Potassium | 0.633% |
| Iron | 0.093% |
| Urea | 6.189% |
| Sodium | 1.033% |
| Zinc | 0.008% |

**Source**: (Syomiti, Unpublished data)

## Future research and development

Although research on urea-molasses blocks has been slowly increased in Kenya, considerable additional research is still needed in order to fully exploit the benefits of incorporating various specific nutrients, minerals, additives and drugs in the blocks. Formulation of blocks based on low-cost and locally available feed resources that do not compete with human food should be one of the thrust areas for future work. Some regions in Kenya are deficient in proteins and specific minerals and should be mapped and blocks tailored and/or formulated to meet the requirements for the deficient nutrients.

Plant secondary metabolites, at high levels of intake, can produce adverse effects on livestock. The use of bentonite has been suggested as a binding agent that reduces protozoal loads and decreases aflatoxins, alkaloids and fungal toxins. There is a need to study the mechanism of action of this binder and those of other agents such as clay and charcoal in decreasing anti-nutritional and toxic factors likely to be present in unconventional feeds. Anthelmintic-containing blocks have been found to be highly successful in controlling nematodes (Syomiti *et al*, 2015). Their strategic use before or during, or both, the peak periods of infestation should be widely advocated and promoted. Commercial anthelmintic preparations are expensive. The strategic use of medicated blocks, in addition to enhancing the effectiveness of the drug, decreases the cost of controlling the parasites and works against drug resistance. In many developing countries, herbal drugs are widely used for controlling internal parasites and some of them have been found to be highly effective and should be advocated. In addition, herbal drugs are more eco-friendly. Some work on the use of blocks as a carrier for herbal digestive stimulants and fertility stimulating herbs has been initiated in other countries such as India with good results. Systematic studies on the incorporation of herbal drugs or additives in the blocks and their evaluation for effectiveness and cost–benefit are needed.

Fresh neem, dried pineapple and mango leaves are also promising anthelmintic agents, and should be emphasized in the development and use of herbal-based blocks for controlling helminth parasitism and enhancing rumen fermentation (Syomiti *et al*, 2015). Similarly, additives such as saponin containing plants could also be added to blocks to decrease protozoal number in the rumen, thus enhancing the efficiency of rumen microbial metabolism and microbial protein supply postruminally. The development and use of the blocks as a carrier of various additives, drugs, natural plant products should be conducted through participatory research through involvement of all stakeholders, and in particular the farmers.

The participatory research will enhance the success rate for adoption of a technology since the technology developed through this approach is more relevant and appropriate.

Although the urea-molasses multi-nutrient technology is picking up well in some KALRO Research Centres in the Country, there is a need to disseminate this technology more widely through the involvement of NGOs, local government extension departments, veterinarians and County Governments. In some situations, the involvement of the private sector could play a vital role in making the technology sustainable, and their role should be recognized. Farmer associations and cooperatives could also have a pivotal role in sustaining the technology through the setting up of revolving funds. It is well established that the benefit of using UMMBs is through enhancing the efficiency of rumen fermentation, which increases the digestibility and intake of forages, leading to greater supply of microbial protein for production purposes.

There is another dimension to supplementing poor quality forage-based diets with the blocks, that is lower emission of methane per unit of forage digested or per unit of meat or milk produced when supplementing with the blocks, because of better rumen fermentation. However, quantitative data on methane emission and microbial protein supply post-ruminally with use of these blocks are not available. Research on generation of this data is also suggested. This paper is presented to sensitize and/or create awareness to the key players in the livestock industry to embark on commercializing supplementary range blocks as low-cost, high quality feed supplements in a Public-Private Partnership to improve animal productivity and employment creation in the smallholder pastoral and agro-pastoral farmers in ASALs of Kenya especially for dry season feeding.

**Establishment of KALRO Buchuma Feed Technology and Innovation Unit**

Feed blocks helped livestock farmers to sustain their animals during the seemingly interminable drought that was declared a National disaster 2017. Thanks for the financial facilitation inform of a working capital by the Director General, KALRO, and the Drought Mitigation Program of the Ministry of Agriculture, Livestock and Fisheries to rescue livestock farmers from the chronic drought that hit the country for the two years (2016 and 2017).

KALRO Buchuma initially began by seeking ways to save animals in the centre and neighboring farms. The centre secured some funding from KALRO headquarters to purchase hay, while the surrounding communities watched their animals die because the cost of hay was not affordable.. The centre was able to purchase hay worth 1.2 million. However, due to harsh climatic conditions, the purchased hay had deteriorated in quality and could not meet the energy and protein requirement of the already starved animals. Funding to purchase supplementary feeds for approximately 300 Boran cattle was scarce.

**Figure 1:** Feed blocks curing in a shade

**Figure 2:** Weighing of Block ingredients

## Options from Invassive bush species

The Centre started by looking at possibilities of utilizing locally available non-conventional feed resources such as *Prosopis Juliflora* which is an ill-fated encroacher bush in Taita Taveta County.

**Figure 3:** Prosopis Pods collection agribusiness established between the KALRO Centre and a women group in Voi

**Figure 4**: Senior officers of KALRO and Ministry demonstrating how to grind

The Centre engaged Rosalia Widows women group from Taita Taveta in Prosopis pods collection agribusiness. Approximately 2.5 tons of Prosopis pods were collected worth about Kes 65,000.

Most of the members of this group were in the fore-front in attending the KALRO contract reservation training for women, youth and people living with disabilities held in the centre in 2016. The Centre then placed an order for 100 bags of Prosopis pods and another 100 bags for another private farm. One fully filled bag of *Prosopis* pods (70 kg gunny bag) costs Kes 300. The group generated Kes 60,000. The actual weight of this fully filled bag with Prosopis pods ranged between 25-30 Kgs. Approximately 75% of prosopis flour was obtained after grinding with hammer mill.

**Figure 5:** Cured and stored feed blocks Ready for packaging at KALRO Buchuma

**Figure 6:** Packaging of blocks ready for delivery to clients

The KALRO Livestock Feed Unit was boosted through the Government Drought mitigation Program, where many contracts were reserved for youth, women and People living with disabilities (PWD), thus many private companies managed by these marginalized/vulnerable groups contracted the centre to make UMMBs for them. Approximately 75 tons of Feed blockshad been manufactured in the Centrefrom January, 2017, worthy Kes 5,400,000. Cost of one blocks ranges from Kes 160-250, depending on farmer category, block ingredients and availability.

**How KALRO Buchuma is contributing to poverty eradication and economic status of unemployed youths and women**

Approximately 15 youths and 2 women secured jobs during feed block manufacturing process. The Centre is usually flooded by youths who walk about 12 Km from Mackinon Road shopping centre during this block production period. They usually make a maximum of 1000 blocks per day, since they use agro-industrial byproduct based materials (and not soil), which have low density and it needs some additional manual compacting. One set of a blocking machine is operated by two youths. Therefore, per day they pocket (700 blocks x Ksh. 4) devide by 2= Ksh. 1,400.

**Figures 7 & 8**: UMMBs (Urea-Molasses Mineral Blocks) production processes and storage

## Conclusions and Recommendations

From this case study, feed block technology has proved to be an effective strategy for providing balanced nutrition for livestock to combat drought situation in Kenya. There is an urgent need to up-scale this technology through commercialization and involvement of Public-Private Partnership for effective dissemination. Funding for capacity building, promotional activities, upscaling and commercialization (establishment of multi-nutrient feed block SMEs) and agricultural machineries are also required.

### Acknowledgement

Thanks to the Director, Sheep and Goat Research Institute, and the Director General, KALRO for their technical and financial support in establishment of the KALRO Feed Technology Unit at Buchuma Research Centre.

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# The use of probiotics in poultry production in Kenya: the case of Kiambu County

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## Abstract

To quantify the use of probiotics in Kiambu county, two surveys were carried out. 100 agro vets were sampled from 9 out of 12 sub-counties of Kiambu County namely: Thika, Juja, Kiambu, Gatundu North, Gatundu South, Kikuyu, Kabete, Ruiru and Limuru. Data was collected using semi-structured questionnaires which were administered so as to identify the products sold in the Kenyan market as probiotics. The second survey was carried out in 3 sub-counties of Kiambu County; Thika, Kiambu and Kabete among 36 poultry farmers who use probiotics. They were grouped into two production systems; household and commercial and catered for broiler, layers and indigenous chicken production. The data was collected using a semi-structured questionnaire so as to obtain information on probiotic use in layer/broiler production and its effect on performance. The data collected was analyzed using Statistical Package for Social Sciences (SPSS) version 22 descriptive statistics, involving the computation of Chi-Square tests, binomial tests, standard mean error and frequencies, and the results were presented in a tabular form. The results of the agro vet survey showed that, a total of 15 types of probiotics were found in the market and the most common probiotics brands were Vipro plus, Diamond V xpc, Mola plus and Super Enzymes. The results from the survey on farmers showed that 74.4% of the poultry farmers were using probiotics as feed additives and the most common brands were; Vipro Plus, Effective Micro-organisms (EM.1), Diamond V xpc and Super Enzymes Poultry Microbes. In conclusion, the Kenyan farmer in Kiambu has accepted to use probiotics in poultry production and is reporting positive feedback on productivity. There are many types of probiotics available in the market and overall, the common probiotics being used are Vipro Plus, EM.1 and Super Enzymes Poultry Microbes. Therefore, there is need to test the effectiveness of common probiotics used in Kenya in broiler production in a controlled experiment.

**Key words**: Probiotics, Poultry, Kenya

## Introduction

The worldwide increase in population growth and urbanization has resulted in an increase in demand of livestock products which has become a major driving force to the rapid changes in livestock production systems (Thornton, 2010). Poultry is one of the world's fastest growing sources of meat, representing nearly a quarter of all the meat produced. In Kenya, the poultry industry is growing fast due to the rise in demand for poultry products. According to the 2009 census, the country had a total of 31.8 million birds out of which 25.7 and 6.1 million were indigenous and commercial type respectively. In Kenya's Kiambu County, there is a relatively high number of chicken constituting 8.5% of the total poultry population (Kenya National Bureau of Statistics, 2009). Due to the high demand for poultry products there has been intensification of livestock production (Udo *et al*., 2011). The use of antibiotics to improve growth and feed efficiency has developed concurrently with the intensification of the livestock industry worldwide. The widespread use of antibiotics is a major risk factor due to an increase in the occurrence of bacterial resistant strains where bacteria species displayed variable levels of resistance to antibiotics. At the global level, the increasing prevalence of antimicrobial-resistant bacteria is a public health risk of concern. Use of antibiotics as growth promoters in animal feeds was prohibited with effect from January 1, 2006 by the European Union (European Union Commission, 2005), which was followed by many other countries worldwide.

In recent years, probiotics have received much attention as they are considered natural alternatives to antibiotics due to their effect on growth promotion and immune response among various animal species.

Probiotics were initially described as "any feed supplements with live microbials which affect the host animal beneficially by improving the intestinal microbial balance. Use of probiotics promotes growth in poultry by ensuring a more effective utilization of nutrient intake" (Fuller, 1989). Probiotics were later redefined as "a preparation of viable microorganisms that is consumed by humans or other animals with the aim of inducing beneficial effects by qualitatively influencing their gut microflora and/or modifying their immune status (Fuller, 2004). According to the currently adopted definition by FAO/WHO (2009); probiotics are "live microorganisms which when administered in adequate amounts, confer a health benefit on the host". In Kenya, the concept of use of probiotics is becoming more comprehensible especially among commercial poultry farmers who wish to improve their flock productivity. The use of probiotics is becoming increasingly common in order to avoid use antibiotics in poultry production. Therefore, the purpose of this study was to assess the extent to which probiotics are used in Kiambu County of Kenya and the perception of their use by farmers.

## Materials and methods

### *Study Area*

The study was carried out in Kiambu County, Kenya. Kiambu county is sub-divided into 12 sub-counties. The economy of Kiambu County is supported by smallholder agriculture which employs about 75 percent of the population (Okello *et al*., 2010). Some of the major economic activities include livestock production (dairy, sheep, goats, pigs and poultry), crop production (coffee, tea, and horticulture), small and large scale businesses and real estate development.

### *Surveys*

Two surveys were carried out between January and May, 2016. The first survey involved Agro Veterinary stockists using a predesigned questionnaire. The sample size was arrived at using the method of Cochran (1963) as indicated below;

$$n = \frac{pqz^2}{e^2}$$

Where n= sample size, z= confidence level (α=0.01), p= proportion of the population containing the variables of interest,

q= 1-p, and E is the allowable (or desired) error because the proportion of the population is not known. In this case, p, q, z and E were assumed to be, 0.1, 0.9, 1.96 and 0.059 respectively.

$$n = 0.1 \times 0.9 \times (1.96)^2 / (0.059)^2$$

$$= 99.32$$

From the above, 100 agro vets were surveyed in the County.

### *Part 1: Survey involving Agro Veterinary stockists*

The study involved a survey which was carried out in agro vet shops in 9 out of 12 sub-counties of Kiambu County namely: Thika, Juja, Kiambu, Gatundu North, Gatundu South, Kikuyu, Kabete, Ruiru and Limuru. Cross-section primary data were used in this study. The primary data was collected on agro vets using a semi-structured questionnaire. The questionnaires were administered to the owners of the agro vets with the aim of documenting which products were sold in the market as probiotics.

### *Part 2: Survey involving the Farmers*

Another survey was carried out in 3 sub-counties of Kiambu County among poultry farmers who used probiotics and were grouped into two production systems; household and commercial, in order to take into account of the unique attributes of the systems with respect to probiotic use. The three sub counties were; Thika, Kiambu and Kabete and it catered for broiler, layers and indigenous chicken production. A total of 36 farmers were sampled.

The primary data were collected on farmers using a semi-structured questionnaire**.** The questionnaires were administered with the aim of obtaining information on probiotic use in layer/broiler production from the farmers and its effect on performance.

## Data Analysis

### *Part 1*

All the questionnaire data from the Agro Veterinary stockist were captured in Microsoft Excel and analyzed in Statistical Package for Social Sciences (SPSS) version 22 descriptive statistics, involving the computation of Chi- Square tests, binomial tests, standard mean error and frequencies, were undertaken to characterize the probiotics use patterns in Kiambu County.

### *Part 2*

All the questionnaire data from the farmers was captured in Microsoft Excel and analyzed in Statistical Package for Social Sciences (SPSS) version 22 for descriptive statistics which involved the computation of Chi- Square tests, standard mean error, binomial tests and frequencies undertaken to characterize the probiotics use patterns and their effect in poultry production in Kiambu County.

## Results

### Part 1: Distribution of Probiotics

In the 100 agro-vet shops, 168 probiotics were found since many agro-vets stocked more than one type of probiotic. The results of this survey showed that, a total of 15 types of probiotics were found in the market in Kiambu County (Table 1). The most common probiotics were Vipro plus (25.6%), Diamond V xpc (14.3%), Mola plus (13.7%) and Super Enzymes (11.3%) and were found to be the most popular brands in this market. Most of the products were locally produced, but a few like Antox, Biospark V and Brema-Bloom are imported.

**Table 1:** Types of Probiotics used in Livestock Production in Kiambu County and the frequency of occurrence.

| Product | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Vipro | 43 | 25.6 | 25.6 |
| Diamond V (xpc) | 24 | 14.3 | 39.9 |
| Molaplus | 23 | 13.7 | 53.6 |
| Super Enzymes | 19 | 11.3 | 64.9 |
| Magic Boost | 18 | 10.7 | 75.6 |
| Magic set Broiler | 16 | 9.5 | 85.1 |
| EM.1 | 6 | 3.6 | 88.7 |
| Bio-active Microbes | 4 | 2.4 | 91.1 |
| Super Booster | 4 | 2.4 | 93.5 |
| Antox | 3 | 1.8 | 95.3 |
| Rhonjas Super Poultry Microbes | 2 | 1.2 | 96.5 |
| Brema- Bloom | 2 | 1.2 | 97.7 |
| Elimin-8 | 2 | 1.2 | 98.9 |
| Bio spark V | 1 | 0.6 | 99.5 |
| Caplix | 1 | 0.6 | 100.0 |

| Product | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Total | 168 | 100.0 | |

**Source:** Survey Data (P<0.05), (S.E. = 0.296)

***Form***

The products were sold either as a powder or in liquid forms as shown in Table 2 and Table 3.

**Table 2:** Proportion of the form in which the Probiotics were packaged

| | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Liquid | 63 | 37.5 | 37.5 |
| Powder | 105 | 62.5 | 100.0 |
| Total | 168 | 100.0 | |

**Table 3**: Commercial names of the Probiotics packaged in either Liquid or Powder form

| Form | Name of product |
|---|---|
| Liquid | Antox, Bio-Active Microbes, Biospark V, Elimin-8, EM.1, Mola plus, Rhonjas Super Poultry Microbes, Super Enzymes and Super Booster. |
| Powder | Brema Bloom, Caplix, Diamond V xpc, Magic Boost, Magic set broiler and Vipro plus |

**Source:** Survey Data (P<0.05), (S.E. = 0.037)

**Descriptions of products in the market**

Using the product labels, each of the probiotics found in the market was described.

**1. Vipro plus**

It is a commercially available yeast culture for both broiler and layer chicken containing *Sacchromyce cerevisiae* and is fortified with vitamins, amino acids and minerals. It is a product of Champion distributor Ltd, Kenya. It is sold in powder form for Ksh 250 per Kilo gram (Kg).

**2. Diamond V (xpc)**

Diamond V (xpc) is a commercially available yeast culture containing *Sacchromyce cerevisiae* and is fortified with vitamins, amino acids and minerals. It is sold in powder form for Ksh 750 per Kg.

**3. Molaplus poultry microbes**

Molaplus poultry microbes is a complex solution of various beneficial microorganisms found naturally and used in food manufacturing. They provide chelated minerals, anti-oxidants, enzymes, vitamins, organic acids, lactic bacteria, yeast and prototrophic bacteria to poultry. It is sold in liquid form at Ksh 250 per liter.

**4. Super Enzymes Live Microbe**

Super Enzymes Live Microbe is a commercially available probiotic containing a mixed microbial culture of selected species of microorganisms such as lactic acid bacteria, yeasts and photosynthetic bacteria

which avail essential amino acids, energy, minerals and enzymes when used in poultry production. It is a product of J.V Enterprises, Kenya. It is sold in liquid form at Ksh 250 per liter.

**5. Magic boost**

This is a commercially yeast culture containing Sacchromyce cerevisiae which provides amino acids, energy, minerals and enzymes when used in poultry production and is a product of Vetpro Ltd, Kenya. It is sold in powder form for Ksh 200 per Kg.

**6. Magic Set Broiler**

It is a commercially yeast culture containing Sacchromyce cerevisiae which provides energy, minerals, amino acids and enzymes when used in poultry production and is a product Afri Vet Ltd, Kenya. It is sold in powder form for Ksh 120 per Kg.

**7. EM.1 (Effective Micro-organisms)**

It is a commercially available probiotic containing a mixed microbial culture of selected species of microorganisms such as lactic acid bacteria, yeasts, photosynthetic bacteria and actinomycetes and can be used both for soil composting and also as a feed additive to animals. It is sold in liquid form at Ksh 300 per liter.

**8. Super Booster**

This is a commercially available probiotic containing a mixed microbial culture of selected species of microorganisms such as lactic acid bacteria, yeasts and photosynthetic bacteria which avail essential amino acids, energy, minerals and enzymes when used in poultry production. It is sold in liquid form at Ksh 250 per liter.

**9. Bio- Active Microbes (BM)**

Bio- Active Microbes (BM) is a commercially available probiotic containing a mixed microbial culture of selected species of microorganisms such as lactic acid bacteria, yeasts, photosynthetic bacteria and actinomycetes and can be used both for soil composting and also as a feed additive to animals. It is a product of Organic Africa Ltd, Kenya. It is sold in liquid form at Ksh 200 per liter.

**10. Antox®**

Antox® is a commercially available monoculture yeast probiotics containing *Sacchromyce cerevisiae* (4.125 log 106cfu). It is a product of Montajat Vet Pharmaceutical Co.Ltd (India). It is sold in liquid form at Ksh 2000 per liter.

**11. Elimin-8**

It is a yeast probiotic manufactured by Venkys Ltd (India) and avails essential amino acids, energy, minerals and enzymes when used in poultry production. It is sold in liquid form at Ksh 1500 per liter.

**12. Rhonjas Super Poultry Microbes**

This is a complex solution of various beneficial microorganisms found naturally and used in food manufacturing which provide chelated minerals, anti-oxidants, enzymes, vitamins, organic acids, lactic bacteria, yeast and prototrophic bacteria when used in poultry production. It is manufactured by Rhonjas Enterprises, Kenya. It is sold in liquid form at Ksh 250 per liter.

**12. Brema Bloom Forte**

It is a probiotic containing live yeast cells (*Sacchromyce cerevisiae*) and bacteria (*Lactobacillus sporogenes*) and fortified with enzymes like phytase, cellulase, Xylanase and pectinase. It is also rich in carbohydrates, vitamins, minerals and UGF (Unknown Growth Factors) and is a product of Bremer Pharma GMBH (Germany). It is sold in powder form at Ksh 1200 per Kg.

**13. Biospark V**

Biospark V is a commercially available yeast probiotic containing *Sacchromyce cerevisiae* which avails essential amino acids, energy, minerals and enzymes when used in poultry production. It is manufactured by Venkys Ltd (India). It is sold in liquid form at Ksh 1500 per liter.

**14. Caplix**

Caplix is a commercial yeast based probiotic containing *Sacchromyce cerevisiae* and avails enzymes like cellulase, amylase, arabinase pectinase, protease, lipase, Xylanase, beta glucanase and alpha galactosidase. It is produced by (Wockhardt Limited) wockhardt towers, bandra-kurla complex, bandra (E) Mumbai- 400 051 and sold in powder form at Ksh 300 per Kg.

## Targeted Livestock

Most of the products (92.2%) – including Antox, Biospark V, Caplix, Diamond V xpc, Elimin-8, EM.1, Magic Boost, Magic set broiler, Molaplus, Rhonjas super poultry microbes, Super booster, Super Enzymes and Vipro were targeted at broiler and layer production. Some products (6.0%) were multipurpose and could be used as probiotics and also for making organic compost. Probiotics such as EM.1 and Bio- active Microbes (BM) are used for composting which is the process of segregating organic waste back to the soil. They are applied straight to the soil as innoculants and function to exert beneficial effects on soil quality by fermenting the organic matter hence removing all the problems of pathogenic bacteria, greenhouse gasses and bad odor from the process. Others were used for silage and septic tank treatments (http://www.livingsoil.co.uk). However, Brema bloom (1.8%) was the only probiotic for cattle (Table 4).

**Table 4:** Proportion of Probiotics administered to various types of Livestock in Kiambu County.

| | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Cattle | 3 | 1.8 | 1.8 |
| Poultry | 155 | 92.3 | 94.0 |
| Poultry /Organic Compost | 10 | 6.0 | 100.0 |
| Total | 168 | 100.0 | |

**Source:** Survey Data ($P<0.05$), (S.E. = 0.038)

***Type: Yeast based or live microbes?***

The classification of the probiotics was based on the active ingredient indicated on the label inserts. According to the study results, 64.3% of the products were yeast based probiotics and contained the *Saccharomyces cervisiae spp*. They included; Antox, Biospark V, Caplix, Diamond V xpc, Elimin-8, Magic Boost, Magic set broiler and Vipro. 35.7% of the products had live microbes which mainly was the *Lactobacillus spp* and included; Bio active Microbes, Brema Bloom, EM.1, Mola plus, Rhonjas Super poultry Microbes, Super booster and Super Enzymes (Table 5).

**Table 5:** Classification of the Probiotics found in Kiambu County

| Class | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Yeast based | 108 | 64.3 | 64.3 |
| Live Microbes | 60 | 35.7 | 100.0 |
| Total | 168 | 100.0 | |

**Source**: Survey Data (P<0.05), (S.E. = 0.037)

## Part 2: Farmers' feedback on the benefits of probiotics

### *Farmer Characteristics and Production System*

The majority of farmers in the county were commercial poultry producers (92.3%) and their flock sizes ranged from 50-800 for all types of poultry. Broiler poultry farmers had the largest flock size which ranged from 300- 600 chicken, followed by layers poultry farmers whose flock ranged from 200-400 and indigenous poultry farmers had the smallest flock size that ranged from 50-200. The farmers who kept poultry for household purpose were about (7.7%) and their flock size ranged from 10-50 chicken which were mainly indigenous chicken (Table 6).

**Table 6:** The type of Poultry Production Systems used by Farmers in Kiambu County

| Type | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Household | 3 | 7.7 | 7.7 |
| Commercial | 36 | 92.3 | 100.0 |
| Total | 39 | 100.0 | |

**Source:** Survey Data (P<0.05) (S.E. = 0.043)

Some 48.7% of the farmers in the County kept indigenous chicken while 35.9% kept broiler chicken. 15.4% of the farmers kept layers (Table 7).

**Table 7**: Distribution of Respondents by the type of Poultry farmed in Kiambu County

| Poultry type | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Broiler | 14 | 35.9 | 35.9 |
| Layers | 6 | 15.4 | 51.3 |
| Local | 19 | 48.7 | 100.0 |
| Total | 39 | 100.0 | |

**Source:** Survey Data (P<0.05) (S.E. = 0.148)

### *The Probiotics used*

Some 74.4% of the poultry farmers used probiotics as feed additives while 25.6% did not. According to the study, probiotics were mainly being used by the commercial poultry farmers. They had other alternatives which included antibiotics, poultry supplements and medicinal plants and trees such as *Aloe vera*, red pepper, desmodium and *Aloe kendogensis* (Table 8). Most of the respondents surveyed in this study administered the probiotics in the early growth stages of the chicken (day 1- 4 weeks) to allegedly increase their appetite hence boost their growth rate. All the poultry farmers who used probiotics gave a positive feedback on their performance in poultry.

**Table 8:** Farmers' response on the use of Probiotics in poultry production in Kiambu County

| Response | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Yes | 29 | 74.4 | 74.4 |
| No | 10 | 25.6 | 100.0 |
| Total | 39 | 100.0 | |

**Source**: Survey Data (P<0.05) (S.E. = 0.071)

The results of the common probiotics used are shown in Table 9.

**Table 9**: Summary of the Probiotics Brands used by Poultry Farmers in Kiambu County

| Probiotics | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Vipro | 9 | 23.1 | 43.6 |
| Super Enzyme | 8 | 20.5 | 20.5 |
| EM.1 | 6 | 15.4 | 61.5 |
| Diamond V | 5 | 12.8 | 74.4 |
| Zegg Booster | 1 | 2.6 | 46.2 |
| N/A | 10 | 25.6 | 100.0 |
| Total | 39 | 100.0 | |

**Note:** N/A represents the number of non-respondents.

Source: Survey Data (P<0.05) (S.E. = 0.314)

Vipro plus for both broilers and layers was widely used among the poultry farmers at 23.1%. It is yeast based, containing *Saccharomyces cerevisiae* and is in powder form. The farmers administered it in poultry feed at 10 grams per 70 kg bag. Super Enzymes followed at 20.5 %. It was administered to the chicken through water at a dosage of 2 ml for 1 litre of water daily for one week especially for day old chicks and thereafter 5 ml for 1 litre of water twice a week which contains live microbes, *Lactobacillus*, and is in liquid form. EM.1 was at 15.4% and contains live microorganisms. It was administered through water at a dosage of 2 ml for 1 litre of water daily for one week especially for day old chicks and thereafter 5 ml for 1 litre of water twice a week. EM1 was also used for making compost by farmers. 12.8% of the farmers used Diamond V (xpc) which is in powder form. It contains yeast and was administered through the feed at 10 grams for 70 kg bag. Zegg Booster, which is for layers, was at 2.6% which is a probiotic for layers and is in powder form. It was administered through the feed at 10 grams for 70 kg bag. Despite Vipro plus being the most readily available probiotic, most respondents preferred the liquid form probiotics like Super Enzymes and EM.1 due to the ease of administration to the poultry.

***Source of Information***

Most poultry farmers got the information about probiotics from agro vet shops (28.2%), while others got the information from the agricultural extension officers assigned in their sub counties (25.6%). This is because agro-vets were readily accessible on average being, less than 4 km away from farmers' homesteads in both production systems. Animal extension officers were also, on average, about 4 km away and occasionally organize seminars and meetings with the farmers to teach them on various aspects of poultry production. About 12.8% of the poultry farmers got the information from the lead farmers in their sub counties or groups, who normally are the leaders for their groups. 5.1% of the farmers received information from the veterinary officer, who are mainly at the livestock offices. 2.6% of the farmers got the information form other sources like; livestock field days and shows, agricultural magazines, seminars and books (Table 10). All the respondents interviewed had some form of agricultural training either through organized seminars and workshops or through the small groups that they formed from where they received training from extension officers.

**Table 10**: The Sources of Information on Probiotics use in Poultry Production in Kiambu County

| Source of information | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Agro vet | 11 | 28.2 | 33.3 |
| Extension Officer | 10 | 25.6 | 59.0 |
| Lead Farmer | 5 | 12.8 | 71.8 |
| Veterinary | 2 | 5.1 | 5.1 |
| Other sources | 1 | 2.6 | 74.4 |
| N/A | 10 | 25.6 | 100.0 |
| Total | 39 | 100.0 | |

**Note:** N/A represents the number of non-respondents.

Source: Survey Data (P<0.05) (S.E. = 0.267)

The average weight of mature broilers at six weeks was 1.4 kg and were sold at Ksh 380 (wholesale price) and 400 (consumer price). For farmers rearing laying hens, they sold an average of 4 trays a week while for farmers rearing indigenous chicken, they sold their chicken every three months with an average weight of 3 kg at Ksh 500.

***Discussion***

Probiotic is a culture of living microorganisms that is used as functional ingredients to manipulate and maintain good health by controlling gut micro flora and increasing digestive enzyme activity. Charalampopolus and Rastall (2009) stated that the species currently being used in the preparations of probiotics are mostly of two bacterial genera: *Bifidobacterium* and *Lactobacillus.*

These include, *Lactobacillus bulgaricus, Lactobacillus sporogenes, Lactobacillus salivarius, Lactobacillus acidophilus, Lactobacillus helveticus, Lactobacillus casei, Lactobacillus lactis, and Lactobacillus plantaru*. *According to* Thomke (1998) , some probiotics are of microscopic fungi such as strains of yeasts belonging to *Saccharomyces cerevisiae* species. The probiotic microorganisms can only be effective if they are capable of exerting a beneficial effect in the form of growth promotion or increased resistance to disease and also be non-pathogenic and non-toxic. They should also be present as viable cells, preferably in large numbers and capable of surviving and metabolizing in the gut environment, e.g. resistant to low pH and organic acids. Probiotics act in various ways like an antagonistic action towards pathogen bacteria through; production of antibacterial compounds, modification of gut pH. Another mode of action is competitive exclusion which is the colonization ability and adhering competition in the intestinal mucous membranes hence preventing the adhesion and invasion of pathogens. They also act through competition for nutrients with the pathogens hence inhibiting their colonization in the gut. They alter the microbial metabolism by increase or decrease of enzyme activity and stimulate immunity by increasing antibody levels and macrophage activity. Probiotics have been used in a wide range of animal species. In poultry, probiotics are used as natural growth promoters and as alternatives to antibiotics and have shown various benefits in the performance and immunity of the birds by increasing growth rate and decreasing e colonization by pathogens in the gut (Mohamed et al., 2013). Probiotics have also been used in cattle health and productivity mainly to reduce incidences of diarrhea in calves, prevent ruminal acidosis through pH stabilization, to control the growth of pathogens in the rumen and also to balance the gut microbiota (Johanne, 2009) and (Yutaka et al., 2015).

The study findings revealed an increase in awareness and use of probiotics among Kenyan farmers. There were 15 brands of probiotics and they were used for poultry, dairy cattle and compost making. After using the probiotics, poultry farmers noted an increase in feed intake among the chicken after administering probiotics and hence faster growth rate. Thes study results tally with Samanya and Yamauchi (2002) findings which reported pronounced intestinal histological changes such as prominent villi height which increase the rate of absorption of available nutrients hence resulting in greater growth performance and increase in body weight gain. The mechanisms by which probiotics improve feed conversion efficiency include alteration of microbial metabolism by increase or decrease of enzyme activity and suppression of growth of intestinal pathogens by production of antibacterial compounds

(Yeo and Kim, 1997). Other studies have shown that supplementation of broilers with probiotics increased the villus height: crypt depth ratio in the ileum significantly (Ghahri *et al*., 2013).

The farmers also reported low mortality rates among the young chicks and good health among their flock after using probiotics. The results were similar to those of Talebi *et al*. (2008) who stated that, probiotics feeding also have been reported to improve antibody titres against viral diseases like Newcastle Disease (ND) and Infectious Bursal Disease (IBD); and Lee *et al*. (2010) stated that probiotics reduced the clinical signs of avian coccidiosis in a set experiment and increases various parameters of immunity in broiler chicken. In another study, Kabir *et al*. (2004) reported significantly higher antibody production in experimental birds as compared to control ones.

In layers, farmers noted reduction in stress factor especially during peak production, production of strong egg shells and maintainace of optimum egg production. Radu-Rusu *et al*. (2010) stated that the use of probiotics would enhance the performance of layers especially during the stress periods that is; at the early stages of life and immediately prior to and after the move from pullet house to layer house. Zarei *et al*. (2011) reported an increase in egg mass and weight and egg shell weight and thickness on feeding laying hens with diets supplemented with some commercial probiotics, prebiotics and synbiotics. Use of probiotics in layers have been reported to improve fertility, egg quality and reduce yolk cholesterol concentration without affecting yolk weight (Chen *et al*., 2005).

Poultry farmers surveyed in the present study reported the production of dry litter by the chicken on administering probiotics and reduction of bad odor in the pens. Probiotics have been found useful in reducing ammonia production in litter and faecal water contents by their antagonistic action towards ammonifying bacteria and reducing urease activity (Patterson and Burkholder, 2003). The same agrees with findings by Chen *et al*. (2003) which concluded that supplementing broiler with the lactobacilli type probiotics Ecozyme reduced the environmental ammonia and volatile organic compound levels. It also reduced the pH and moisture content of the excreta. Recently, there has been a great increase in the productivity of indigenous chicken in Kenya, which has caused a shift in consumer preference from broiler to indigenous chicken products since they are considered tasty, healthy and safe as they are produced naturally without the influence of growth hormones (Wachira, 2003). Another reason is due to the high production cost of broiler chicken rearing in terms of feed and disease control in comparison with rearing indigenous chicken. There has also been an increase in campaign for indigenous chicken rearing from the Ministry of Livestock. Poultry farmers are encouraged to venture into indigenous chicken rearing commercially by offering seminars and support to the common interest groups of farmers in various sub counties (Sibitali, 2013). The trend was observed in Kiambu County during the survey.

## Conclusions

The Kenyan farmer in Kiambu has accepted to use probiotics in poultry production and is reporting positive feedback on production. There are many types of probiotics available in the market and the common probiotics being used are Vipro Plus, EM.1 and Super Enzymes Poultry Microbes. Therefore there is need to test the effectiveness of common probiotics used in Kenya in broiler production in a controlled experiment.

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# Prevalence of Aflatoxins in commercial broiler feeds in Nakuru, Kenya

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## Abstract

This study aimed at determining the prevalence and concentration of aflatoxins (AFs) in commercial broiler feeds in Nakuru, Kenya. A total of 40 broiler feed samples (20 starter and 20 finisher) were collected from 10 randomly selected feed milling companies in Nakuru Town that manufacture broiler feeds. The samples were subjected to ELISA technique to test for total aflatoxins and data analyzed using MS Excel and SAS (version 6.0). All the samples tested positive for aflatoxins with a range of 1.07 µg/kg and 41.005 µg/kg. 92.5% of the samples exceeded the WHO 5µg/kg total AFs limits in animal feeds. Whilst 52.5% of the samples exceeded the FDA 20µg/kg total AFs limits in poultry feeds. Efforts need be dedicated to sustain testing of feed raw materials and feed products to minimize Mycotoxins contaminations along the feed production value chain. The study findings are expected to enhance efforts in policy and standards development to promote the production and manufacture of safe and quality poultry feeds as outlined in the Kenya code of practice.

## Introduction

Livestock production contributes about 30% of agricultural GDP and approximately 10% of Kenya's GDP (Groote *et al.*, 2010). Broiler chicken is the most important animal under intensive production systems in Kenya. Nevertheless, poultry are suggested to be the species most sensitive to the effects of mycotoxins (Denli and Okan, 2006). The sector therefore faces great economic losses mainly due to the impact of aflatoxins (AFs) on poultry performance parameters (Marchioro *et al*., 2013) including; reduced daily feed intake, feed conversion efficiency, average daily gain and poor feed conversion ratios (Atherstone *et al*., 2016).

Mycotoxins are secondary fungal metabolites with very different chemical configurations (Bryden, 2012). The AFs are a type of mycotoxins produced by members of the genus *Aspergillus*, mainly *Aspergillus flavus* and *Aspergillus parasiticus* in cereals and grains when conditions are favourable (Marchioro *et al*., 2013) particularly moisture and ambient temperature appropriate for development of spoilage fungi ( Bryden, 2012; Spragg and Watts, 2013)

There are worldwide standards set by different countries and regulatory bodies to govern AFs levels in foods and animal feeds. The limits of AFB1 and total AFs in foods are 2 and 4µg/kg in the European Union (EU) whilst they are 5 and 10µg/kg, respectively, in more than 75 countries around the world (Herzallah, 2009). The AFs limits for animal feeds by WHO are 5µg/kg (Kajuna *et al*., 2013) and 20µg/kg by FDA (Reddy *et al*., 2007). Contamination of feeds with aflatoxins may result in the presence of AFs residues in food of animal origin such as meat, milk, eggs and processed foods like cheese. The AFs have mutagenic effects and are carcinogenic, teratogenic and hepatotoxic hence are a serious threat to public health (Leslie *et al*., 2008 ; Abrar and Anjum, 2013; Herzallah, 2009).

## Materials and methods

### *Sampling and Study Area*

The study was carried out in Nakuru county, Kenya. Feed samples (40) were collected from ten randomly selected broiler feed manufacturing companies within Nakuru town. Ten broiler starter and 10 broiler finisher feed samples were collected per company in two phases, between the month of April 2017 and July 2017. Each collection phase was determined by the frequency of purchase of raw materials by the individual milling companies. The samples were collected in different khaki bags, labeled, transported to the laboratory and stored at 4$^{o}$C as per awaiting analysis (Nemati *et al.*, (2014). All samples were analysed at the Mycotoxin Research laboratory in the Biochemistry Department, Egerton University. A 1kg composite sample each was collected by picking small random portions of samples from the same feed lot and thoroughly mixing them together to form a homogeneous sample (Rodrigues *et al*., 2011). The samples were then subjected to ELISA technique to test for AFs prevalence and concentration levels.

### Sample Analysis

### *Aflatoxins extraction from the samples*

Representative feed samples were individually ground to fine particle size such that 95% passes through a 20 mm mesh screen making a homogeneous sample. Extraction Solution (70% methanol) was prepared by adding 30 mL of distilled water to 70 mL of methanol (reagent grade) for each sample to be tested. Some 20 g ground portion of feed sample was weighed and added 100 ml of the Extraction Solvent (70% methanol). The mixture was mixed by shaking in a sealed container for a minimum of 2 minutes. The particulate matter was allowed to settle. About 5-10 ml of the extract was filtered through a Whatman number 1 filter paper and the filtrate collected for testing.

### *Assay Procedure*

All the reagents were allowed to cool to room temperature before use. The PSB-Tween packet was reconstituted by washing out the contents in a gentle stream of distilled water into a 1Liter container. One mixing well was placed in a microwell holder for each Standard and Sample to be tested. An equal number of Antibody Coated Microtiter Wells were placed in another microwell holder. 200 µL of the HRP-Conjugate was dispensed into each mixing well. Using a new pipette tip for each, 100 µL of each Standard and Sample were added to appropriate mixing well containing HRP-Conjugate. Priming pipette was used to mix for at least 3 times. Using a new pipette tip for each, 100 µL of contents were transferred from each mixing well to a corresponding Antibody Coated Microtiter Well then incubated at room temperature for 15 minutes. The contents from microwells were decanted into a discard basin. The microwells were washed by filling each with PSB-Tween washing buffer, decanting the buffer into a discard basin. Washing was repeated for a total of 5 washes. The microwells were tapped face down on a layer of absorbent towels to remove residual buffer. The required volume of Substrate Reagent (120 µL/well) was measured and placed in a separate container. Some 100 µL was added to each microwell and incubated at room temperature for 5 minutes while covered to avoid direct light. The required volume of Stop Solution (120 µL/well) was measured and placed in a separate container. Some 100 µL was added in the same sequence and at the same pace as the Substrate was added. The optical density (OD) of each microwell was read with a microtiter plate reader using a 450 nm filter.

### *Data recording and analysis*

The optical density (OD) of each microwell was recorded in MS Excel. Data analysis was done using MS Excel where percentages and means ± standard deviation were calculated and SAS (version 6.0) was used to calculate paired T-Test.

## Results – Prof lets discuss this section - confirm

There was 100% prevalence of total AFs in the compounded broiler feed samples collected (Table 1), with the registered levels ranging between 1.07 µg/kg and 41.005 µg/kg.

**Table 1:** The proportion (%) of commercial broiler feed containing various concentrations of total aflatoxins.

| Aflatoxin Levels (ppb) | Presence of Aflatoxins in samples (%) | | |
|---|---|---|---|
| | Broiler Starter | Broiler Finisher | All Samples |
| 0.00 (undetectable levels) | 0 | 0 | 0 |
| < 5 | 10 | 5 | 7.5 |
| 5-10 | 15 | 15 | 15 |
| 10.001-20 | 25 | 25 | 25 |
| 20.001-30 | 35 | 45 | 40 |
| 30.001-40 | 10 | 10 | 10 |
| 40.001-50 | 5 | 0 | 2.5 |
| > 5 | 90 | 95 | 92.5 |
| >10 | 75 | 80 | 77.5 |
| >20.001 | 50 | 55 | 52.5 |

The range of AFs in broiler starter was 1.07-41.01 µg/kg whereas those for broiler finisher were 4.69-35.76 µg/kg. 92.5% of the samples (90% broiler starter and 95% broiler finisher) exceeded the WHO 5µg/kg total AFs limits in animal feeds. Whilst 52.5% of the samples (50% broiler starter and 55% broiler finisher) exceeded the FDA 20µg/kg total AFs limits in poultry feeds. The mean total AFs levels for the broiler starter and broiler finisher feed samples were 19.3677 ± 2.4 and 19.8563 ± 2.2 µg/kg respectively. There was no significant difference between the aflatoxin levels found in the starter and finisher samples (P=0.88), neither between the phase 1 and 2 of samples collection (P=0.33) nor among the ten companies (P=0.17) at 95% confidence interval.

The variations AFs from the individual feed manufactures' is shown in Table 2 and Fig 1. Feed mill had a consistently low levels of AFs in its products.

**Table 2:** Aflatoxin levels means and mean separation data per feed miller.

| Miller | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean Separation Data | 7.55±4.97 $^{c}$ | 14.16±4.97 $^{bc}$ | 22.50±4.97 $^{ab}$ | 21.14±4.97 $^{abc}$ | 24.20±4.97 $^{ab}$ | 17.43±4.97 $^{abc}$ | 18.16 ±4.97 $^{abc}$ | 23.95±4.97 $^{ab}$ | 17.79±4.97 $^{abc}$ | 29.27±4.97 $^{a}$ |

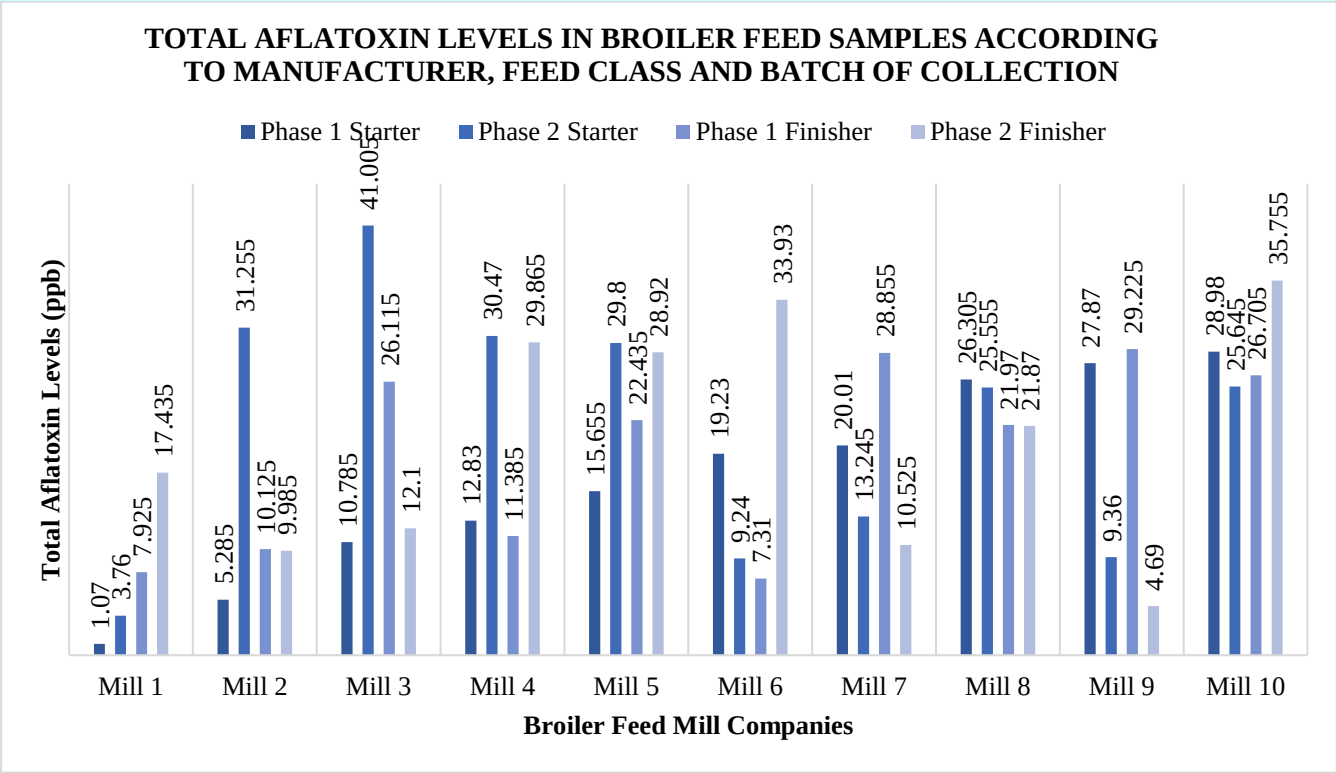


**Figure 1**: Illustration of AFs Levels in Samples Collected According to Manufacturer, Class of Feed and Phase of Collection

## Discussions

All the broiler feed samples collected tested positive for aflatoxins with levels ranging from 1.07 µg/kg to 41.005 µg/kg. There were no differences in AFs contamination levels between the feed samples collection phases or between the starter and finisher (P>0.05). Although there was no significant difference in AFs levels among feed millers samples (P>0.05), one feed miller's samples were consistently low in total AFs (below 10ppb). This is a good indicator that it is possible to produce broiler feeds consistently meeting the set AFs limits. In a study conducted by Kajuna *et al* (2013) in Tanzania, 78.1% of all the compounded feed samples collected were contaminated with aflatoxins with broiler feeds having the highest contamination percentage (91.7%). According to another study conducted in the Middle East and Africa where 324 samples of grains, finished animal feeds and other feed commodities were collected, samples from Kenya were found to have the highest prevalence level of aflatoxins (78%) (Rodrigues *et al*., 2011). High AFs prevalence in agricultural products in tropical and subtropical regions is due to warm and humid weather which provides optimal conditions for the growth of the molds (Abrar and Anjum, 2013; Bryden, 2012). High AFs prevalence in broiler feeds could also be due to use of lower quality raw materials in feed production caused by competition for feed materials shared by animals and humans (Abidin *et al*., 2011).

## Conclusions and recommendations

The study findings showed that available broiler feeds in Kenyan markets are contaminated with AFs, at levels exceeding the FDA and WHO total AFs minimum limits for poultry feeds and animal feeds respectively. More research needs to be carried out to come up with better ways of testing feeds raw materials to ensure they are not contaminated beyond the set regulatory standard requirements. Detoxification of contaminated feed materials and appropriate use of mycotoxin binders may be explored for sustainable poultry industry.

## Acknowledgement

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# Evaluating Triticale Grain Grown in Kenya as an Alternative Feed Ingredient in Broiler Diet

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## Abstract

This study was conducted to evaluate the potential of triticale grain as an alternative feed ingredient in broiler diets. The feeding trials of broilers were conducted over a period of six weeks to assess the optimal inclusion level of raw triticale grain in broiler diet as a substitute for maize and also assess their performance. Five triticale based diets were prepared and incorporated in five inclusion levels of 0%, 15%, 30%, 45% and 60%. The diets were assigned to the experimental units in a completely randomized design. The results of this study showed that inclusion of triticale in broiler diet significantly improved feed intake (FI) and body weight gain (BWG) ($p<0.05$) with improved performance with increase in inclusion level. Inclusion of triticale up to a level of 60% had no significant effect on feed conversion efficiency (FCE) as FI and BWG increased concurrently. The protein efficiency ratio (PER) was not significantly different between diets. It was concluded that Triticale may be used as an alternative feed ingredient in broiler diets in raw form without causing any detrimental effect on the performance up to an inclusion level of 60% and it may wholly substitute maize. However the comparative advantage should be economically assessed especially in terms of grain yield and cost of production.

**Key words**: Maize, Triticale, Feed intake, Broilers, Performance

## Introduction

Triticale (*Triticosecale*) is a synthetic crop developed by crossing Durum wheat (*Triticumaestivum*) and rye (*Secalecereale* L) (Garcia et al., 1995). The name combines the scientific names of the two crop species, that is wheat (Triticum) and rye (Secale) (Taylor, 2012). Although triticale was described in scientific reports in 1870's, early attempts to cross wheat and rye produced sterile plants. In 1891, German Botanist Wilhelm Rimpau discovered by chance a natural cross of wheat and rye offspring that was partially fertile. The discovery of colchicines in 1937 led to the creation of fertile triticale. This is a natural substance extracted from crocuses, enables doubling of the number of chromosomes in plant cells. The first large scale triticale breeding programme was started at the University of Manitoba in early 1950's.

Triticale is normally used as a feed grain for livestock, production of bio-fuel and in food products. It has shown promise as a forage and alternative source of protein, energy, amino acids and vitamins in formulated rations for ruminants and non ruminants (Taylor, 2012). At the time of this study triticale was being utilized by dairy farmers in Kenya in form of green chop, hay and haylage as well as use of grain in compounding of dairy concentrate at farm level.

It is well recognized that feed represents the most significant cost of broiler production. This cost ranges from 60-70%. The major portion of feed cost is ingredient related and a minor but significant portion is feed processing related. Every effort should be geared towards obtaining a cheap but nutrient sufficient ingredient. It has been documented that triticale contains anti nutritional factors (ANFs) such as trypsin and chymotrypsin inhibitors that may inhibit feed intake (Belaid, 1994), pentosan (Flores et al., 1994) and soluble arabinoxylans (Cyran, 1996). These findings imply that caution should be taken when triticale is incorporated in feed rations. However the adverse effect of the earlier can be minimized through heat treatment and incorporation of enzymatic preparation for the later (Peterson and Aman, 1988). Metabolizable energy (ME) and crude protein (CP) are the major nutrients that are mainly required by poultry in large amounts. ME can easily be provided by carbohydrates in cereals.

Maximizing digestible energy yields and bioavailability of protein is fundamental to optimizing efficiency in poultry production.

In view of the aforementioned, feeding trials were carried out to assess performance of broiler chicken fed with triticale based diet in raw form. The main objective of this study was to determine the optimal inclusion level of triticale grain in raw form and the effect of the inclusion in the diet on performance of broilers.

## Materials and methods

This study was conducted at Dairy Training Institute, Nakuru County, Kenya. The respective grains were ground and incorporated into the experimental diets in specific percentages to compound the trial diets. The birds used in this study were Bovans goldline of mixed sex obtained from Kenbreed Ltd hatchery at one day old. They were fed on conventional broiler starter mash before being fed on the experimental diets from day fourteen of age.

### *Dietary treatment*

Five isocaloric and isonitrogenous diets were formulated to meet the National Research Council (NRC, 1984) requirements for broiler chickens; 3150 ME/kg and 21% CP as illustrated in Table 1. The diets comprised raw maize and triticale grains at the inclusion levels of 60/0, 45/15, 30/ 30, 15/ 45, and 0/60% respectively. All the ingredients were analyzed using Near Infra Red Spectroscopy (NIRS) at Kenya Agricultural and Livestock Research Organization (KALRO) centre, Naivasha.

**Table 1**: Composition of the experimental diets used to assess the performance of broilers fed on triticale based diets (3rd to 8th week of age)..

| | | | Diets | | |
|---|---|---|---|---|---|
| Ingredient (% in diet | 1 | 2 | 3 | 4 | 5 |
| Maize | 60 | 45 | 30 | 15 | 0 |
| Triticale | 0 | 15 | 30 | 45 | 60 |
| Corn gluten | 20 | 16 | 15 | 12 | 9 |
| Corn germ | 0 | 4 | 6 | 9 | 11 |
| Fish meal | 10 | 11 | 10 | 9 | 10 |
| Wheat bran | 4 | 3 | 0 | 4 | 4 |
| Corn oil | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Limestone | 3 | 3 | 3 | 3 | 3 |
| DCP | 2 | 2 | 2 | 2 | 2 |
| Broiler Premix | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Iodized salt | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Synthetic Lysine | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Synthetic Methionine | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Total | 100% | 100% | 100% | 100% | 100% |
| Calculated composition | | | | | |
| CP% | 21.90% | 21.51% | 21.54% | 21.51% | 21.69% |
| ME ( K ME/kg) | 3156 | 3156 | 3151 | 3178 | 3156 |

## Experimental procedure

One hundred and fifty (150), one day old broiler chicks of mixed sex (Bovans goldline) were obtained from a local hatchery (Kenbreed Farm Ltd) and used in this experiment. The chicks were reared under conventional brooding conditions, receiving 24 hours of light and at a temperature of 30-34$^{o}$ C during the first 14 days of life. The brooding temperature was maintained using infra red electric bulb and gradually adjusted to room temperature towards the end of the third week. Other management practices such as vaccination against New Castle disease and infectious bursal disease (gumboro) were timely done as well as de-worming. In addition, the chicks were fed on conventional commercial broiler starter diet during this period. On the 14th day, the chicks were weighed individually. Ninety chicks of the

middle weight range (201-209 grams) were randomly assigned to 15 experimental cages (1m by 1.5 m) in a conventional chicken house in deep litter system. Each cage was equipped with a round metal feeder and a semi-automatic water drinker. Each cage had six chicks which formed the experimental unit. The five broiler diets were then randomly assigned to the experimental cages in a completely randomized design. This represented 5 inclusion levels (0, 15, 30, 45, 60 %) of triticale. The first diet was maize based with 0% triticale grain inclusion andacted as the control diet. Each experimental diet was assigned to three experimental units..

***Data collection and statistical analyses***

Data collection was done for six weeks (day 14 to day 56). Clean drinking water was offered on daily basis at *ad libitum.* Parameters of interest were weight gain, feed intake, feed conversion efficiency and protein quality (protein efficiency ratio-PER).

**Feed intake (FI)**

The birds were offered a precise amount of feed on daily basis and the leftovers collected before offering fresh feed. The total leftover for every week for the respective experimental unit was weighed every Friday of the week and recorded. The average intake per bird was calculated as feed offered per week per unit less feed leftover per week divided by seven days then divided by number of birds per unit cage. This was recorded as feed intake per bird per day.

**Body weight gain (BWG)**

Weekly body weight gain was calculated as the difference between final body weight and initial body weight at the end of every week divided by the number of birds in the experimental unit. The average body weight gain for the entire experimental period (6 weeks) was obtained as the difference between weight at the end of the 6 weeks less body weight at the beginning of the experiment. The weight gain for the individual bird was obtained by dividing the total body weight gain per pen by the number of birds in the pen. The final body weight was recorded at the end of the experimental period.

**Feed conversion efficiency (FCE)**

Feed conversion efficiency was calculated as the ratio of feed intake per bird to the total body weight gained during the experimental period (six weeks).

**Protein efficiency ratio (PER)**

This was used to assess the quality of protein and was evaluated on basis of Protein Efficiency Ratio (PER) which is an expression of weight gained per protein consumed in grams for a period of 6 weeks in the case of this study.

The data was analyzed using one way analysis of variance (ANOVA) for a completely randomized design using SAS (1998) with 5 trial diets based on the triticale inclusion level.

**Results and discussion**

The results of feed intake, body weight gain, feed conversion efficiency and protein efficiency ratio are presented in Table 2. Comparison was made between maize and triticale based diets to determine the possibility of substituting maize with triticale in broiler finisher diets.

**Table 2:** Effect of inclusion of triticale grain in broiler diet on performance.

| | Diets (% Triticale inclusion level) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 60 | SE |
| FI ( g/bird) | 3051.99[c] | 3448.33[b] | 3538.72[ab] | 3510.23[b] | 4025.82[a] | 98.754 |
| BWG ( g/g) | 1093.45[c] | 1216.94[b] | 1405.17[a] | 1385.38[a] | 1416.47[a] | 56.021 |
| FCE | 2.798[a] | 2.839[a] | 2.528[a] | 2.536[a] | 2.84[a] | 0.0823 |
| PER | 1.637[a] | 1.639[a] | 1.841[a] | 1.835[a] | 1.623[a] | 0.0533 |

[abc]means within a row with a different superscript are significantly different ( P<0.05)

FI -Feed intake: BWG -Weight gain: FCE -Feed conversion efficiency: PER- Protein efficiency ratio

There was a significant difference in feed intake between maize and triticale based diets (p<0.05). Feed intake was lowest for the control diet. Feed intake increased as the level of triticale inclusion increased withthe 60% inclusion levelhaving the highest feed intake. However the feed intake was similar for diets 2, 3 and 4 with 15%, 30% and 45% triticale inclusion level.

These results are in agreement with those obtained by Althari and Guenter (1988); Abdelrahman et al. (2008) who reported that feed intake was significantly increased with inclusion of triticale in broiler diets. Emam (2010) also observed that feed intake was significantly increased when yellow corn was replaced with triticale grains in diets of broilers at rate of 25 to 100%. The results also agree with the study of Ragab and Namra (2010) in a quail study who also reported increased feed intake. However, the results differ with the findings of Azmal et al. (2001) and Korver et al. (2004) who reported no significant difference in feed intake between triticale and maize or wheat based diets in broiler diets. The results also differ with those of Janushonis et al. (2004) who indicated that feed intake was lowest when maize was replaced with triticale at the rate of 25 to 35% in broiler turkey diets. It can be concluded that inclusion of triticale grain in the diets improved feed intake

The body weight gain differed significantly between the maize-based diets and the triticale based diets (p< 0.05). The triticale based diets recorded better BWG than control. Diet 2 (15%) triticale inclusion resulted in the least weight gain. Diets 3,4 and 5 with 30%, 45% and 60% inclusion levels recorded the same weight gain but significantly higher (p<0.05) than control.

Similar observations were previously reported by Yaqoob and Netke (1975) who found that substituting maize with triticale, weight for weight but not on iso-nitrogenous basis in a soya meal diet, improved LBW and LBWG at 50% inclusion or more. Furthermore Althari and Guenter (1988) observed that diets containing 50 to 100% triticale resulted in increased live body weight (LBW) and live body weight gain (LBWG) in agreement with our findings. Janushonis et al. (2004) reported similar findings when maize was replaced with triticale in turkey broiler diets at the rate of 25 to 35%. Chapman et al. (2005) observed that LBW and gain was 5% more in triticale than the corn based diet. Recently, Eman (2010) indicated that average LBWG and LBW was higher when yellow corn was replaced with triticale grains.Results of this study are in agreement with previous reports of non detrimental effect of triticale in poultry feeding trials. Johnson and Eason (1988) observed that growth of broiler chickens was similar whether triticale or wheat was the main cereal source in the diets that contained 50% cereal and were equalized for nutrient content. Vieira and Penz (1995), Attia and Abdelrahman (2001) found that graded inclusion of up to 40% triticale as substitute for yellow corn had no negative effect on LBW and LBWG of broiler.

There was no significant different in feed FCE between all the diets (p>0.05). This is because feed intake and weight gain increased concurrently. The FCE ranged between 2.5 and 2.8 in all the diets. The results are in agreement with those reported earlier of no significant difference (p>0.05) among feed conversion efficiencies when increasing proportions of maize was replaced with triticale (Vohra et al., 1991 and Azmal et al., 2001). However, Althari and Al- Bustany (1997) reported a significantly lower FCE when chicks were fed a diet containing 40.6 % triticale with 19.2% corn when compared with control group fed on diets containing 60% corn-based diets. Korver et al (2004) found that birds fed a diet containing triticale grain had the lowestt FCE compared with those fed wheat based diets. The values of FCE in this study are higher than 1.9 to 2.24 (Hughes and Cooper, 2002) when they different varieties of triticale

to broiler chicken. The difference may be attributed to difference in breed of the birds and varieties of the triticale used.

Protein quality was evaluated through PER was and did not differ significantly across all the diets ($p>0.05$) ranging between 1.63 to 1.84. This meant that the protein quality from maize and triticale resulted in same performance in broilers so long as the diets were isocaloric and isonitrogenous. The superiority of amino acid profile in triticale was not expressed through performance of the birds in this study.. These results are in agreement with Yaqoob and Natke (1975) who demonstrated that substituting triticale for maize exceeding 75% on weight basis did not affect protein efficiency ratio in broiler starters. The results differ with those of Al-Athari and Guenter (1988) who reported that diets containing 50 to 100% triticale resulted in better energy and protein efficiencies compared with wheat diet.

## Conclusion

1. Triticale grain can be included in the broiler diet up to 60% inclusion level.
2. Triticale grain may wholly substitute maize in broiler finisher diet when fed in raw form without adverse effect on the performance of the birds.

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# On farm performance evaluation of sweet lupin cultivars in cool highlands of central Kenya

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## Abstract

In most smallholder dairy systems in the high potential areas of Kenya, provision of adequate feed to lactating animals is a major challenge to production. Where forage availability and quality are inadequate to meet the requirements of dairy cows, use of sweet lupin grain could be a suitable feed supplement. The objective of the study was to test the adaptability of five sweet lupin cultivars in the cool highlands of Central Kenya. The varieties included two *Lupinus albas* and three *Lupinus anguistifolius*. Data were subjected to analysis of variance (ANOVA) using a mixed linear model. There was significant (P<0.05) difference on general performance between Lupinus albas V1-4.09, V2-3.77 and *Lupinus angustifolius* V3-3.21, V4-3.20 and V5-2.42. Likewise, there was significant difference (P<0.05) on general performance between the two sites (4.35 and 2.80) Passenga and Silanga respectively across the 5 cultivars. Other findings on general performance showed significant difference (P<0.05) between cultivars where Lupinus albas cvv Ultra and Kieve had good performance, *Lupinus angustifolius* cvv 28137 and 28324 had average performance. *Lupinus angustifolius* cv 26974 was mediocre in performance. Results on plant lodging indicated very low lodging <10% across cultivars and seasons but were significantly different (P<0.05) between the two sites of 4.35 and 2.80 for Passenga and Silanga respectively. Other findings of the study showed very high plant population across all the cultivars except for cv 26974 and very low disease and pest incidences <4% for all the cultivars. The root nodule results were significantly different (p<0.05) between sites 2.77g, 1.63 g for Passenga and Silanga respectively and seasons 2.33 and 1.67 g for Passenga and Silanga respectively. The findings on average height (103.36 and 70.23) and circumference (107.18 and 86) indicated significant difference between Passenga and Silanga sites respectively. The grain yield findings from Passenga site showed that *Lupinus albas* (Ultra) produced significantly (P<0.05) highest yield - 5217 kg $Ha^{-1}$, compared to the other varieties. However, the grain yield results from Silanga site indicated that *Lupinus angustifolius* cvv 28137 and 28324 produced significantly higher grain (P<0.05) - 2900 and 2450kg $Ha^{-1}$ respectively compared to the other varieties. The overall grain yield findings from the two sites indicated that *Lupinus angustifolius* cv 28137 is a more promising Lupin cultivar for the cool high altitude climatic conditions of Central Kenya.

**Key words:** On farm, sweet lupin, cultivars, cool highlands of central Kenya

## Introduction

In most smallholder dairy systems in the high potential areas of Kenya, provision of adequate feed to lactating animals is a major challenge to production (Lanyasunya *et al,* 2006). Dairy cows in smallholder systems are fed on crop residues during the dry season which are generally of low quality and therefore deficient in energy and protein and hence inadequate to meet maintenance requirements of lactating cows (Mukisira *et al* 1995). In circumstances where forage availability and quality are inadequate to meet the requirements of dairy cows, use of sweet lupin grain could be a suitable feed supplement (Kenney *et al,* 1980). Lupin grain has widely been used as a source of protein and energy in livestock feeds in Europe, Australia and United states. Apart from their comparatively high protein content (over 30% on dry matter basis), lupin is easy to feed and convenient to store. (Mukisira *et al* 1995). In Kenya, the potential of Lupin as livestock feed has been under-utilized due to inadequate data and information and low adoption by farmers. However, there are two species of sweet lupin in Kenya whose agronomy and nutritive evaluation has received considerable attention. These are the blue lupin cultivars (Uniwhite, Uniharvest and Unicrop) and the white lupins represented by the cultivar Ultra (Wanjala,

1979). The two varieties are annual in nature and take 4-7 months to mature. (Gladstones *et al*, 1998; Wanjala, 1979). Trials undertaken at the National Agricultural Research Station, Kitale, included testing the adaptability of lupin varieties in different agro ecological zones (Bauer and Oketch, 1976). The research work on lupins in Kenya has been geared towards establishing a cheap source of protein as a concentrate for livestock supplementation. Their high protein content makes them a suitable feed resource for monogastrics and ruminants (Kohajdova *et al*, 2011). Generally, they have low level of starch but are rich in fermentable carbohydrates and hence ideal for ruminant feeding due to low risk of acidosis. As leguminous plants, they have ability to fix and utilize atmospheric nitrogen into the soil through symbiotic relationship with Rhizobium bacteria (Anonymous, 2009). The objective of the study was to test the adaptability (growth behavior and grain yield) of five sweet lupin cultivars in the cool highlands of Central Kenya and to demonstrate the effects of these varieties under farmer management and obtain farmer feedback.

## Materials and methods

### Study sites

The study was conducted in the Central highlands agro ecological zones (UH 2-3) located in the Nyandarua County. The soils in Nyandarua are of medium fertility and almost neutral acidity (pH approx. 6.0). The trial plots were established in two seasons and set on two farmer's fields in two locations of Passenga (UH 2) and Silanga (UH 3). The first season was established in August 2012 and the second season in August 2013.

### Treatments and trial management

Five Sweet Lupin varieties were tested in complete randomized block design with varieties as the independent variable. The dependent variables included plant height, plant circumference, plant lodging, pest and diseases, number of pods and grain yield. The varieties included two *Lupinus albas* (*cvs* V1-*Lupinus albas cv* Ultra and V2-*Lupinus albas cv* Kiev mutant), and three *Lupinus anguistifolius* (*cvs V3*-28324, V4-28137 *and V5*-26974).The treatments were randomized in each site and replicated four times in plot sizes measuring 5 x 6 m. Basal application of phosphate fertilizer (26 kg P/ha as DAP at an approximate rate of 5g per hole) was used at planting. Lupin seeds were sowed at 50cm x 30cm spacing and 3 seeds per hole and later thinned to 2 seedlings. The seeds were inoculated with rhizobium bacteria bio fix prior to planting.

## Data collection and statistical analysis

The assessment for height and circumference were measured using a tape measure when the plants had attained 50% podding. Plant lodging was assessed at 100% podding and was scored on a scale of 1-5 where 1 was very high at 100%, 2 high at 75%, 3 average at 50%, 4 –low at 25% and 5-very low at <10%. Stand population for each plot was assessed at 50% podding on a scale of 1-5 where 1 very high, 4-high, 3-average, 4-low and 5-very low. The general performance of the plots was assessed at 100% podding and scored on a scale of 1-5 where 1-poor, 2-mediocre, 3-average, 4-good and 5-excellent. Root nodules numbers were counted, weighed and recorded. The pest and disease incidence were scored on a scale of 1-5 where 1-very high at 100%, 2- high at 75%, 3-average at 50%, 4-low at 25% and 5-very low at <10% and included physical presence of parasitic insects and disease symptoms on the affected plants. The grain yields were determined for the net plot after the beans had attained physiological maturity. Harvesting of the beans was done by uprooting of the whole plant. The uprooted plants were sun dried for a week after which, the grains were separated from the haulms through physical threshing and winnowing. The grains were weighed and recorded for each net plot.

The generated data were subjected to analysis of variance (ANOVA) using a mixed linear model (MIXED procedure, SAS Institute Inc., 2003). The findings are presented by descriptive statistics using tables and figures.

## Results

There was significant (P<0.05) difference between *Lupinus albas* V1-4.09, V2-3.77 and *Lupinus angustifolius* V3-3.21, V4-3.20 and V5-2.42 on general performance. Likewise, there were significant difference (P<0.05) on general performance between the two sites (4.35 and 2.80) Passenga and Silanga respectively across the 5 cultivars (Table 1). The difference could be attributed to the difference in AEZ and soil types. This could further suggest that the soil type and climatic factors at Passenga site were more favorable for performance of sweet lupins than at Silanga. The results of the study on plant lodging indicated that there was very low lodging <10% across cultivars, sites and seasons (table 1). On general performance, the result indicated significant difference (P<0.05) between the two sites of 4.35 and 2.80 for Passenga and Silanga respectively. Likewise, the results indicated significant difference (P<0.05) on general performance between cultivars where *Lupinus albas* cvv Ultra and Kieve showed good performance, *Lupinus angustifolius* cvv 28137 and 28324 had average performance. *Lupinus angustifolius* cv 26974 was mediocre in performance perhaps due to its low seed germination. The results of the study showed very high plant population across all the cultivars except for cv 26974 and very low disease and pest incidences <4% for all the cultivars. The root nodule results were significantly different (p<0.05) between sites 2.77, 1.63 g for Passenga and Silanga respectively and seasons 2.33 and 1.67 g for Passenga and Silanga respectively but insignificant between varieties. (Table 1)

**Table 1:** Physiological performance of Sweet lupins and reaction to pests and diseases at Passenga and Silanga

| Treatment | General Performance | Lodging | Stand population | Root nodules (grams) | Pest/Disease incidences (%) |
|---|---|---|---|---|---|
| V1 | $4.09^{a}$ | $5.00^{a}$ | $1.11^{a}$ | $1.77^{a}$ | $0.70^{a}$ |
| V2 | $3.77^{a}$ | $4.86^{a}$ | $1.21^{a}$ | $2.22^{a}$ | $2.35^{a}$ |
| V3 | $3.21^{b}$ | $4.99^{a}$ | $1.13^{a}$ | $1.94^{a}$ | $0.96^{a}$ |
| V4 | $3.20^{b}$ | $4.99^{a}$ | $1.22^{a}$ | $1.94^{a}$ | $3.81^{a}$ |
| V5 | $2.42^{c}$ | $4.77^{a}$ | $3.41^{b}$ | $2.52^{a}$ | * |
| Season | | | | | |
| 1 | $3.43^{a}$ | $4.94^{a}$ | $1.68^{a}$ | $2.33^{a}$ | * |
| 2 | $3.42^{a}$ | $4.92^{a}$ | $1.31^{a}$ | $1.67^{b}$ | * |
| Site | | | | | |
| Passenga | $4.35^{a}$ | $4.90^{a}$ | $1.70^{a}$ | $2.77^{a}$ | $0.56^{a}$ |
| Silanga | $2.80^{b}$ | $4.93^{a}$ | $1.47^{a}$ | $1.63^{b}$ | $3.14^{a}$ |

Different superscripts of values within columns denote significant difference at P<0.05 * Not assessed

V1-Lupinus albas (Ultra), V2- Lupinus albas (Kieve mutant), V3-Lupinus angustifolius (28137), V4-Lupinus angustifolius (28324), V5- Lupinus angustifolius (26974)

The results on assessment of average height (103.36 and 70.23) and circumference (107.18 and 86) indicated significant difference between Passenga and Silanga sites respectively. This implied that the five sweet lupin cultivars were bushier and grew taller at Passenga than Silanga. Likewise, there was significant difference on the average height (101.7) of *Lupinus albas cv* Ultra compared with the other sweet lupin cultivars which were shorter. This implied that *Lupinus albas cv* Ultra grew taller than all other lupin cultivars. (Table 2)

**Table 2**: Growth characteristics of Sweet Lupin cultivars - circumference and height (cm)

| Treatment | Circum1 | Circum2 | Circum3 | Circum4 | Circum5 | Av Cir | Ht 1 | Ht 2 | Ht 3 | Ht 4 | Ht 5 | Av Ht |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V1 | $102.67^{a}$ | $87.87^{a}$ | $91.93^{a}$ | $80.41^{a}$ | $87.93^{a}$ | $90.16^{a}$ | $114.92^{a}$ | $97.99^{a}$ | $107.82^{a}$ | $98.88^{a}$ | $88.89^{a}$ | $101.7^{a}$ |
| V2 | $94.01^{a}$ | $87.35^{a}$ | $78.71^{a}$ | $93.62^{a}$ | $83.58^{a}$ | $87.46^{a}$ | $79.1^{b}$ | $74.69^{a}$ | $72.96^{b}$ | $80.2^{b}$ | $75.08^{a}$ | $76.41^{b}$ |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V3 | 94.53[a] | 87.98[a] | 107.01[a] | 86.25[a] | 107.68[a] | 96.69[a] | 68.69[c] | 72.82[a] | 74.79[c] | 68.99[c] | 73.94[a] | 71.85[b] |
| V4 | 100.67[a] | 90.98[a] | 93.26[a] | 104.17[a] | 95.06[a] | 96.83[a] | 85.94[d] | 82.94[a] | 75.29[c] | 76.62[b] | 77.38[a] | 79.63[b] |
| V5 | 107.35[a] | 104.15[a] | 114.15[a] | 117.12[b] | 107.33[a] | 110.02[a] | 81.65[d] | 86.65[a] | 95.17[d] | 82.52[b] | 73.52[a] | 83.9[b] |
| Season | | | | | | | | | | | | |
| 1 | 103.93[a] | 87.53[a] | 101.31[a] | 98.74[a] | 97.89[a] | 97.88[a] | 87.38[a] | 84.5[a] | 90.89[a] | 86.44[a] | 77.74[a] | 85.39[a] |
| 2 | 93.09[a] | 94.03[a] | 85.69[a] | 87.57[a] | 89.71[a] | 90.02[a] | 88.13[a] | 81.55[a] | 77.96[a] | 77.18[b] | 79.60[a] | 80.88[a] |
| Site | | | | | | | | | | | | |
| Passenga | 110.00[a] | 102.05[a] | 101.11[a] | 107.77[a] | 115.00[a] | 107.18[a] | 111.61[a] | 102.72[a] | 101.94[a] | 98.94[a] | 101.61[a] | 103.36[a] |
| Silanga | 90.96[b] | 81.63[b] | 90.60[a] | 85.46[b] | 81.36[b] | 86[b] | 71.80[b] | 69.93[b] | 74.06[b] | 71.50[b] | 63.86[b] | 70.23[b] |

Different superscripts of values within columns denote significant difference at $P<0.05$

V1-Lupinus albas (Ultra) V2- Lupinus albas (Kieve mutant), V3-Lupinus angustifolius (28137), V4-Lupinus angustifolius (28324), V5- Lupinus angustifolius (26974)

The results on grain yield at Silanga site indicated that *Lupinus angustifolius cvs* 20137 and 28324 produced significantly the highest grain yield - 2900 and 2450 kg $Ha^{-1}$ respectively compared with the other cultivars (Figure1 and 3). However, *Lupinus albas cv* Ultra produced significantly the highest grain yield - 5217 kg $Ha^{-1}$ at Passenga (Figure 2 and 3). The difference in grain yield - 183 kg $Ha^{-1}$ at Passenga of *Lupinus angustifolius* cultivar (26974) was significantly the lowest perhaps due to its low seed germination.

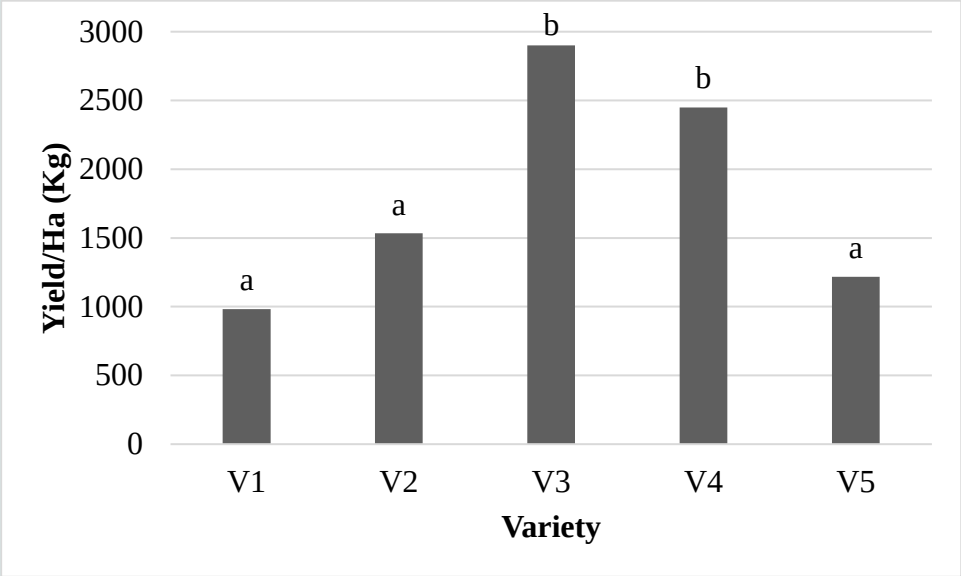


**Figure 1:** Grain yield of Sweet Lupin cultivars at Silanga

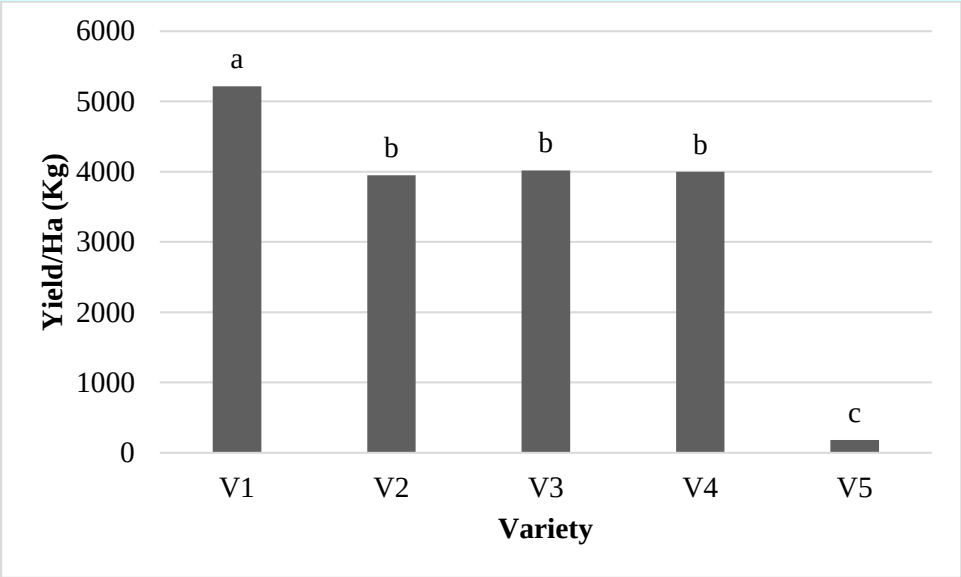


**Figure 2:** Grain of Sweet Lupin cultivars at Passenga

The results from Passenga site showed that *Lupinus albas* (Ultra) produced significantly (P<0.05) highest grain yield - 5217 kg Ha-¹, compared to *Lupinus angustifolius* (28137) - 4017 kg Ha-¹, *Lupinus angustifolius* (28324) - 4000 kg Ha-¹, *Lupinus albus* (Kieve mutant) - 3950 kg Ha-¹ and *Lupinus angustifolius* (26974) - 183 kg Ha-¹. However, the results from Silanga site indicated that Lupinus angustifolius cvv 28137 and 28324 produced significantly (P<0.05) - 2900 and 2450kg Ha-¹ respectively compared to Lupinus albas (ultra) - 1593 kg Ha-¹, *Lupinus angustifolius* (29674)-1217 kg Ha-¹ and *Lupinus albus* (ultra)-983 kg Ha-¹ respectively. (Figures 2 and 3).

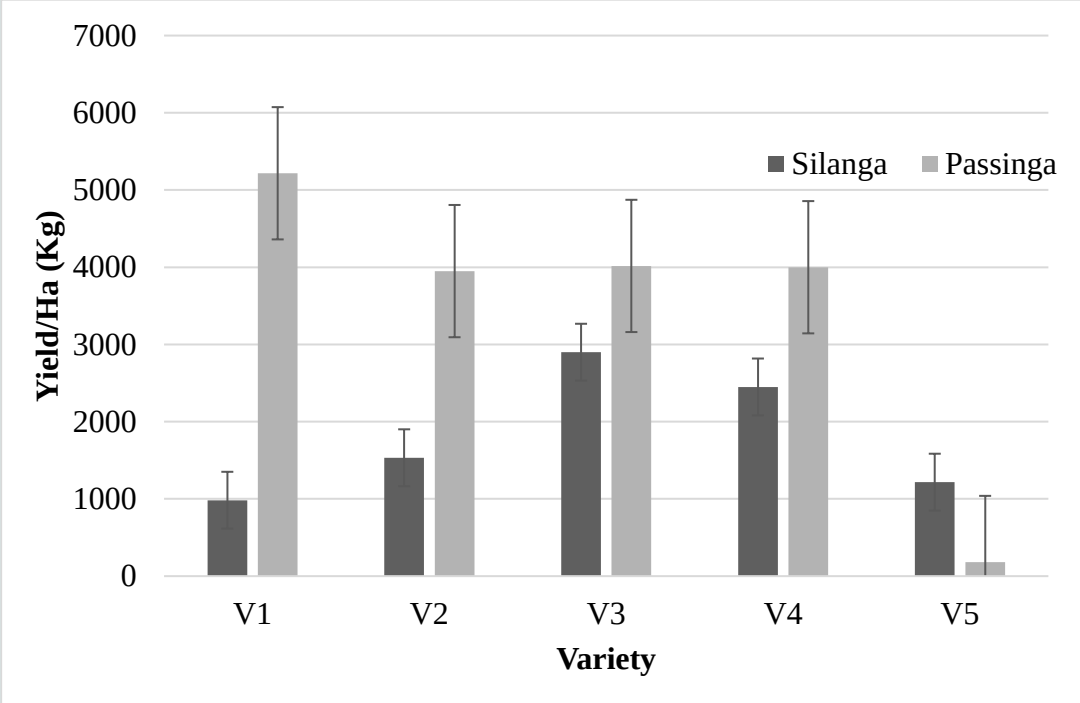


**Figure 3:** Grain yield of Sweet lupins at Passenga and Silanga

## Discussion

The findings on height of *Lupinus albas* cv Ultra concurs with those of Bauer and Oketch, 1976 in a study conducted in Nyandarua. The grain yield results of this study corroborates with the findings of

Jullier *et al* 2009 which studied the yield and yield stability of determinate and indeterminate autumn sown white lupins grown at different locations in France and The United Kingdom. Similarly, Kusewa *et al* 1980, reported seed yield of 4 tons for *Lupinus albas* ultra in a study conducted at Kitale to determine herbage and seed yield of different cultivars of Lupins.

## Conclusion

The grain yield findings from the two sites of Passenga and Silanga suggest that *Lupinus angustifolius cv* 28137 is a more promising cultivar for the cool high altitude climatic conditions of Central Kenya.

## Recommendation

The study recommends further evaluation of sweet lupin cultivars to generate more stable data to enable a concrete conclusion.

The 5 sweet Lupin cultivars should be evaluated in an expanded national performance trial (NPT) to identify and release the suitable sweet lupin cultivars for commercial seed production by Kenya plant health inspectorate services (KEPHIS) for the cool central highlands of Kenya.

Analysis of chemical composition of sweet lupin grain based on the association of analytical chemistry (AOAC) is recommended.

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# INNOVATIONS IN ANIMAL BREEDING

# Implementation of long term breeding and conservation programs for indigenous chicken in Kenya

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## Abstract

The Kenya Agricultural and Livestock Research Organization (KALRO), together with its main partners (Egerton University, State department of livestock and Kenya livestock Breeders' Association) have made deliberate efforts in setting up long term indigenous chicken (IC) breeding and conservation programs for sustainable meat and egg production taking cognizant of lesson learnt from previous endeavors and more recently climate change related challenges. This is being pursued alongside stabilization of the famous dual purpose KARI *kienyeji* chicken (KC) which was largely developed from hybrid exotic germplasm. The ultimate goals are to develop; 1) two IC breed lines each for egg and meat production under various production systems, 2) develop two KC lines from the hybrid populations that are genetically and morphologically stable and, 3) combine desirable attributes in the IC lines and stable KC lines through systematic crossbreeding to form stable synthetic breed lines that suit various agro-ecological conditions with unique climate change related challenges in the country. The IC populations maintained for continuous selection will serve as conservation units for the local chicken populations. Some of the intermediate outcomes from the aforementioned long term interventions include; 1) A comprehensive pedigree and performance data collection to support both selection and characterization of the different IC ecotypes and genotypes, and KC lines , 2) Inspection and bird registration platform for each of the ecotype and genotypes to aid in periodic characterization and to facilitate selection and breeding, 3) A pilot artificial insemination scheme in the IC egg line which will ultimately form one of the alternatives for cryopreservation of semen from genetically superior cocks, 4) Breeding objective as set out in previous studies to improve egg and growth performance has been initiated and selection for improvement of the two egg and meat IC lines, and dual purpose KC lines has commenced. With regard to KC lines, already two distinct lines of the KC have been isolated from the systematic *interse* matings initiated. Currently there are over 6000 IC birds at various ages and stages of selection in the breeding and conservation facility at Naivasha.

**Key Words;** Breeding programs, Conservation, Indigenous Chicken, Breed lines.

## Introduction

Indigenous chickens possess high genetic diversity for many traits and are indisputably valuable genetic resources both for the present and future generations. They could therefore form the basis for genetic improvement and diversification to produce adapted and high yielding breeds (Okeno et al., 2013). Various ecotypes and genotypes with superior adaptability, body weights and increased egg production

exist (Magothe et al., 2012a and b; Ng'eno, 2011); however, their potential has not been fully exploited (Magothe et al., 2012a). To increase meat and egg production at household level, the need to utilize and improve these ecotypes and genotypes is apparent. Recently Magothe et al. (2012a and b) identified lack of organized breeding programs for IC in Kenya as one of the major challenges towards improving meat and egg performance on sustained basis. Even where selection could be preferred under intensive high-input management system, the resultant improved genotypes will be expected to perform under resources constraint extensive production systems. Unique IC populations have been identified, characterized and promising populations identified (Ng'eno, 2011; Khobondo et al., 2014). Comprehensive characterization of production and marketing systems for IC including identifying the main challenges in the poultry value chain, estimating their economic contribution, identifying traits of economic contributions and their corresponding economic weights have been done (Bett et al., 2011a and b; Okeno et al., 2011; Okeno et al., 2012a and b).

**Objectives of the breeding and conservation program**

The aforementioned efforts clearly demonstrate the enormous potential to up-grade the IC value to commercial status through strategic research and development initiatives. These interventions should be consolidated into transformative actionable thematic areas that address the challenges along the value chain so as to guarantee poverty alleviation, income generation, food and nutritional security of smallholder poultry producers, youth and other disadvantaged groups in the IC sub-sector in Kenya. One such strategy is setting up of sustainable breeding and conservation programs that aim at improving indigenous chicken productivity taking the prevailing production environments into consideration. The specific goals are 1) Genetic improvement of chicken productivity without adversely affecting adaptability, unique attributes and diversity. The program aims at improving body size, growth rate, egg yield, egg size, fertility, hatchability, prolificacy, broodiness, meat and egg taste and survival rate of the KC and IC, 2) Conduct research along the IC value chain. This includes research on phenomics and genomics, nutrition, meat and egg quality, disease and parasites tolerance, among others and 4), to conserve as many ecotypes and genotypes from across the country as possible. This would form the basis for identifying desirable genes that would be infused in future selected populations

**Historical perspective**

The poultry research unit at Non-Ruminant Institute (NRI) - Naivasha has been managing a breeding program for genetic improvement of IC for the last two decades. This has been a long-term investment program that involved collection of various IC ecotypes from various parts of the country and maintaining the flocks under intensive management. In the last 7 years, introgression of imported blood lines has been undertaken to broaden the genetic base of the breeding population for enhanced selection. The resultant progeny has been commonly referred to as 'KARI improved chicken' (abbreviated as KC in this paper). The ultimate objective of this initiative has been to increase growth, reproductive performance as well as adaptation. Farmers have been sourcing breeding material (live birds and eggs) for KC breed lines for either pure breeding or upgrading of their IC flocks especially under smallholder scavenging conditions. Such upgrading programs are rarely organized, a scenario that could easily compromise the existing genetic base and result in serious erosion of important attributes of IC ecotypes in the country. One way of averting this is to set-up organized breeding and systematic crossbreeding programs. Line breeding programs would result in development of pure IC and KC meat and egg breed lines, while organized crossbreeding strategies between IC and KC would result in optimal gene combinations between the two breed lines that would poses optimal gene proportions to fit into the challenging scavenging production systems.

**Design of the breeding and conservation programmes**

***Basic approach***

Design of the breeding and conservation program was based on a comprehensive review of literature on specific previous studies in Kenya and the region on indigenous chicken improvement programs. The FAO guidelines on development of breeding programs were also carefully considered during this process. A team of breeding experts from KALRO, Egerton University, state department of Livestock and KLBA was set up to review the draft and produce the final version of the program. The program

captured different themes such as the current and future production systems, traits of importance and their current production levels, main genotypes, breeding objectives, breeding strategies, selection traits and criteria, performance recording and evaluation, mate allocation, dissemination of genetic gain and evaluation of the program.

***Setting up of Breeding Objectives***

Based on this, four specific breeding objectives are being pursued (1) To develop IC meat lines for extensive and semi-intensive production systems; this is being achieved by increase live weight at 26 weeks of age from 1.5 Kgs to 2.0 Kgs and egg weight from the current average 45.5g to 55.0g, (2) To develop IC egg lines for extensive and semi-intensive production systems by increasing egg production from 15 to 20 eggs per clutch, (3) To develop KC lines into breeds. by stabilizing the genetic makeup of each KC line for true to type reproduction, and (4) To develop dual purpose synthetic lines for extensive and semi-intensive production systems. This is being achieved by increasing live weight at 26 weeks of age from 1.5 Kgs to 2.0 Kgs, increasing egg weight from 45.5 g to 55.0 g and also increasing egg production from 15 to 20 eggs per clutch

***Establishment of pure breeding programs for the various ecotypes and genotypes***

Figure 1 summarizes pure breeding scheme for development of IC and KC breed lines. Within line selection will develop two separate IC lines for each egg (IC1) and meat (IC2) production, by divergently selecting and mating superior individuals within the IC ecotypes for three generations. In each developed line, superior individuals will be continuously selected and mated for at least 5 generations to establish IC egg and meat breed, respectively. Pure breeding is being used to stabilize each KC line through systematic *interse* mating and selection of superior individuals for five generations until at least 96% morphological and genetic stability is achieved. In this program two distinct lines have been isolated for continuous selection and mating of superior individuals for 5 generations to establish stable KC1 and KC2 breeds (Figure 6). The two KC lines were selected based on their predominance in the segregated populations of the hybrid lines as KC 1 (spotted plumage for both males and females) and KC (black hens and cocks). After the development of IC egg and meat lines, stake holders will be consulted to determine the most appropriate morphological characteristics such as plumage colour, comb type, skin colour, egg shell colour, among others.

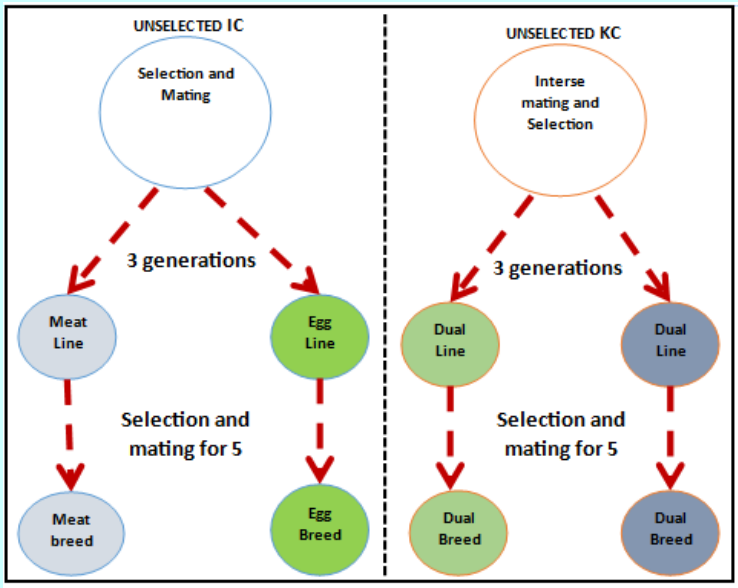


**Figure 6:** Summarized pure breeding scheme for development of IC and KC breed lines

***Use of organized systematic cross breeding programs***

After stabilization of KC lines and development of IC egg and meat lines, cross breeding will commence. Each KC line will be systematically crossed with each IC line, to the appropriate combinations, and the resultant genotypes stabilized through *interse* mating to create new synthetic egg, meat and dual purpose

lines. The envisaged crossbreeding strategy will commence once the KC lines have achieved the 5th generation of *interse* with over 96% stability. It is assumed that the two IC lines for meat and egg production will be distinct by the third generation of selection. The ultimate objective will be produce synthetic lines that combine desirable attributes in the KC lines (which have exotic blood) with adaption characteristic in the IC lines (locally adapted). Various gene combinations will be developed and tested under different production environment to determine the most suitable, so as to match the genotypes to given environments as part of climate change adaption. It is through such a program that some of the KC genotypes will be able to contribute to egg and meat production in some extreme production environments where pure exotic germplasm might not survive.

**Bird identification, recording systems and selection criteria**

For pedigree data, an identification system has been developed to allow chicks upon hatch to be allocated a wing tag number that corresponds to its sire and dam number as indicated from the egg it hatched. A combination of artificial insemination, battery cage system and trap nest systems are being used to enable identification of sire and dam upon collection of fertilized eggs. To associate a hatched chick to a particular egg, each egg is placed in an individual compartment at day 18 of incubation. Performances of selection traits are recorded on each individual progeny in contemporary hatching groups. Body weights of individual birds are recorded at hatching (Day old), 2, 4, 6, 8, 10, 12, 16, 20 and 26 weeks of age. Pullets are placed in individual cages at the age of between 24 and 26 weeks for a period of 90 days to record the parameters such as the date at which each egg is laid, the date at which the pullet goes broody, the Pullet's body weight when first egg is laid and the weight of each egg laid. The dates are then used to compute parameters such as age at first egg, laying rate, clutch size etc. In order to estimate the mortality rate, the parameters such as mortality date, cause of death (if known) and the wing tag number of the dead bird are recorded. Table 1 summarizes the selection criteria traits and their detailed description. The performances of each group of selected candidates are analyzed per sex to determine the mean and standard deviation. For IC meat line, both cocks and hens whose body weights at 12 weeks of age are at least one standard deviation above average are selected. The heaviest cocks are allocated to the heaviest unrelated hens in a mating ration of 1 male to between 5-7 females. In the case of IC egg line, the hens whose clutch sizes are above average are selected. Cocks related to the selected hens are identified and allocated the best performing hens. For KC dual purpose lines, both cocks and hens whose body weights at 12 weeks of age are at least one standard deviation above average are selected. During mate allocation, the heaviest cocks are allocated to the lightest unrelated hens.

**Development of descriptors for Bird inspection and registration**

Livestock are mostly bred according to pre-determined breed standards. In light of this, indigenous chicken (IC) descriptors have been developed, guided by the British Poultry Standards and in collaboration with the Kenya Livestock Breeders Organization (KLBO). The descriptors allow for description at flock and individual level. Flock descriptors describe the type of breed, origin, utility, population size, breeding strategy and identification method. Individual bird descriptors narrow down to individuals within the breeding flock.

**Table 1:** Detailed selection criteria to improve egg and body weight

| Trait | Description |
|---|---|
| Live body weight at 12 weeks of age | This trait will be used to pre-select chicks that will be retained until mate allocation time. Chicks that do not meet the following criteria will be culled. (a) For IC egg and meat lines, the males above 800 grams and females above 500 grams are selected. (b). For KC dual purpose lines, the males above 1000 grams and females above 800 grams are selected. |
| Age at first egg | This trait is being used to pre-select pullets for the IC egg line. (a) For IC egg line, all pullets above average egg production are selected. (b) For IC meat line all average and below average pullets are culled. |

| | |
|---|---|
| Eggs per clutch | This trait will be used to select pullets for the IC egg line. (a) For IC egg line, all pullets above average will be selected. (b) For IC meat line, all average and below average pullets…..? |
| Plumage colour | This trait is used to select KC dual lines at week 12 of age. All birds not meeting the following criteria are culled. (a) For KC line 1, all barred plumage (shavers) for both males and females and those with white shanks will be selected. (b) For KC line 2, those with completely black plumage for both males and females with black shanks are selected. |

These records include individual bird's identification number, sex, pedigree information and genotype. Selection of the descriptors was based on IC phenotypic characterization, in which traits of economic and social value either at farm level or market level were considered (Ngeno let a., 2014; Mengesha and Tsenga, 2011; Duguma, 2006). These include; plumage colour and pattern, skin colour, shank colour, facial features (earlobe colour; eye colour; comb colour, type and size; beak shape and length; wattle size and colour), body stature and presence of spur (only in females). Given that IC have a mixture of feather colour and pattern, the plumage descriptor is allowed to vary from head, body to tail (Dana et al., 2010). Based on the IC descriptors, a standard registration form (in print) was designed and deposited with Kenya Livestock Breeding Association (KLBA). In addition, an online registration platform has been designed and is being used to hasten the registration process. The electronic platform is based on a mobile application that has to be downloaded and installed on a smartphone. Besides registration, the tool also captures pedigree and performance data allowing the database to be integrated into the KLBO registration platform. With such comprehensive database, the tool is able to support selection and mating (genetic evaluation), phenotypic characterization and monitoring trends on performance and population. The descriptors are reviewed from time to time as the selection process brings out changes in the desired traits.

**Establishment of IC and KC conservation programs for sustainable use**

Conservation of chicken breeds in the country and region is basic to genetic improvement and development of poultry industry for enhanced productivity in the products value chain. Appropriate breeding and conservation procedures are desirable for the different poultry breeds so that they can be effectively maintained, and their contribution to the poultry products value chain ascertained. The current breeding and conservation initiatives at Naivasha fit well in the FAO Global Action Plan on Animal Genetic Resources. The conservation work covers the aspects of conservation through sustainable use, genetic characterisation and monitoring of trends, involvement of stakeholders and formulation of policy to guide in use of animal genetic resources for food and agriculture. The project has established a foundation stock through collection of indigenous chicken from various regions in the country. Regions were selected based on the low levels of introgression of foreign germplasm (Ngeno et al., 2015). The activity was carried out in three phases. In the first phase, the activity focused on counties reported to have the highest population of IC; Bomet, Homa Bay, Siaya, Kakamega, Bungoma and Busia Counties (Magothe at al., 2012a). Given that IC from these counties belong to the same phylogenetic cluster group, there was need to broaden the diversity by introducing additional ecotypes from other geographical areas (Ngeno et al., 2015). As such, the second phase focused on IC from Laikipia County and Isiolo County while the third phase focused on the coastal region (Taita-Taveta County, Kilifi County and Kwale County). By increasing the geographical representation, this ensures a rich gene pool that will stretch the selection alternatives to breed envisaged IC lines for meat and egg. The number of cocks and hens in an ecotype per generation is such that the effective population size is adequate to avoid random drift and inbreeding. Characterization of 10 poultry ecotypes in the country brought to the Centre is an on-going research activity and so far over 6000 birds have been hatched under this program. The KC lines are at the 3$^{rd}$ generation of *interse* mating with preliminary results showing above 80% morphological and genetic stability in the resultant progenies. The major priorities for the conservation program are 1) genetic and phenotypic characterization of individual birds from the

ecotypes collected across the country, 2) Continuous inspection and registration of genotypes by the Kenya Livestock Breeders Association to maintain identified breed descriptors, 3) Collection of additional IC germplasm from other parts of the country to enrich the genetic base of the existing conservation flock, 4) Establish a cryopreservation protocol for semen from genetic superior cocks identified through breeding and selection, 5) Routine husbandry support to the conservation flock such as feeding, vaccination programs, disease and parasite management, maintenance of biosafety measures in the housing and hatchery facility and 6) Setting up of dispersed open nucleus breeding and conservation programs.

## Conclusions

This paper highlights some of the initial steps that have been undertaken to set up long term sustainable breeding and conservation programs for various IC and KC genotypes in the country. This is an on-going process that requires concerted efforts by all actors in the chicken value chain. Mobilization of critical mass of experts and financial resources will be key in ensuring sustainability of the efforts already put in place. Future planned activities include transformative research and development themes such as use of genomic tools to support breeding work, testing suitability of existing feed resources for suitability as chicken feed, diversification of IC meat products through value addition, new approaches in disease and parasite control, and technology packaging and dissemination.

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# Effect of controlling future rate of inbreeding on expected genetic gain and genetic variability in Sahiwal breed population in Kenya

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## Abstract

The current study assessed the use of average relationship as a means to control future rates of inbreeding in a small cattle closed nucleus and its effect on genetic gain for milk yield as a means of managing genetic variability in livestock improvement programmes. A total of 8452 milk yield records of Sahiwal cows from National Sahiwal Stud, Kenya were used to estimate breeding values and 19315 records used to estimate average relatedness of all individuals. The estimated breeding values and genetic relationships were used to optimise individual genetic contributions between the best two males and the best 210 females in 2000-2008 year group based on estimated breeding values for lactation milk yield. Weights on genetic merit and average relationship considered in this study were (1, 0), (1, −300), (1, −500), (1, −1000) and (0, −1). When the best sires were selected and used for mating disregarding average relationship with their mates i.e. (0, -1), genetic gain of up to 213 kg was realized accompanied by a rate of inbreeding per generation of 4%. Intermediate levels of restrictions on genetic merit and average relationship (1, -300; 1, -500 and 1, -1000) gave average future rates of inbreeding per generation ranging from 1.1% to 3.2 % and average genetic merit of 137 kg to 209 kg. Controlling average relationship between mates resulted in increased genetic variability i.e. lower rate of inbreeding though average merit declined. A rate of inbreeding per generation of <1% is required for a population to maintain its long term viability. For this level to be attained, practical implications for the Sahiwal breeding programme in Kenya should include expanding the nucleus to allow other institutional and privately owned herds.

**Key words**: average relationship; genetic merit; Kenyan Sahiwal; optimum contribution

## Introduction

Genetic diversity of any breed is required to meet current and future production requirements in different or changing environments, to allow sustainable important genetic improvement, and to adapt rapidly to current and future breeding objectives (Melka, and Schenkel, 2010; Tang et al., 2013). Maintaining local breed diversity is usually an acknowledged conservation objective as it contributes a lot to farm animal genetic diversity (Gandini et al., 2014; Piccoli et al., 2014). Many local breeds such as Sahiwal cattle breed are important as they provide ecosystem services and are associated to specific agro-ecological zones and pastoral social diversity which necessitates their conservation. Local breeds help in maintaining livelihoods for communities living in marginal areas (FAO, 1998). The future genetic progress of any breed will depend largely on availability of adequate genetic variation.

The Kenyan Sahiwal cattle are bred under a closed nucleus breeding program (CNBP) where performance recording and selection is confined to the nucleus, and the pastoral herds are the main recipients of the resultant genetic superiority (Ilatsia et al., 2011). Small and closed populations are always at risk because of a higher loss of genetic diversity and increased rates of inbreeding as a result of small effective population size (Seré et al., 2008). Closed nucleus breeding programmes have been advocated for genetic improvement of cattle in developing countries (Kahi et al., 2004) due to their ease and lower cost of implementation since recording selection are done in the nucleus only. However,

CNBPs are associated with high inbreeding levels and low effective population sizes due to increased focus on a few high performing animals often closely related animals (Fernández et al., 2011). In the Kenyan Sahiwal population, current rate of inbreeding and average relatedness (AR) among animals are on an upward trend (Muasya *et al*., 2011; Kamiti, 2014 (Unpublished Thesis)) and are above value of 1% recommended by FAO (1998) beyond which a population loses its fitness. As a consequence, effective population size (Ne) is declining and is currently below the threshold of 500 recommended by Franklin and Frankham, (1998) for a population to maintain its long-term viability (Muasya *et al*., 2011; Kamiti, 2014(Unpublished Thesis)). Further, a small number of ancestors (16) account for over half of the total variation in the population suggesting overuse of a small number of some animals as parents over generations (Muasya *et al*., 2009; Mwangi et al., 2016).

The optimum genetic contribution, a strategy that maximises the genetic gain while restricting the rate of inbreeding or the relationships among the candidates has been developed and applied in large livestock populations (Koenig and Simianer, 2006; König et al., 2010; Woolliams et al., 2015). The strategy leads to increased genetic gain at the same rate of inbreeding compared to traditional selection schemes ( Hinrichs and Wetten, 2006; Henryon et al., 2015). The objective of the current study was to estimate the average relatedness and coancestry of individuals in the Sahiwal herd evaluate the effect of controlling future rates of inbreeding on expected genetic gain and mate allocation in the Kenyan Sahiwal cattle population.

## Methodology

Data for this study were obtained from the National Sahiwal Stud (NSS) at the Kenya Agricultural and Livestock Research Organization (KALRO) Naivasha. Information collected included animal identification, its sire and dam, and date of birth and sex of each animal. The pedigrees of the animals were traced as far back as possible in the birth record book database. A total of 8452 lactation milk yield records were used to estimate breeding values of all cows and sires with milk yield records at the NSS. The pedigree database included 18315 animals. The pedigree records were used to estimate parameters related to inbreeding, average relatedness and to predict future rate of inbreeding.

### Estimation of parameters

### Selection of candidates to be parents of the next generation

The candidates for the study were selected based on their merit for lactation milk yield. The best two sires were selected and each mated to 105 elite females according to (Meyn and Wilkins, 1974). The number of top males used was 2 in order to determine whether the size of the breeding herd influenced measures of genetic gain and variability.

### Estimation of breeding values

Breeding values for all animals for lactation milk yield were estimated using a single trait repeatability animal model. The mixed model equation for the model was as Mrode, (2014):

$$\mathbf{Y} = \mathbf{Xb} + \mathbf{Za} + \mathbf{Wpe} + \mathbf{e} \qquad [1]$$

where, **y** = vector of lactation milk yield records; **b**= vector of fixed effects; **a**= vector of random animal effects; **e** = vector of random residual effects; **pe**=vector of random permanent environmental effects; **X** = incidence matrix relating records to fixed effects; **Z** = incidence matrix relating records to random animal effects; **W**=incidence matrix for permanent environmental effects.

### Optimal genetic contributions

Assuming discrete generations, the contribution to the average relationship, *c* in year *t* as a function of current genetic contributions is: $c = \mathbf{c}'\mathbf{Ac}$, where *A* is the numerator relationship matrix of candidates for selection in year t−1. Optimal genetic contributions maximizes a criterion which is:

$$C = w_a.\mathbf{c}'.\hat{\mathbf{a}} + \frac{w_r}{(2L)^2}(\mathbf{c}'.\mathbf{A}.\mathbf{c} + 2\mathbf{c}'.\mathbf{A}.\mathbf{P}.\mathbf{v} + \mathbf{v}'\mathbf{P}'.\mathbf{A}.\mathbf{P}.\mathbf{v}) \quad [2]$$

where **A**, is the numerator relationship matrix, $\hat{\boldsymbol{a}}$ is a vector of predicted breeding values, **P** is previous genetic contributions, ***v*** is a lifetime breeding profile (Grundy et al., 2000); **c'Ac** and **Pv** are average relationship among breeding animals in the next generation and commited future contributions, respectively; **v'P'APv** and **c'APv** are the average relationship among offspring of animals with committed future contributions and average relationship among breeding animals and offspring of breeding animals with committed future contributions in the next generation; $w_a$ is the value of merit and $w_r$ is the cost of inbreeding/relationship and ***c*** is the vector of genetic contributions to be optimize (Berg et al., 2007). The pairs of weights ($w_a$, $w_r$) considered in this study were (1, 0), (1, −300), (1, −500), (1, −1000) and (0, −1) (Sørensen *et al*., 2008). EVA software was used to optimise individual genetic contributions by optimizing a criterion as defined by (Grundy et al., 2000), while breeding values for lactation milk yield were estimated using BLUPF90 software (Misztal *et al.*, 2014).

## Results and Discussion

Optimal genetic contributions were first calculated for the best 2 sires and 210 dams based on lactation milk yield according to the breeding programme developed by (Meyn and Wilkins, 1974). The number of breeding males was gradually increased while maintain the mating ratio in order to assess the effect of size of breeding population on genetic merit and predicted rate of inbreeding per generation. Table 1 shows the average merit and average relationships for the selected matings along with the expected rate of inbreeding for different weightings on merit and genetic relationship. For weight on merit alone (i.e. 1, 0), the average merit for the selected matings was 213.0 and average relationship of 0.05. For weights of 1, -300; and 1, -500 for average merit and relationship, respectively, the resulting average merit was 209.3 kg and an average relationship of 0.05 for both levels. Weights of 1 and -1000 for average merit and relationships led to an average merit and average relationship of 169.0 kg and 0.045 %, respectively.

When there was weight on average relationship only (i.e. 0, 1), average merit was 154.0 kg while average relationship was 0.045%. Therefore when more weight was to be put on average relationship as compared to merit, lower average merit and average relationship would be realised. The checking of average relationship was attributed to a more dispersed utilization of sires. When weight was on merit alone, the resulting average merit was high for any size of the breeding population. The high average merit is due to lack of consideration of pedigree information that is useful in determination of the relationship among the mates. This is similar to the current approach in the National Sahiwal Stud, in Kenya, where focus has been on merit only, leading to a decline of the population's effective population size (Muasya *et al*., 2009; Kamiti, 2014 (Unpublished Thesis) due to increased inbreeding.

**Table 1:** Average merit for lactation milk yield and average genetic relationship among the selected matings for the Kenyan Sahiwal breed for different weights on genetic merit and relationship and size of breeding population

| Weights | Average merit | Average relationship | Average inbreeding (%) | Predicted rate of inbreeding per generation (%) |
|---|---|---|---|---|
| 1, 0 | 210.0 | 0.049 | 14.51 | 4.03 |
| 1,-300 | 209.3 | 0.048 | 4.52 | 3.22 |
| 1,-500 | 209.3 | 0.048 | 4.52 | 3.22 |
| 1,-1000 | 169.0 | 0.046 | 0.93 | 1.92 |
| 0,-1 | 154.0 | 0.045 | 0.70 | 1.60 |

Average inbreeding was high (14.5%) when there was no restriction on average relationship but was accompanied by the highest gain in merit (i.e. 210.0). When there was restriction on average relationship as well, (i.e. 1, -1000; and 0, -1) the average inbreeding was 0.9% and 0.7% and 0.3 and 0.2%. This is an indication that when pedigree information is used as a basis for mate selection, future inbreeding levels can be controlled leading to maintenance of genetic diversity, while at the same time achieving genetic progress. More importantly the results point out the need to increase the size of the breeding herd if viability and fitness of the population is part of the breeding objective (FAO, 1998;Franklin and Frankham, 1998). Females with low relationship to the breeding males can be chosen as parents when large cost is applied on average relationship relative to merit. This should be done with caution since the dams or sires may have low recorded relationship due to pedigree information that is incomplete (Sørensen et al., 2008; Mwangi et al., 2016).

For the current Sahiwal cattle breeding programme in Kenya, where only two sires are selected after progeny testing (Meyn and Wilkins, 1974), the predicted rate of inbreeding per generation even when only relationship was constrained (0, -1) was above 1% which is recommended for long term maintenance of the breeds (FAO, 1998). This number of breeding males (2) is lower than the 20 to 30 used in other studies evaluating the benefits of optimum genetic contributions in managing genetic diversity (Koenig and Simianer, 2006; Sørensen et al., 2008). The rate of inbreeding per generation of a breeding population should not exceed 1%, if the population is to maintain its longterm viability (FAO, 1998). For selected matings as recommended by Meyn and Wilkins (1974), rates of inbreeding per generation were above 1% for all possible weights on merit and average relationship. Therefore the Sahiwal population will continue to lose genetic variability over time. Mwangi et al. (2016) found that the Kenyan Sahiwal population to be losing variability through genetic drift attributed to a small effective population size. Franklin and Frankham (1998) recommended an effective population size of between 500 and 1000 for a population to maintain its fitness in the longterm, translating to a rate of inbreeding per generation of 0.1%.

To achieve the desired level of genetic viability in future generations, the size of the breeding population should be increased. This approach may be unrealistic for the closed nucleus at the National Sahiwal Stud, Kenya, due to limited resources. Ilatsia et al. (2011) recommended opening up the nucleus to include other institutional and private Sahiwal herds in Kenya. In general, males to be used for breeding should be also selected based on more complete pedigree information and lower average relationship to ensure that the rate of inbreeding per generation doesn't exceed the recommended level. However, the value of optimal genetic contribution selection could decrease with increased intensive pre-selection of possible parents (Sørensen et al., 2008).

## Conclusion

Using optimum genetic contributions it was possible to optimizing the genetic gain, while controlling the rates of inbreeding per generation. Increasing the number of top bulls will be possible to constrain the future rate of inbreeding per generation to below 1%, although less genetic merit was realised. This implies that sustainable genetic improvement and maintenance of genetic variability for the Kenyan Sahiwal cattle population can be realised but the closed nucleus would require opening up to include other institutional and private herds and the number of potential breeding bulls increased, barring logistical and cost implications for small livestock populations

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# Evaluation of the current and alternative dairy cattle breeding goal in Kenya

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## Abstract

This study aimed at estimating the response to selection for the alternative breeding goal (ABG) when protein yield (PY) and mastitis resistance are incorporated into the current dairy cattle breeding goal (CBG) in Kenya. Data was obtained from literature on dairy cattle production systems in Kenya and the tropics. The breeding goal and schemes were modelled and evaluated in ZPLAN. We hypothesized that the expansion of the current dairy cattle breeding goal to include mastitis resistance and high protein yield could increase genetic and economic response to selection by up to 45% compared to selection for high milk yield alone. Two breeding schemes were considered: Artificial insemination using conventional semen (AI-CS) and multiple ovulation and embryo transfer using X-sorted semen (MOET-XS). The findings confirmed our hypothesis as the overall genetic gain for the ABG in Kenya shillings (KES) was 510.88 for MOET-X and 299.97 for AI-CS. Profitability was 1892.21 for MOET-XS and 1850.90 for AI-CS. Lower figures were observed for CBG in all parameters estimated. Genetic gain was 345.37 for MOET-CS and 203.75 for AI-CS. Profitability was 1186.21 for MOET-XS and 1211.34 for AI-CS. The findings of this study showed that expanding the current dairy cattle breeding goal to include protein yield and mastitis resistance is more profitable.

**Key words**: Dairy cattle, Mastitis resistance; Protein yield; Simulation, Milk quality

## Introduction

Dairy production is one of the flagship programs for vision 2030 in Kenya. The current per capita milk consumption is 145 litres and it is projected to reach 220 litres by 2030 (KDB, 2015; KNDMP, 2010). There is a shift in the dairy sector towards commercialization which is driven by quality. However, high incidences of mastitis and low milk protein content are constraints to quality milk production in Kenya. Inclusion of milk quality traits in the dairy cattle breeding goal is a cheaper and sustainable strategy to improve milk quality. Evaluation of alternative cattle breeding program is important to inform the choices for sustainable investment (Rewe *et al.*, 2011). In Kenya, the current breeding goal is defined based on payment of milk based on volume (Kahi *et al.*, 2004). However, there is a shift towards quality. This necessitates the redefining of the breeding goal objectives to be in tandem with market requirements. A breeding objective should be defined for genetic improvement of a cow population such that the future progeny will produce the desired product more efficiently under expected future production environment (Kariuki *et al*., 2017).

Breeding of dairy cattle genotypes that are resistant to mastitis and also produce milk with high fat and protein is desirable. Selective breeding to take advantage of within breed variation in disease resistance is an important strategy in the control of a number of diseases (McManus *et al.*, 2014). Previous studies have also evaluated breeding programs that implement reproductive technologies in comparison to traditional programs (Pryce *et al.*, 2010). However, Information on the genetic and economic gains realized when reproductive technologies are used either singly or in combination using the alternative breeding goal is lacking in Kenya. We hypothesized that expansion of the current dairy cattle breeding goal to include mastitis resistance and high protein yield could increase genetic and economic response to selection by up to 45% compared to selection for high milk yield alone. The objective of this study was therefore to evaluate the genetic and economic efficiency of the alternative two tier nucleus breeding system that incorporate protein yield and mastitis resistance in the current dairy cattle breeding goal in the light of reproductive technologies.

## Materials and method

### Procedure

We used deterministic simulation to predict response to selection realized by the alternative dairy cattle breeding goal in Kenya when PY and mastitis resistance are incorporated in the current breeding goal in breeding schemes utilizing AI and MOET with XS.

### Breeding Schemes

Two breeding schemes based on the reproductive technology adopted were considered. First scheme was an AI-CS scheme focusing on increasing the reproductive rate of males in the population. The second, was MOET-XS based scheme focusing on production of more than one calf per cow per year. This scheme was combined with AI and therefore targeted increasing the reproductive rates of both sexes.

**Table 1**: Heritability (along the diagonal), genetic (above diagonal) and phenotypic correlations (below diagonal) for traits in the breeding objective

| Traits[a] | MY | FY | PY | SCC | AFC | CI | DG | PDG | LW | PSR | PWR | PLT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\sigma_p$ | 1208.46 | 41.30 | 39.5 | 1.85 | 448.76 | 75.34 | 19.00 | 743.00 | 54.14 | 30.00 | 30.00 | 864.90 |
| EVs | **16.05** | 79.44 | 778.9 | -2363.9 | -2.72 | 2.65 | 1.04 | 3.4 | 7.95 | 9.96 | 45.15 | 0.07 |
| MY | **0.30** | 0.75 | 0.70 | -0.03 | 0.20 | 0.17 | 0.10 | 0.11 | 0.23 | 0.00 | 0.00 | 0.00 |
| FY | 0.75 | **0.10** | 0.61 | -0.19 | -0.10 | 0.08 | 0.10 | 0.11 | 0.12 | 0.00 | 0.00 | 0.00 |
| PY | 0.95 | 0.78 | **0.34** | -0.02 | -0.14 | 0.10 | 0.00 | 0.00 | 0.13 | 0.20 | -0.20 | 0.16 |
| SCC | -0.20 | 0.02 | -0.13 | **0.09** | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | -0.13 | 0.06 |
| AFC | -0.21 | 0.05 | 0.22 | 0.00 | **0.38** | -0.21 | -0.25 | -0.25 | 0.15 | 0.00 | 0.00 | 0.00 |
| CI | 0.17 | 0.08 | 0.00 | 0.00 | -0.21 | **0.06** | 0.00 | 0.00 | -0.53 | 0.00 | 0.00 | 0.10 |
| DG | 0.10 | 0.10 | 0.00 | 0.00 | -0.25 | 0.10 | **0.29** | -0.25 | 0.40 | 0.06 | 0.03 | 0.10 |
| PDG | 0.11 | 0.11 | 0.00 | 0.00 | -0.25 | 0.10 | 0.49 | **0.32** | 0.47 | 0.03 | 0.06 | 0.10 |
| LW | 0.23 | 0.12 | 0.06 | 0.00 | 0.15 | -0.53 | 0.40 | 0.47 | **0.30** | 0.01 | 0.00 | 0.27 |
| PSR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.03 | 0.00 | **0.09** | 0.00 | 0.00 |
| PWR | 0.00 | 0.00 | 0.11 | -0.14 | 0.00 | 0.00 | 0.03 | 0.06 | 0.00 | 0.01 | **0.09** | 0.00 |
| PLT | 0.00 | 0.00 | 0.00 | 0.00 | -0.13 | 0.10 | 0.10 | 0.10 | 0.27 | 0.00 | 0.00 | **0.11** |

See text for definition of terms

**Population structure, breeding goal and economic values**

In this study, an alternative breeding objective that incorporated protein yield (PY) and mastitis resistance (MR) in the current dairy cattle breeding goal in Kenya was adopted. The traits in the breeding goal and their respective economic values are presented in (Table 1). A simulated population of 50,000 cows distributed in two tiers was considered. The top tier (nucleus) consisted of 5% of the highest ranking cows in the population while the remaining 95% constituted the lower tier (commercial population). Truncation selection based on estimated breeding values was used to select top ranking males and females for breeding in the nucleus. The second top ranking males and females were used for breeding in the lower tier. Candidates not selected for breeding were culled. In all the schemes the young bull system was adopted to disseminate genetic materials in the population. The breeding goal for dairy cattle as described by Kahi *et al*. (2004) was adopted in the current investigation. The genetic and economic parameters used were obtained from studies carried out in Kenya (Kahi *et al.*, 2004; Kahi & Nitter, 2004: Okeno *et al.*, 2010).

**Prediction of response to selection**

All the breeding values were predicted using best linear unbiased prediction (BLUP) by fitting a multivariate animal model to the phenotypes. The model was computed as:

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Za} + \mathbf{e} \tag{1}$$

where **Y** is the vector of phenotypes, a vector of fixed effects, **a is** a vector of random animal effects, **e**, a vector of residual errors, and **X** and **Z** the incidence matrices. The breeding values were computed using (co)variance matrix presented below:

$$\begin{pmatrix} \mathbf{a} \\ \mathbf{e} \end{pmatrix} \sim \mathrm{N}\left(0; \begin{bmatrix} \mathrm{G} \otimes \mathrm{A} & 0 \\ 0 & \mathrm{R} \otimes \mathrm{I} \end{bmatrix}\right) \tag{2}$$

where the matrix **A** is the numerator relationship matrix among all animals, and the matrix **G** is the additive genetic (co)variance matrix of traits in the breeding goal. The matrix **R** is the (co)variance matrix for residual effects.

The of rate of genetic gain for each cow was predicted as linear regression of true breeding values for each trait in the breeding goal weighted by its corresponding economic values and expressed per year.

The economic returns were determined based on profitably per cow in each breeding scheme. The profitability per cow was estimated as:

$$\pi = \sum_{t=0}^{T} \left( \frac{R_t - c_t}{(1+r)^t} \right) \tag{3}$$

where $T$ is the evaluation period (25 years), $R_t$ the annual benefits of genetic improvement calculated as realized genetic gain per cow per year, $c_t$ the costs of genetic improvement which includes fixed and variable costs and $r$ the discounting rate. The discounting rate of 5% has been recommended when evaluating animal breeding programs (Bird & Mitchel, 1980).

## Data analysis

The deterministic simulation program ZPLAN (William *et al.,* 2008) was used to model and evaluate the breeding schemes. The findings were expressed as economic responses per cow per year.

## Results and Discussion

### Annual response to selection

The annual genetic gain, returns, costs and profit per cow of the evaluated schemes are presented in Table 2.

**Table 2.** Returns to selection per cow per year (KES) for the current and alternative dairy cattle breeding goals in breeding schemes using artificial insemination with conventional semen (AI-CS) and Multiple Ovulation and Embryo Transfer with X-sorted semen (MOET-XS) with sexed semen

| Parameter | Current breeding goal | | Alternative breeding goal | |
|---|---|---|---|---|
| | [a]AI-CS | MOET-XS | AI-CS | MOET-XS |
| Annual genetic gain | 203.75 | 345.37 | 299.97 | 510.88 |
| Returns per cow | 1265.01 | 1398.92 | 1904.57 | 2104.94 |
| Cost per cow | 53.67 | 212.71 | 53.67 | 212.71 |
| Profit per cow | 1211.34 | 1186.21 | 1850.90 | 1892.21 |

[a]See text for definition of terms

The findings of this study indicate that the alternative dairy cattle goal in Kenya yields the highest response to selection in comparison to the current breeding goal. This was evident by the marked increase in response for all parameters investigated. For instance the overall genetic gain in the AI-CS scenario shot up from 203.75 to 299.97 representing a 47.22% increase. In strategies that used MOET-XS, the genetic gain rose from 345.37 to 510.88 equivalent to 47.9%. The results for annual monetary returns per cow per year followed the same trend and were 50.6% more for AI-CS in the alternative breeding goal. There was no change in costs for the various breeding strategies among the two breeding objectives. Profitability was higher in the alternative breeding goal in comparison to the current breeding goal in all the breeding strategies under examination. Profitability was 52.9% and 59.5% more in the alternative breeding goal for AI-CS and MOET-XS respectively. The high returns to selection in MOET scheme could be explained by the fact that, MOET scheme not only increased the reproductive rates of females but also males.

## Conclusion

This study demonstrates that expanding the current breeding goal to include protein yield and mastitis resistance results to over 45% increase in genetic and economic returns. Secondly response to selection is optimized when X- sorted semen and MOET are used in the alternative breeding goal. Finally, Inclusion of milk quality traits in the dairy cattle breeding goal is a cheaper and sustainable strategy to improve milk quality.

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# Genetic parameters for measures of longevity in Kenyan Sahiwal cattle

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## Abstract

Performance data of Sahiwal cows born between 1972 and 2004, and with milk production records between 1976 and 2008 from the National Sahiwal Stud, Kenya, were analyzed to estimate genetic parameters for longevity. Longevity was defined alternatively as related to productive life or survival. Measures of longevity related to productive life were: time between birth and last milking record in months (Long_1), time between first calving and last milking record in months (Long_2), number of lactations initiated (Long_3), total number of days in lactation over all lactations (Long_4) and total milk yield over all lactations (kg) (Long_5). Heritability estimates for measures of longevity related to productive life ranged from 0.038±0.032 for Long_3 to 0.097± 0.04 for Long_5. Estimates of heritability for longevity measures estimated using linear models were low. However, among these measures Long_5 i.e. lifetime milk production had the highest additive genetic variance and heritability estimate and should therefore be used for genetic evaluation of longevity in Sahiwal cattle in Kenya.

**Keywords:** Linear models, Kenya, Productive life, Sahiwal

## Introduction

Milk production has been considered as the single most important trait in dairy farming. However, dairy cattle breeding programmes are changing their breeding objectives to include longevity and other traits (type and functional) (Banga et al 2013; 2014), with a view to enabling cows to meet the challenges of high milk production. Longevity or the age at which a cow leaves the breeding herd is a trait of great economic importance in dairy cattle breeding programmes (Banga et al 2013). Productive longevity can also be described as the number of calvings per female (Varona et al 2012).

Direct selection for longevity results in improved health and fitness (Garcia et al 2015) and increased milk production of cows (Kern et al 2014). Therefore, breeding for longevity is considered to have ethical and economic benefits since it results in favorable response in profitability of beef and dairy cattle enterprises (Garciaet al 2015). In beef and dairy cattle, longevity plays a considerable role in the farm economy by increasing the profit realised per cow and enables greater response to selection because fewer animals exit the herd due to involuntary culling (Logrotta et al 2010; Garcia et al 2015). This situation provides greater selection intensity among females, and surplus heifers for sale (Banga et al 2013), contributing to the profitability is dairy and beef enterprises.

The inclusion of longevity in the breeding objective is hampered by lack of information on genetic parameters partly because of inadequate phenotypic information (Lagrota et al 2010), which may lead to increase in generation interval (de Mello et al 2014). The Sahiwal cattle have been in Kenya for over 50 years (Meyn and Wilkins, 1974) and, performance and disposal data is available at the National Sahiwal Stud, Naivasha. Genetic parameters for milk yield, fertility and growth traits have been estimated (Iltasia et al., 2007a,b; Ilatsia et al., 2011). However, parameters for longevity related traits are lacking and this hinders the inclusion of longevity in the breeding objective for the breed. The objective of this study was to estimate

variance components, genetic and phenotypic parameters for longevity for the Sahiwal cattle breed in Kenya using linear models.

## Materials and Methods

### Description of the study sites and data collection

Performance data was obtained from Sahiwal cows born between 1972 and 2004 at the National Sahiwal Stud at Kenya Agricultural and Livestock Research organization (KALRO), Naivasha, and the cows had production records 1976 to 2008. Production and reproduction data i.e. date of birth, date of first calving, date of last milking, milk yield by parity for each cow were collected. Longevity was defined as related to productive life. Measures of longevity were: time between birth and last milking record in months (Long1), time between first calving and last milking record in months (Long2), number of lactations initiated (Long3), and total number of days in lactation over all lactations (Long4), total milk yield over all lactations (kg) (Long5).

**Table 1:** Data structure used for analysis of measures of longevity for Sahiwal cattle in Kenya

| Measure of longevity | No. of animals with records | Number of sires |
|---|---|---|
| Long1 | 2524 | 303 |
| Long2 | 1991 | 302 |
| Long3 | 2707 | 317 |
| Long4 | 2707 | 317 |
| Long5 | 1990 | 303 |

Longevity was defined as (Long1), time between first calving and last milking record in months (Long2), number of lactations initiated (Long3), and total number of days in lactation over all lactations (Long4), total milk yield over all lactations (kg) (Long5)

### Data analysis

### Estimation of variance components, genetic and phenotypic parameters for longevity

Variance components, genetic and phenotypic parameters for longevity were estimated using a linear model using the expectation maximization method in WOMBAT (Meyer 2007) using a convergence criterion of $10^{-9}$. The analysis was restarted at each convergence and the values obtained in the previous convergence used as initial values for the new analysis until there occurred no change at the $4^{th}$ decimal value of -2log likelihood in successive runs. The statistical model was:

$$\boldsymbol{y} = \boldsymbol{X\beta} + \boldsymbol{Za} + \boldsymbol{e}$$

where $\boldsymbol{y}, \boldsymbol{\beta}, \boldsymbol{a}$ and $\boldsymbol{e}$ are vectors of observation for longevity measures, fixed effects (contemporary group, first lactation milky yield class and age class at first calving), random additive genetic effects and random residual effects, respectively. $\boldsymbol{X}$ and $\boldsymbol{Z}$ are incidence matrices linking fixed and random additive genetic effects to observations.

## Results

Sahiwal cows produced 3425.5 ±3534.2 kg of milk throughout a productive life of 2.73 ± 1.44 lactations. The number of lactations initiated ranged from 1 to 11 with an average of 2.73 ± 1.44 per cow (Long3). The average days in milk during productive life were 1172.7±703.7 days and ranged from 960 to 6246 days. The period of time that cows remained in the herd from birth (Long1) or from first calving (Long2) to last day in milk was 2231.1±887.8 days and 1172.7±703.7 days, respectively.

**Table 2:** Means, standard deviations, minimum and maximum for longevity measures related to productive life for Sahiwal cattle in Kenya

| Measure | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|
| Long1 | 2231.1 | 887.8 | 960.0 | 6246.0 |
| Long2 | 1172.7 | 703.7 | 226.0 | 4720.0 |
| Long3 | 2.7 | 1.44 | 1.0 | 11.0 |
| Long4 | 738.0 | 428.4 | 10.0 | 3147.0 |
| Long5 | 3425.5 | 3534.2 | 10.0 | 11616.0 |

Longevity was defined as (Long1), time between first calving and last milking record in months (Long2), number of lactations initiated (Long3), and total number of days in lactation over all lactations (Long4), total milk yield over all lactations (kg) (Long5)

Estimates of components of additive genetic and residual variances are shown in Table 3. Additive genetic variances were lower than residual variances for all measures of longevity related to productive life (Table 3). The values of additive genetic variance ranged from 0.058 (Long3) to 366033 (Long5). Heritability estimates for measures of longevity related to productive life were low, with the highest being 0.097± 0.04 (Long5).

**Table 3:** Estimates of additive genetic variance ($\sigma_a^2$), residual ($\sigma_e^2$) and heritability estimates ($h^2$) for measures of productive life for the Sahiwal cattle in Kenya

| Parameter | Long1 | Long2 | Long3 | Long4 | Long5 |
|---|---|---|---|---|---|
| $\sigma_a^2$ | 25208.9 | 24740.5 | 0.0589 | 8820.0 | 366033 |
| $\sigma_e^2$ | 296090 | 318344 | 1.505 | 118783 | 3397910 |
| $h^2$ | 0.078 ±0.038 | 0.072±0.027 | 0.038±0.032 | 0.069±0.034 | 0.097±0.037 |

Longevity was defined as (Long1), time between first calving and last milking record in months (Long2), number of lactations initiated (Long3), and total number of days in lactation over all lactations (Long4), total milk yield over all lactations (kg) (Long5)

## Discussion

The average observed for age from birth to last day in milk (74.4 months), age from first calving to last milking day (39.1 months) and number of lactations initiated (2.7) were different from those reported for other cattle populations. Kern et al (2014) and Tsurata et al (2005) reported an average of 2.7 and 2.8 for Brazilian and United States Holsteins, respectively. A higher estimate of 3.4 was reported for Simmental

dairy cows (Strapak et al 2011). The average observed age from birth and calving to last day in milk of 74.4 months and 39.1 months, respectively. Kern et al. (2014) reported estimated age from birth and calving to last day in milk as 60.1 and 33.5 months, respectively, for Brazilian Holsteins. However, the estimates reported in the current study were similar to those reported for Simmental dairy cows of 72 and 47.5 months in Croatia (Javanovac and Raguz 2011). The diversity of measures of productive life could be attributed to genetic and environmental differences between the populations.

Longevity measures related to productive life had low estimates of heritability. This could be partly attributed to exclusion of censored records (Forabosco et al 2006). However, the inclusion of longevity in the breeding objective can lead to higher rates of genetic gains for the trait in selection programmes. The benefits arising from direct selection for longevity include improved health and fitness (Garcia et al 2015) as well as milk production of cows (Kern et al 2014). Longevity is influenced by culling decisions, whether voluntary or involuntary. An increase in longevity of cows due to decreased involuntary culling contributes to reduced replacement costs and greater selection intensity for milk yield. This results in greater genetic gains due to increased chances of voluntary culling (Logrotta et al 2010; Garcia et al2015). Lower replacement rates also lead to surplus heifers for sale (Banga et al 2013), contributing to profitability of cattle enterprises. Breeding for longevity is therefore considered to have ethical and economic benefits since it results in favorable response in profitability of beef and dairy cattle enterprises (Garciaet al2015). However, direct selection for longevity should nevertheless be compared with indirect selection on correlated traits expressed early in a cow's life because such traits have higher heritability.

## Conclusion

Among the measures of longevity studied, lifetime milk production has the highest heritability. However, all other measures of longevity had low heritability estimates. The study has provided genetic and phenotypic parameters that could be used in determining the benefits that arise from including longevity in breeding objectives.

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# Evaluation of Body Weight Traits in Indigenous Chicken Hybrids in Kenya

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## Abstract

The study aimed at evaluating body weight and growth traits in indigenous chicken hybrids (identified as KARI improved) and indigenous chicken (IC) under intensive management. The hybrids have been backcrossed resulting in two distinct lines, in terms of plumage colour, identified as KCA and KCB. Body weight was collected on 1184 experimental birds after every 4 weeks from hatch to week 20. A general linear model was fitted to determine the effect of breed/line on mean performance on body weight at hatch, week 4, 8, 12 and 20. These body weight traits were then subjected to the Gompertz-Laird function to estimate growth parameters in each breed. Breed significantly influenced ($p<0.05$) body weight traits across the ages considered with KCB line having the highest weights followed by KCA and IC having the least. In terms of growth parameters, KCB had the highest estimates for initial growth rate (L) and exponential decay rate (K) with its growth curve having an early plateau compared to KCA. This implies that KCB is likely to attain maturity at an early age with low body weight as indicated by its estimated asymptotic weight (1480g). The KCA line, on the other hand, will mature at a later age and attain a higher asymptotic weight (1775g). Predicted body weight traits for IC was in between those of KCA and KCB. Given these difference in growth parameters, KCA may be suitable to consider as a meat line while KCB as an egg line. However, there is need to further consider evaluating these lines for egg production traits to establish trait suitability of each line.

**Key words:** indigenous chicken hybrids, body weight traits, growth curves

## Introduction

Indigenous chicken (IC), *Gallus gallus*, is majorly kept for meat as over 80% of the eggs laid are used for hatching, purposely to maintain flock sizes (Pym *et al*., 2006). In addition, body weight and growth are ranked as the most preferred traits by actors along the value chain (Okeno *et al*., 2011). Consequently, breeding for improved IC has emphasized on these traits to increase output levels through various interventions (Khobondo *et al*., 2014). The poultry research unit at the Non-ruminants Research Institute (NRI)-Naivasha has been managing a breeding program for genetic improvement of IC for the last two decades. In the last seven years, introgression of imported blood lines has been undertaken to broaden the genetic base of the IC breeding population for enhanced selection to increase performance. The resultant progeny is commonly referred to as KARI improved chicken (KC).

The program at NRI-Naivasha, however, has not been sustainable due to the challenges associated with production systems and indiscriminate upgrading of IC using KC at farm level (Bett *et al*., 2012; Ilatsia *et al*., 2017). To control this situation, measures have been undertaken to ensure a systematic and organized selective breeding and crossbreeding programs for improved IC. These measures include line breeding programs to develop pure IC and KC meat and egg lines, while organized crossbreeding strategies between IC and KC to develop dual purpose breeds of optimal gene combinations to fit into the challenging scavenging production circumstances (Okeno *et al*., 2013; Ilatsia *et al*., 2017). Currently, the KC have been

subjected to backcrossing and this has resulted in two distinct lines, dominant black identified as KCA and dominant shavered identified as KCB. Prior to inclusion of these lines into the breeding program, there is need to characterize their body weight and growth traits to identify the line superior for these traits. Therefore, the aim of this study was to determine the level of body weight and growth performance of the two KC lines against indigenous chicken.

## Materials and Methods

### *Data source and chicken management*

The study was conducted at Non-ruminants Research Institute (NRI) of the Kenya Agricultural and Livestock Research Organization (KALRO), Naivasha-Kenya. The experimental flock comprised of the two KC lines (KCA and KCB) and IC reared intensively at the poultry unit. In this study, breed and line is used interchangeably to describe IC, KCA and KCB. The KC flock comprised of the normal feathered genotype while the IC flock consisted of the normal feathered, naked neck, frizzle feather, dwarf, crested head and feathered shank genotypes. To produce the flcok, eggs were collected daily, identified by their sire-family and stored at room temperature for at most 14 days before incubation. At hatch, each chick was wing tagged and allocated a number identifying it by breed, genotype and sire family. Brooding of chicks was done artificially in deep litter brooders for 8 weeks after which they were tranferred to deep litter rearing pens. Standard commercial feeds and clean water were supplied ad libitum at all ages and other standard management practises such as vaccinations and treatments applied procedurally.

### *Data collection*

Each egg was weighed before incubation. At hatch, each bird was weighed and thereafter every 4 weeks up to 20 weeks of age using a digital weighing scale calibrated to the nearest 1 gram. Due to missing records of upto 90% at week 16, this body weight trait was omitted from the analysis. Therefore, each bird from the three breeds (IC, KCA and KCB) had a total of 5 weight records starting from body weight at hatching (BW0) and ending with body weight at 20 weeks of age (BW20 ). A total of 1184 experimental birds produced from 8 hatchings and with 5 body weight records were available for analysis.

#### *Statistical analyses*

Analysis of variance for body weight traits at each age was carried out using the GLM procedure of SAS 9.1 (SAS, 2002). Taking into account the effect of sex, hatch and breed, model presented in Equation 1 was fitted to determine the effect of breed on live body weights. Due to variation in egg weight, between 32g to 79g, this trait was fitted as a linear covariate ($P<0.05$) in the analysis of hatch weight to correct for these differences. The fixed effect model fitted was:

$$Y_{ijklm} = \mu + S_i + H_j + B_k + e_{ijk} \quad (1)$$

where: $Y_{ijklm}$ is the performance trait of the $m^{th}$ bird; μ the overall mean; $S_i$ is the effect of $i^{th}$ sex (i = male, female); $H_j$ is the effect of $j^{th}$ hatch group (j = 1, 2,...8); $B_k$ is the effect of $k^{th}$ breed (k = IC, KCA, KCB); and $e_{ijklm}$ is the random error term.

Further, an analysis was done to determine the effect of genotype on body weight within the IC breed using Equation 1 but replacing the effect of breed with genotype ($G_k$ is the effect of $k^{th}$ genotype: $k$= normal feathered, naked neck, crested head, feathered shank, frizzle feathered, dwarf). Given that the KCA and KCB breeds were composed of only normal feathered genotype, they were ommited from this analysis.

The growth pattern of each breed was described using the Gompertz-Laird function as descibed by Aggrey (2002). Recorded body weights at hatch, week 4, 8, 12 and 20 were fitted into the function to estimate growth parameters for each bird using the NLIN procedure of SAS 9.1 (SAS 2002). These parameters included body weight at hatch ($BW_0$), initial specific growth rate (L) and exponential rate of decay of the initial specific growth rate (K). In addition, age at inflection ($T_i$), body weight at inflection ($BW_i$) and

asymptotic weight ($BW_A$) were estimated using models described by Aggrey (2002). Analysis of variance for the modelled body weight traits and growth parameters were performed according to Equation 1. The least squares means for each breed were then plotted against age to obtain growth curve patterns.

## Results and Discussion

The overall mean, mean square values and levels of significance of fixed effects included in the analysis of variance for the body weight traits are presented in Table 1. Sex, hatch group and breed significantly influenced ($P<0.05$) variation in the body weight traits. Least square means for the breed effect on body weight traits is presented in Table 2. At hatch, KCB had the highest weight and was statistically different from those of IC and KCA. Similar case was also observed at week 8. However, IC had the lowest body weight traits at week 4, 12 and 20 and was significantly different to those of KCA and KCB. Although not statistically different, KCB had higher body weight than KCA at week 4, 12 and 20. Within IC, the body weight traits recorded in this study were higher than those reported by Binda et al. (2012) and Ngeno et al. (2012). Considering the genotypes existing among IC, the factor had no significant effect ($P>0.05$) on any of the body weight traits (Table 3). This is contrary to previous studies on IC genotypes that reported significant influence of major genes on body weight traits from week 8 (Magothe *et al*., 2010).

**Table 1:** Overall mean (±SD), mean square values and level of significance of fixed factors that influence body weight traits in chicken

| **Traits[1] (g)** | **BW0** | **BW4** | **BW8** | **BW12** | **BW20** |
|---|---|---|---|---|---|
| Overall means | 34.06±2.42 (n = 1115) | 211.46±40.89 (n = 685) | 607.78±138.81 (n = 528) | 1002.28±201.94 (n = 630) | 1531.43±226.12 (n = 290) |
| Fixed effects | | | | | |
| Sex | 43.65** | 58708.66*** | 1497216.03*** | 8820849.80*** | 7137164.34*** |
| Hatch group | 46.74*** | 138480.07*** | 1453163.62*** | 971562.39*** | 1292481.74*** |
| Breed | 66.18*** | 7876.26** | 80690.04* | 924849.99*** | 1436545.46*** |
| Egg weight | [a]4952.29*** | | | | |

[1]BW0, BW4, BW8, BW12, BW20 = body weight at hatch, week 4, 8 12 and 20, respectively

±SD = standard deviation

The least square means of the Gompertz-Laird growth parameters are presented in Table 4 and the modelled growth curve in Figure 1. The estimated growth parameters significantly varied across the three breeds. Indigenous chicken had the highest estimated hatch weight while KCB had the least. However, in terms of initial growth (L) and decay (K) rates, KCB had the highest estimates while IC had the lowest. This implies that in spite of the high hatch weight, IC grow and mature at a slower rate compared to the KCA and KCB breeds. Similar observation on IC pattern has been reported however, the L and K estimates in this study are higher than those previously published (Magothe et al., 2010: Ngeno et al., 2012). Consequently, IC attained inflection weight (620g) at a later time compared to KCB that took the shortest time to attain its inflection weight. For the estimated $BW_0$, L, K and $T_i$, KCA had estimates that were in between those of IC and KCB, however, its weight at point of inflection (653g) and asymptote weight (1775g) were the highest across the breeds.

**Table 2:** Least square means[1] (±s.e.) of body weight traits across breeds

| **Traits[2] (g)** | **Breed[3]** | | |
|---|---|---|---|
| | IC | KCA | KCB |
| BW0 | 33.91±0.11[a] | 34.00±0.28[a] | 35.53±0.34[b] |
| BW4 | 208.26±1.92[a] | 220.96±4.90[b] | 223.38±6.06[b] |
| BW8 | 645.63±7.42[a] | 683.96±21.35[a] | 719.28±28.63[b] |
| BW12 | 983.84±12.14[a] | 1103.05±22.01[b] | 1134.22±30.44[b] |
| BW20 | 1513.21±20.07[a] | 1655.86±21.54[b] | 1695.95±20.45[b] |

[1]Least square means within a row with different superscript differ ($p<0.05$); ±s.e. = standard error
[2]BW0, BW4, BW8, BW12, BW20 = body weight at hatch, week 4, 8 12 and 20, respectively
[3]IC= indigenous chicken; KCA =KC breed A; KCB= KC breed B

**Table 3:** Overall mean(±SD), mean square values and level of significance of fixed factors that influence body weight traits in indigenous chicken

| **Traits[1] (g)** | **BW0** | **BW4** | **BW8** | **BW12** | **BW20** |
|---|---|---|---|---|---|
| Overall Means | 32. 64±1.13 (n = 888) | 212.73±39.13 (n = 549) | 593.05±124.22 (n = 456) | 956.46±220.78 (n = 462) | 1513.21±246.16 (n = 225) |
| Fixed effects | | | | | |
| Sex | 48.80** | 54972.22*** | 1109841.38*** | 5033743.98*** | 10153638.36*** |
| Hatch group | 37.74*** | 114639.00*** | 1016512.08*** | 555721.05*** | 2138848.69*** |
| Genotype | 9.08ns | 2096.12ns | 7073.34ns | 48718.98ns | 169169.23ns |
| Egg weight | [a]4034.99*** | | | | |

[1]BW0, BW4, BW8, BW12, BW20 = body weight at hatch, week 4, 8 12 and 20, respectively;±SD = standard deviation

**Table 4:** Least square means[1] (±s.e.) for growth parameters across breeds at different ages

| Parameters[2] | Breed[3] | | | |
|---|---|---|---|---|
| | IC | KCA | KCB | Overall means |
| $BW_0$ | 32.84±3.46[a] | 24.63±7.75[b] | 18.57±6.13[c] | 25.34±5.78 |
| L | 0.6272±0.0311[a] | 0.7741±0.0976[b] | 1.2068±0.2481[c] | 0.8693±0.1256 |
| K | 0.1555±0.0044[a] | 0.1789±0.0113[a] | 0.2377±0.0215[b] | 0.1933±0.0124 |
| $T_i$ | 26.04±0.14[a] | 24.50±0.01[a] | 20.44±0.44[b] | 23.66±0.20 |
| $BW_i$ | 619.65±10.07[a] | 653.11±19.24[a] | 544.74±20.17[b] | 605.83±16.49 |
| $BW_A$ | 1684.37±22.67[a] | 1775.33±34.21[b] | 1480.74±30.46[c] | 1646.82±29.11 |

[1]Least square means within a row with different superscript differ ($p<0.05$); ±s.e. = standard error
[2]$BW_0$=estimated hatch weight; L=initial specific growth rate (g/day);K=exponential rate of decay of the intial specific growth rate (g/day); $T_i$=age at infelction (days); $BW_i$=body weight at inflection (g); $BW_A$=asymptotic weight
[3]IC= indigenous chicken; KCA =KC breed A; KCB= KC breed B

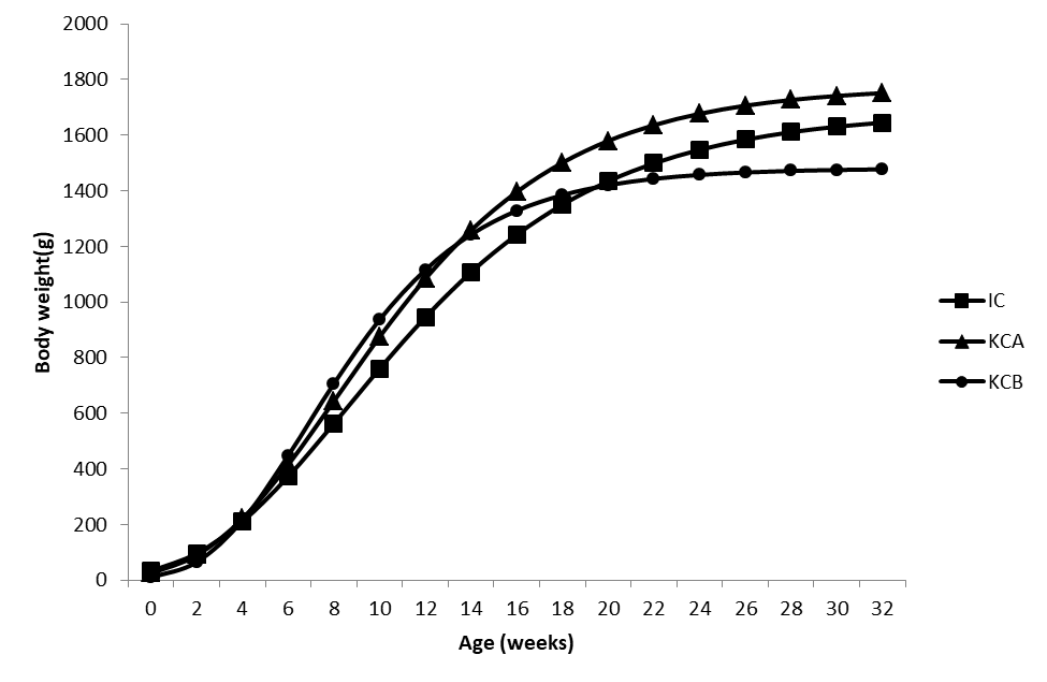


**Figure 1**: Growth curves from the Gompertz-Laird function among indigenous chicken (IC), KC breed A (KCA) and breed B (KCB)

On basis of the Pearson's correlation between growth parameters, hatch weight was negatively correlated to initial growth rate and exponential decay rate with estimates ranging between -0.89 and -0.98. These relationships imply that birds with high hatch weight tend to have a lower intial growth rate which decays at a slower rate. Reports from similar studies indicate that such birds attain larger mature weights compared to those that have higher K and L values given the negative correlations between growth rate and mature weight (Norris *et al*., 2007; Magothe *et al*., 2010). However, between K and L, the correlation was positive with estimates between 0.92 to 0.96. Contrary to the observed body weight traits presented in Table 2, growth patterns in Figure 1 showed that body weight among the three breeds were similar from hatch to week six, after which differences in growth was observed. The KCB breed had the highest growth between week 6 and 14 while IC had the lowest. Thereafter, growth in KCA breed peaked and maintained high growth rates compared to KCB whose growth rate started declining at week 18. Indigenous chicken on the other hand was in between KC and KCB during this period.

## Conclusion

Evaluation of body weight and growth parameters between the two KC lines show that KCB was a better performer than KCA based on measured body weights. However, using predicted weights, the growth curve for KCB attained an early plateau compared to KCA. Based on the growth parameters, KCA is likely to attan maturity at a later time with higher aysmptotic weight hence a suitable line for meat production while KCB with lower asymptotic weight and early maturity may be suitable for egg production. Therefore, there is need to further consider evaluating these KC lines for egg production traits to establish the suitability of each lines in terms of production.

## Acknowledgement

The authors acknowledge the Poultry breeding: towards registration of indigenous KALRO breed lines project for support. The project is funded by European Union through the Arid and Semi-Arid Lands Agricultural Productivity Research Programme (ASAL-APRP). The authors also acknowledge the Kenya Agricultural and Livestock Research Organization (KALRO – Naivasha) for provision of facilities.

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# Breeding program for genetic improvement and conservation of the Red Maasai sheep in Kenya – a synopsis

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## Abstract

The Red Maasai sheep in Kenya is threatened by indiscriminate crossbreeding with the Dorper. A simple and practical breeding program has been developed to improve productivity and conservation of the sheep. The main elements of the program include a description of the production environment, breeding objective and strategy, recording system, selection traits, mating and dissemination of genetic gain.

**Key words**: breeding program, conservation, red Maasai sheep, genetic improvement

## Introduction

The Red Maasai (RM) is an East African fat-tailed sheep kept mainly by Maasai pastoralists in Kenya and Tanzania. Until the mid-1970s, purebred RM sheep were abundant in most of the southern pastoral lands of Kenya. In the 1970s, a large population of Dorper sheep was imported for upgrading to increase weight and body size of the RM. This resulted in widespread indiscriminate crossbreeding between RM and Dorper (Zonabend, 2016). Today, the RM sheep is faced with a serious threat of extinction, more so because no long term improvement and conservation strategy is in place for the breed. A simple and well-designed breeding program would increase the genetic potential of the RM (Kosgey and Okeyo, 2007). Zonabend *et al.* (2017) recommended a combination of conventional and community based breeding program for improvement of the RM. This paper outlines a practical breeding program designed to improve productivity of RM sheep under low to medium input production systems while retaining their adaptive characteristics and diversity required for the unknown future.

## Methodology

In designing the breeding program, available literature on small ruminants and the RM sheep specific studies in Kenya and elsewhere were reviewed. In addition, processes involved in designing breeding programs were carefully considered (FAO, 2010). A draft breeding program was designed, presented and discussed with RM pastoralists keepers and stakeholders through a series of workshops. The inputs from the workshops were incooperated to produce the final version of the breeding program.

## The breeding program

### Red Maasai production systems

The RM sheep is mainly kept in marginal areas where production systems are categorized into grass based agro-pastoralism and pastoralism (FAO, 1991). These marginal areas are characterized by low rainfall patterns, high temperatures, poor quality forage and frequent droughts. The RM sheep is used for food (meat, fat and milk), income and cultural purposes.. Fat is particularly important not only as a source of food but also for cultural purposes such as circumcision and during sickness or injury, among others. Other uses of the sheep include payment of bride price, savings and insurance against emergencies (Liljestrand, 2012).

### Traits of importance

The most important traits are body size, growth, fat deposition, conformation, coat colour, mothering ability, fertility, meat yield, milk yield and survival rate. Others are disease and parasite resistance, drought and heat tolerance, and ability to walk long distances in search of pastures (Zonabend, 2016).

### Breeding objective

One of the main guiding principles of genetic improvement is the definition of breeding objectives (Kosgey and Okeyo, 2007). In community based programs, breeding objectives invariably include both tangible and intangible traits. Among the Maasai community, the main reasons for keeping the RM sheep are its resistance to diseases, worms and drought, production of large amounts of fat and ability to walk long distances. The breeding objective traits defined by the pastoralists were body size, fat deposition, milk yield, drought tolerance and disease resistance (Zonabend, 2016). In this program, the breeding objective is to improve body size, fat deposition and milk yield of the RM sheep in low to medium input production systems without losing their drought tolerance and disease resistance qualities.

### Breeding strategy

## Breeding method

The main genetic improvement methods include pure-breeding and cross-breeding. Although pure-breeding takes a longer time to achieve genetic progress, the gains are permanent and cumulative unlike in cross-breeding (FAO, 2010). Zonabend *et al.* (2017) showed that at least 15 years of continuous RM selection would lead to a substantial genetic gain in body size. In this program, pure breeding method will apply. The commercial flocks, however, may use Dorper sires to mate RM ewes to produce crosses for the market.

### Breeding structure

A nucleus breeding structure is a convenient start for many genetic improvement programs as trait measurements, selection and mating are accurately made and easily managed (Kosgey and Okeyo, 2007). Furthermore, it is not practical and cost effective to record all animals in a population as an active part of a breeding program. A nucleus may be open or closed and centralized or dispersed. Open nucleus schemes are technically attractive because they are potentially associated with higher selection intensity and flexibility in meeting breeding objectives (Kosgey and Okeyo, 2007). Zonabend *et al.* (2017) recommended a 3 tier structure comprising of the nucleus, sub-nucleus and commercial flocks. This program will adopt a three tier structure comprising of the open dispersed nucleus, sub-nucleus and commercial flocks (Figure 1). The nucleus will compose of institutional and government farms while progressive RM pastoralists will be recruited as sub-nucleus.

**Recording system**

Animal identification and the recording of animals' pedigree and performances are the driving forces in genetic improvement programs (FAO, 2015). Abundant and accurate measurements lead to efficient selection. The greatest benefits of on-farm pedigree and performance recording lie in the use of such records to estimate breeding values and inform the day-to-day farm management decision-making. In the program, all breeding rams and ewes at the nucleus and sub-nucleus will be tagged using numbered ear tags for identification. At weaning, all lambs will be ear tagged. A harmonised numbering system conforming to the International Committee for Animal Recording (ICAR) standards (ICAR, 2016) will be adopted. Pedigree and performance recording for all animals in the breeding program will be routinely done and the records electronically transmitted for genetic evaluation and custody.

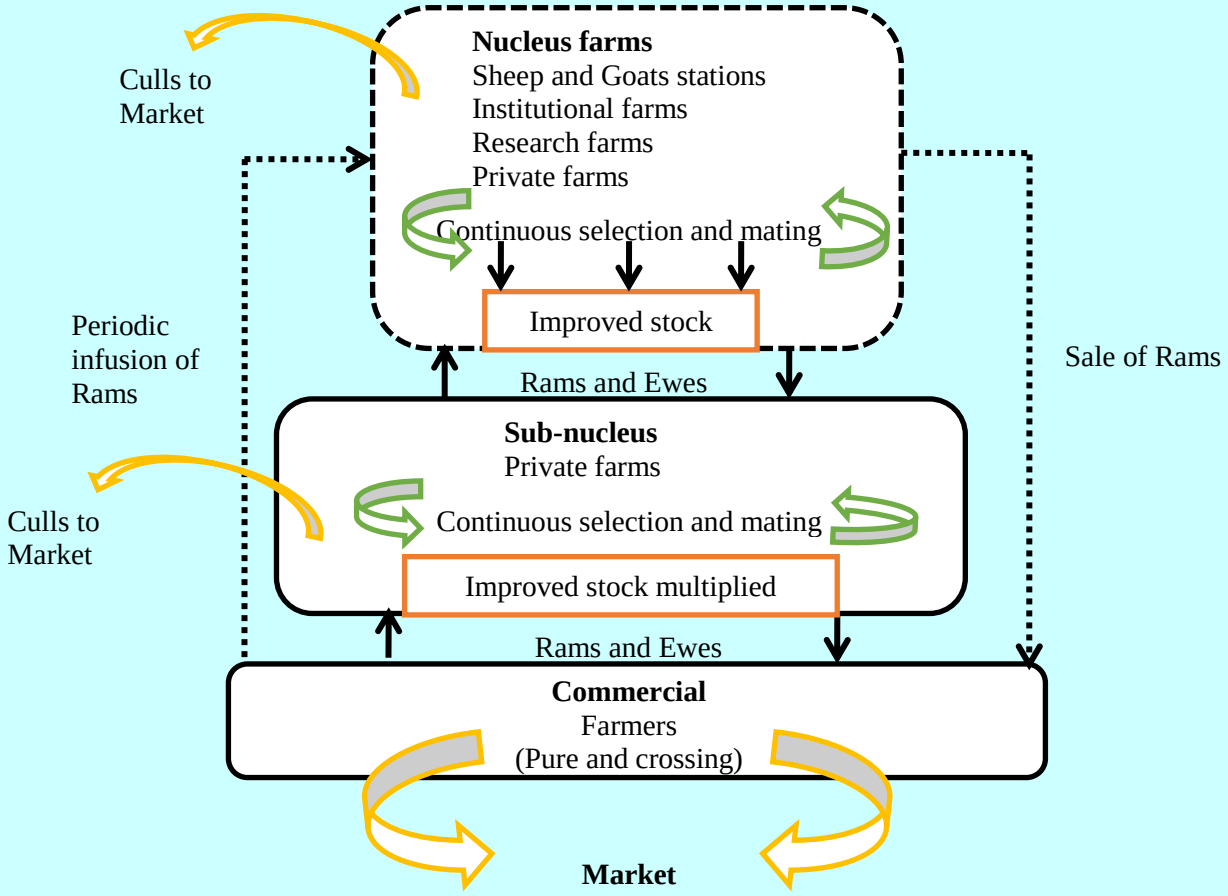


**Figure 1:** Red Maasai Sheep breeding Program Structure

**Selection traits**

Live body weight at 12 months is a good measure of body size, while body condition is a good measure of fat deposition in the RM sheep (Zonabend et al., 2017). Body weight and tail condition score at 12 months will be used to select males and body weight at 12 months and dam's lactation milk yield to select females. Since the sub-nucleus flocks will be in situ, drought tolerance and disease resistance will be selected indirectly.

**Mating**

Controlling inbreeding can be a major issue in breeding programs. Mate allocation should, therefore, aim at reducing the rate of inbreeding in a population. Strategies for minimizing inbreeding include rotation of males within the participating flocks, sire referencing schemes and allocation of few dams to a sire (FAO, 2015). Zonabend et al. (2017) recommended a male to female ratio of 1:15-20. In the program, a male to female ratio of 1:30 will be used. In both the nucleus and sub-nucleus, a breeding ram will only be kept for a maximum of 24 months (2 years) in one flock and then taken to the farthest unrelated flock participating in the breeding program.

**Dissemination of improvement**

Logistics of disseminating improved germplasm are always challenging under smallholder production systems (Kosgey and Okeyo, 2007). Zonabend (2016) suggested that the sub-nucleus should be the market for breeding animals from the nucleus while commercial farms should be the markets for breeding animals from the sub-nucleus. In the program, the best rams and ewes will be retained at the nucleus or sub-nucleus. The second best rams and ewes from the nucleus will be sold to the sub-nucleus flocks and the ones from sub-nucleus to the commercial flocks. The worst rams and ewes form both the nucleus and sub-nucleus will be sold for slaughter.

**Breeding programme evaluation**

After the design and implementation of a breeding program it is essential to evaluate the result.This involves regular analyses of the outcome of the programme (FAO, 2010). Such analyses should demonstrate the genetic improvements obtained in all important traits and the economic impacts at both farm and national levels. By regularly monitoring the breeding programme, corrective measures can be taken to improve it. A generation interval of 4.35 years has been reported for the RM sheep (Zonabend et al., 2017). This program will be evaluated initially after 15 year of operation and thereafter every 10 years.

**Implementation of the program**

Technical and infrastructural related issues have been identified as the greatest bottlenecks in the implementation of genetic improvement programs under smallholder farming systems (Kosgey and Okeyo, 2007). The breeding program was initiated in December 2017 and is at its early stages of implementation. Prior to its initiation, the Red Maasai Breeders Sheep Breeders Society of Kenya was formed, registered and launched. The Red Maasai sheep standards of excellence were prepared and adopted and breed inspectors trained. The base population of Red Maasai breeding stock were selected, tagged and mated to produce the first generation offspring. Other institutions involved in the implementation of the breeding program include the Kenya Livestock Breeders Association, the Kenya Agricultural and Livestock Research Organization and Livestock Recording Centre (Kosgey *et al.*, 2011).

## Conclusion

The breeding program is envisaged to achieve genetic improvement and sustain a large population of the RM sheep. With the scaled-up community based breeding programs integrated with optimal use of natural resources and better husbandry practices, pastoralists will access genetically improved RM sheep with high growth and reproductive performance. Besides being a source of quality young rams and ewes, the nucleus and sub-nucleus flocks will form strategic *in situ* conservation units for the RM sheep.

## Acknowledgement

The authors acknowledge the African Union Inter-African Bureau for Animal Resources, State Department for Livestock and Kenya Agricultural and Livestock Research Organization for the provision of resources and facilities.

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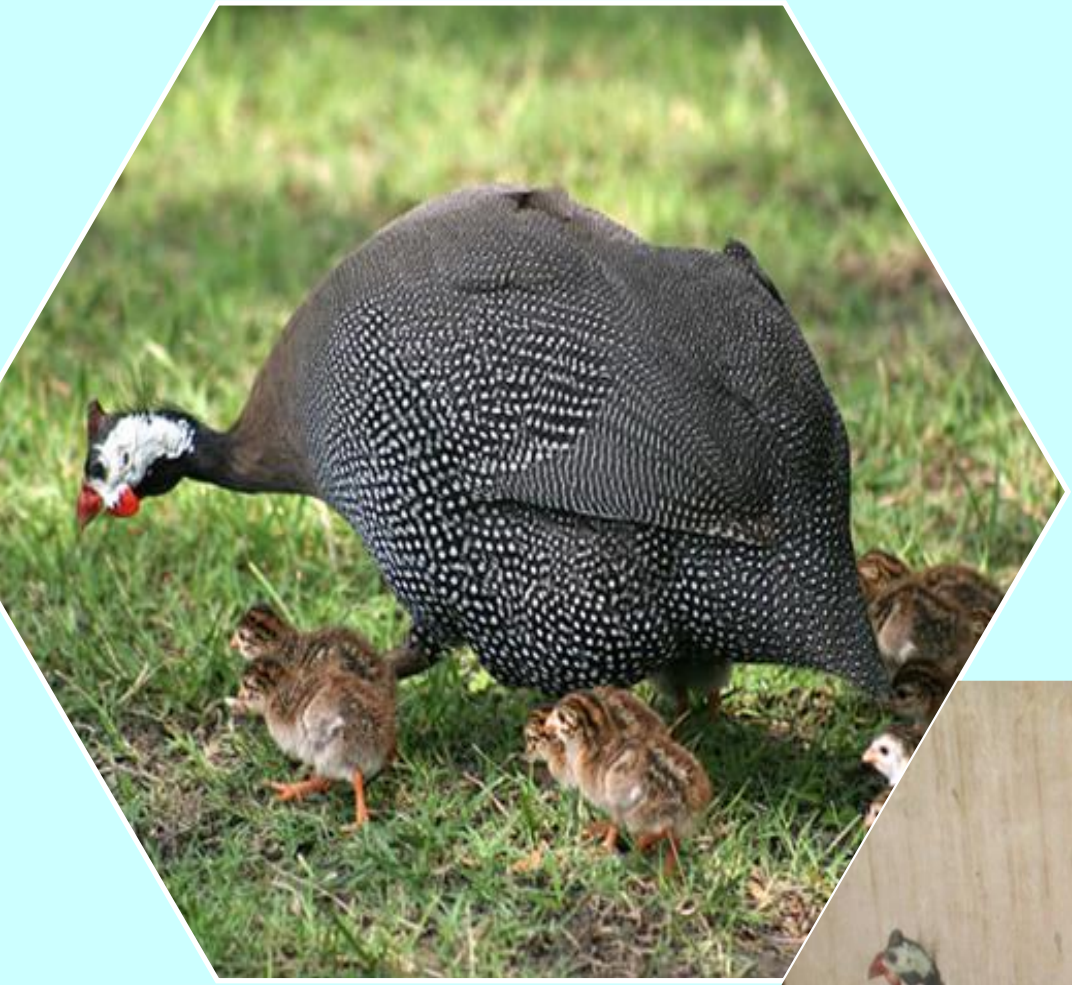
# SUSTAINABLE LIVESTOCK PRODUCTION SYSTEMS



# Fodder interventions to increase yield and improve quality

**Jos Creemers**

**The Kenya Market-led Dairy Programme (KMDP)**

The Kenya Market-led Dairy Programme (KMDP) is funded by the Embassy of the Kingdom of the Netherlands in Nairobi and is implemented by SNV Kenya. Amongst the many intervention areas under KMDP, Feed & Fodder is prominent.

Summarized is a brief of KMDP's approach and activities in Feed & Fodder:

- KMDP intervened in fodder production and fodder supply chains for smallholders, medium and large-scale farmers with the aim to increase on quality of farm fodder produced and assist on how to access to better forages supplied by commercial fodder producers.
- The feed and fodder program focuses on energy and/or protein rich fodder crops and the preservation of these crops through silage making. The aim is to reduce the cost of milk production with a well balanced diet for the dairy cow resulting in a better margin above feed cost for the dairy farmer.
- In those regions in Kenya where pasture grazing is practiced, improved pastures and better pasture management practices were introduced like rotational grazing, alternating grazing and mowing, fertilization of pasture grasses and cut and carry systems.
- KMDP strongly supports the concept of service providers or agricultural contractors assisting the farmer to produce and ensile quality forages. Examples of this are the semi-mechanized Service Providers Enterprises Network (SPEN) groups that prepare silages for smallholder farmers at a fee, and on the other end of the spectrum fully mechanized contracting companies with 1-2 row and even 6 row maize harvesters, loaders and tractors to harvest, chop and ensile maize, oats, sorghum and grass fast and with the right compaction.
- The concept of a "maize train" was developed for Medium Scale Farmers (MSF) and Large Scale Farmers (LSFs). This has the advantage that contractors can invest in modern machinery with the latest technology and a very high capacity (ha/hour). The use of kernel crushers, right chopping length, speed of working and level of compaction will result in being able to finalize and close the silage clamp or pit within 24 hours after the start (reduction of losses) giving a much better silage with a higher nutritive value and therefore a higher intake when the silage is fed to the dairy cows.
- In addition commercial fodder producers have been supported to grow better quality hay, cut the forages at the right stage or with the right cutting interval and use the best preservation technology available. The intervention focused on land preparation, seed selection, suitability of forages in relation to AEZ, planting, crop management un till to the moment of harvesting and storage.
- The concept of baled silages was introduced by KMDP in collaboration with a group of local and international investors. High quality maize silage is vacuum packaged in 350 kg bales. Other investors followed suit and the concept is now being upscaled by others to other sizes and crops
- The silage in the bunker (clamp, silo) has to ferment for a minimum period of 6-8 weeks. Experience in the field showed that the dimensions of the silage bunker(s) is in most cases a challenge for the farmer particularly during feedout when the required feeding speed is not achieved resulting in big nutritional losses or in some cases silage that is completely rotten. SNV-KMDP supported commercial entrepreneurs with investments in mechanized baled silage systems that are suitably sized (50 kg – 375 kg), well compacted, sealed and wrapped for SHF, MSF and LSF.

- Currently SNV and CIAT have combined forces to develop various demonstration plots in the areas where SNV-KMDP has been active, Meru, Central Kenya and North Rift. The different Brachiaria varieties (Mulato II, Cayman, Cobra and Basilisk) suitable for cut and carry and grazing systems are demonstrated next to the leguminous crops like Vetch and green leaf Desmodium.
- The next step after the SNV-KMDP interventions in the fodder production and fodder supply chain is to improve the diet/ratio formulation on farm for the different animal categories on the dairy farm and provide them with a well-balanced diet focusing on energy and protein. SNV-KMDP in collaboration with PUM, ProDairy and Perfometer is piloting the Rumen8 ration formulation Software in Kenya. The software has seen a few changes to accommodate the Kenyan production levels and a Kenyanized feed Library with over 225 feeds and forages is available. The program is now being tested on 20 farms spread over Kenya

**Policy recommendations by SNV KMDP:**

1. Increased supply of fodder with focus on quality is essential to meet the nutrient requirements of modern exotic breeds (pure and cross). Matching the genetic potential with feed management requires differentiation within the national forage strategy between intensive and extensive livestock production systems.
2. This will address both economic and environmental sustainability of the industry.
3. Professional, efficient fodder production embraces chain management and GAP in all steps of the process from seed-to-feed. This translates in very significant increases in productivity per acre per cow, reduced cost price of feeds and raw milk, and reduced carbon footprint per litre of milk produced. This will result in more profitable dairy farms for SHs, MSFs and LSFs alike and it will reduce seasonality of milk supply and price volatility in the market.
4. Focus needs to be on applied research and improvement of practical knowledge and skills to produce and preserve quality fodder crops.
5. Fodder crop production and preservation needs further mechanisation to assure scale, speed, proper timing, compaction and shelf-life for enhanced quality, nutritive value and reduction of losses.
6. Government and donors should create an enabling environment for international fodder seed companies and for private investors in agricultural contracting and large scale mechanized commercial fodder production (CFP).
7. Focus on CFP business models that add value to the dairy sector and not only assures high return on investment for the CFP (i.e. current hay market).
8. Better use can be made of available information on agro-ecological zones, climate, weather data in relation to suitable fodder crops and timing of crop production related activities during the growing season and harvest.
9. Addressing these issues will bring innovations; create business opportunities, employment, income, enhanced profitability of the dairy value chain (DVC), increased affordability of milk (products) to consumers, and a more climate smart sector.

# Impact of tsetse and trypanosomiasis control on poverty: A case of Pate Island of Lamu County, Kenya.

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## Abstract

The Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC), the Government of Kenya and the farming communities in Pate Island in the Northern coast of Kenya have been participating in the control of tsetse flies and the disease that it spreads in livestock. The impact of the interventions in the island had however not been quantified. An understanding of the benefits of tsetse and trypanosomiasis control would encourage government, development partners and communities to allocate resources for the control of the flies and the disease that they spread. It was therefore necessary to carry out this study. The objective of the study was to estimate the impact of tsetse and trypanosomiasis control on poverty in Pate Island of Lamu County, Kenya. The study applied proportional random sampling method to draw a sample of 254 farm households from Pate Island where interventions were carried out and 282 farm households from Amu and Hindi divisions of the county where the PATTEC initiative had not been implemented. Using structured questionnaires administered through household interviews, the study collected socio-economic data including household characteristics, livestock (cattle, sheep, goats, donkeys and poultry) production, ownership of durable assets and living conditions in the household. Principal Components Analysis (PCA) was used to construct the household wealth index as an outcome to measure the well-being of project households versus non-project households in Lamu County, Kenya. The results indicated that the proportion of households categorized as very wealthy was higher in the project areas than in non-project areas implying a rise in Wealth Index among Pate Island households. The mean wealth index for project households was 0.698793 (Std. Err. = 0.0476051) compared to -0.745156 (Std. Err. = 0.0772896) for the non-project households. This finding suggests that the household incomes increased and were conserved over time in durable assets such as livestock, bicycles, boats or cars, land, mobile phones, radio sets, television sets, motorcycles and in improved living conditions. The findings can be used for resource mobilization among governments and development partners to enable implementation a similar project in other areas affected by tsetse flies to alleviate poverty among beneficiary communities.

**Key words**: Impact, Tsetse, Trypanosomiasis, Poverty

## Introduction

Tsetse flies (*Glossina spp*) transmit a fatal zoonotic disease called trypanosomiasis. The disease is known as sleeping sickness in humans and *nagana* in livestock. Tsetse flies infest 37 sub-Saharan African countries covering approximately 9 million km$^2$ and threaten about 60 million people and 48 million cattle (WHO, 2001). It is one of the greatest constraints to agricultural development in the sub-humid and humid zones of Africa. Sleeping sickness was under control in Africa during the 1960s and 1970s. However, the last two decades have seen the disease spread to epidemic proportions due to the breakdown of control programmes causing a public health crisis in many affected areas (Smith *et al.,* 1998). If the goal of poverty reduction and food security is to be achieved, this major constraint to rural development needs to be removed.

To address the problem, African Heads of State and Government collectively launched the Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) project in 2000 with a view of guiding the process of eradicating tsetse flies and trypanosomiasis (T&T). As part of this initiative, the African Union

PATTEC (AU-PATTEC), the African Development Bank (AfDB) and the governments of affected countries prepared a proposal for a Pan-African programme, the Eradication of Tsetse and Trypanosomiasis in Sub-Saharan Africa (ETTSSA), as well a proposal for the first phase of the eradication campaign (AfDB, 2004). Six countries participated in the Phase I Project, three countries in West Africa (Burkina Faso, Mali and Ghana) and three others in East Africa (Ethiopia, Kenya and Uganda).

In Kenya, the area infested by tsetse is estimated to be 138,000 square kilometers covering 38 out of 47 counties (KENTTEC, 2011). The disease impoverishes livestock farmers and threatens food security and livelihoods. The risk of human sleeping sickness outbreak is high in the Lakes Victoria and Bogoria basins and the Mara Serengeti tsetse belt all with a total human population of about 11 million people at risk of infection (KENTTEC, 2011; KNBS, 2010). The first phase of PATTEC-Kenya project was implemented from 2005 to 2011 covering a total area of 24,000 square kilometres in three tsetse belts namely Lake Victoria basin, Lake Bogoria and Meru/Mwea. The control of tsetse and trypanosomiasis in Pate Island served as a pilot project in the Coastal tsetse belt in an area of approximately 62 square kilometres with control starting in 2010. The direct achievements of tsetse and trypanosomiasis eradication interventions under the PATTEC-Kenya programme include reduction of tsetse fly populations and reduced disease prevalence in cattle and in humans (KENTTEC, 2009; 2011; 2012; 2013; 2014; AfDB, 2011). The impact of these changes on income and wellbeing of households had not been quantified. It was therefore important to understand the impact of the project on poverty for governments to roll out tsetse and trypanosomiasis eradication campaign to other tsetse infested areas which had not been covered by such a programme. This study therefore seeks to estimate the wealth index of the project and non-project households in Lamu County

## Research methodology

### The Study area

Pate Island is located in the Indian Ocean along the Northern Coast of Kenya in Lamu County lying between latitude 1°40, 20° 30 S and longitude 40° 15 and 40° 35 East (GoK, 2013). The Pate Island is the largest Island in the Lamu Archipelago, which lies between the towns of Lamu and Kiunga, close to the border of Kenya and Somalia. There are two administrative divisions in the Island namely Faza and Kizingitini (GoK, 2013).

The Island has a total area of 92.9 square kilometers of which the agricultural farm land area is about 60 square kilometres. The Island had a livestock population of about 8,150 heads of cattle, 6,250 goats and 3,200 donkeys. The Lamu East sub-county of Lamu County where the study area is situated enjoys two rainy seasons and temperatures ranging between $23^0$ and $32^0$ C throughout the year. The long rainy season comes in April and May and ends by June while the shorter rainy season from November and December. The main economic activities in the island include agriculture, livestock keeping and marine activities with the residents being predominantly Muslim.

The study site was selected because of being an isolated area which served as a control for the interaction between the project area and the adjacent areas where there were no project inputs. The flow of resources between the project area and non-project areas was naturally restricted reducing the confounding effects. For example, if livestock from non-project households had access to the project area grazing lands where insecticide treated targets were deployed and livestock had been sprayed with insecticides, the benefits would spill over to the non-project households which is the control group. Figure 1 gives a picture of the study area.

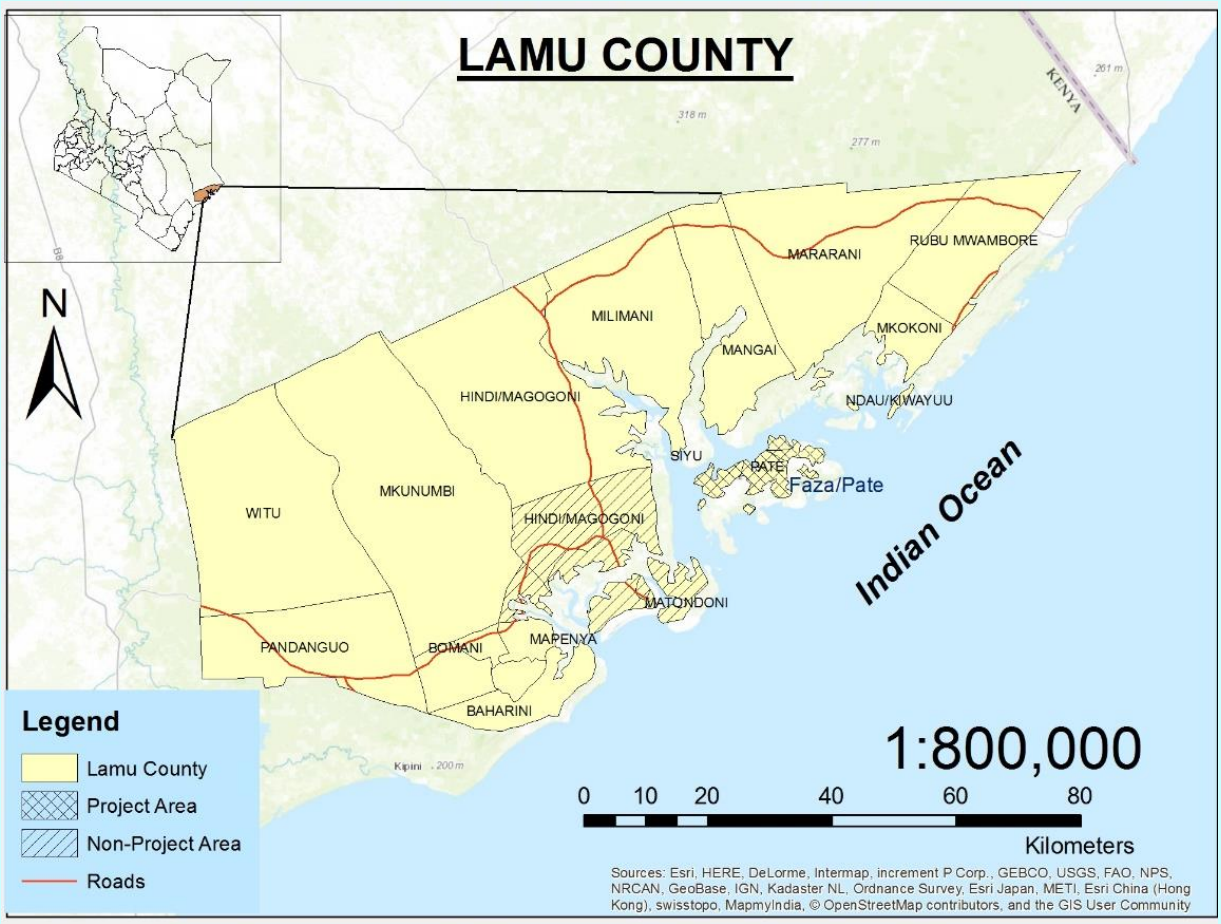


**Figure 1**: A Map showing the study areas of Pate Island, Amu Island and Hindi division of Lamu County, Kenya

**Source**: Author

## Sampling

### Sample size determination

The number of farm households practicing livestock rearing in the two Islands and in Hindi division was obtained from the extension reports of the County Government of Lamu. According to Kothari and Gaurav (2014) the formula which is applicable in the case of a finite population is given as:

$$n = \frac{z_{\alpha/2}^2 N\sigma^2}{(N-1)e^2 + z_{\alpha/2}^2\sigma^2} \quad \text{.....(2.1)}$$

where

*n* is the size of the sample

*N* is the size of population

*e* is the acceptable estimation error given by $e = z_{\alpha/2}\frac{\sigma}{\sqrt{n}}$

$\sigma$ is the standard deviation of the population

$z_{\alpha/2}$ is the critical value using the N(0,1) distribution for confidence level $\alpha$

In this study, the sample size was computed using the above stated formula at a Confidence level of 95% and a margin of error of 5%. The population of project households was 734 and that of non-project households 959. With the critical value $Z_{\alpha/2}$ = 1.96 and $\sigma$ = 0.5, the sample size for the project households was determined as:

$$n = \frac{1.96^2 * 734 * 0.5^2}{(734-1)0.05^2 + 1.96^2 * 0.5^2} = 252.4 \simeq 253$$

and the sample size for the non-project households was:

$$n = \frac{1.96^2 * 959 * 0.5^2}{(959-1)0.05^2 + 1.96^2 * 0.5^2} = 274.5.9 \simeq 275$$

***Sample selection***

The sample of project households was drawn from the tsetse and trypanosomiasis controlled area of Pate Island. The area covers eight administrative sub-locations namely Kwatini, Kwatongani, Pate, Siyu, Shanga, Tchundwa, Kizingitini and Myabogi all with different number of households owning livestock. The village roads were used as transects along which proportional samples were systematically drawn from each village until a total of 253 households was obtained for the non-project households. The first household along each transect was randomly selected. There after every 5$^{th}$ household with livestock was selected for interviewing. The sample of non-project households was drawn from Amu division and Hindi division of Lamu County where the Kenya Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) had not commenced tsetse and trypanosomiasis control interventions. The sub-locations covered in Hindi division were Hindi, Bargoni, Mokowe and Kilimani while those covered in Amu division were Matondoni, Kipungani, and Manda. Households with livestock in the non-project area were sampled following the same sampling protocol adopted for the households in the project area. A total of 275 non-project households were selected and interviewed.

***Data collection***

Using structured questionnaires administered through household interviews, the study collected socio-economic data including household characteristics, livestock (cattle, sheep, goats, donkeys and poultry) production, ownership of durable assets and living conditions in the household.

## Indicators of household welfare

There are various indicators of welfare that may be used as outcomes to gauge impacts of a program. Baker (1960) considers poverty measures including head count index, poverty gap index, squared poverty gap and Watts's index. The head count index measures the proportion of the population living in households with income per person below the poverty line while the poverty gap for each household is the difference between the poverty line and the household income (Ravallion, 1994). The two methods are however not distribution sensitive. Some distribution sensitive measures include squared poverty gap where individual poverty gaps as a proportion of poverty line are squared before taking the mean and Watts's index which is the mean of log of the ratio of the poverty line to income (Atkinson, 1987).

According to Deaton (1997), expenditure-based economic status indicators have been found to be more reliable than indices that are income based. The main reason is the relatively high non-response rate for income based measures as well as under or over reporting typically found in income items utilized in standard of living household surveys.

Filmer and Pritchett (2001) popularized the use of Principal Component Analysis (PCA) for estimating wealth levels using asset indicators to replace income or consumption data and concluded that PCA provides plausible and defensible weights for an index of assets to serve as proxy for wealth. Asset-based measures depict an individual or a household's long-run economic status and therefore do not necessarily account for short-term fluctuations in economic well-being or economic shocks. This study estimated the wealth index as an outcome for the assessment of impact of tsetse and trypanosomiasis control. Cordova (2008) points out that the indicator together may tap a long term dimension of economic well-being of the households.

***Constructing the household wealth index***

The wealth index (WI) is a composite index composed of key asset ownership variables. The WI is normally used as a proxy indicator of household level wealth. This was calculated using the Principal Component Analysis (PCA) method performed on variables which are indicators of wealth among the farm households in Lamu County, Kenya. The following indicators of wealth were adopted from those used in a number of Demographic and Health Surveys (DHS):

**Table 1:** Indicators of wealth among households

| Asset | Rich household | Poor household |
|---|---|---|
| Whether household owns these assets or not | | |
| Land | 1= Yes | 0= No. |
| TV | 1= Yes | 0= No. |
| Radio | 1= Yes | 0= No. |
| Mobile phone | 1= Yes | 0= No. |
| Bicycle | 1= Yes | 0= No. |
| Car or Boat | 1= Yes | 0= No. |
| Motorcycle | 1= Yes | 0= No. |
| Cattle | 1= Yes | 0= No |
| Improved cattle | 1= Yes | 0= No |
| Donkeys | 1= Yes | 0= No. |
| Goats | 1= Yes | 0= No. |
| Dairy goats | 1= Yes | 0= No |
| Sheep | 1= Yes | 0= No. |
| Poultry | 1= Yes | 0= No. |
| Type of dwelling unit | | |
| Roofing material | 1= Iron sheet or Tiles | 0= Makuti or Grass thatch |
| Walling material | 1= Bricks or Stone | 0= Mud, lime or Timber |
| Floor material | 1= cement | 0= dust |

Source: Author

The estimation of relative wealth using PCA is based on the first principal component concept. Following the example of Cordova (2008), the study expressed the wealth index (WI) for farm household *i* in Lamu county as:

$$y_i = \alpha_1\left(\frac{x_1 - \bar{x}_1}{s_1}\right) + \alpha_2\left(\frac{x_2 - \bar{x}_2}{s_2}\right) + \ldots\ldots\ldots + \alpha_k\left(\frac{x_k - \bar{x}_k}{s_k}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.2)$$

where:

$y_i$ is the wealth index for Lamu county farm household i.

$x_1$, $x_2$ ..... $x_k$ is a vector of asset variables which include ownership of land, television set, radio set, mobile phone, bicycle, a car or boat, motorcycle, cattle, donkeys, goats, sheep, poultry; whether roofing material is made of thatch or iron sheets, whether walling material is made of stones or mud, whether floor material is made of cement or earth).

$\bar{x}_1$, $\bar{x}_2$ ..... $\bar{x}_k$ are means of assets $x_1$, $x_2$ ..... $x_k$ respectively

$s_1$, $s_2$ ..... $s_k$ are the standard deviations of assets $x_1$, $x_2$ ..... $x_k$ respectively

$\alpha_1$ $\alpha_2$ ,..... $\alpha_k$ are weights for each variable $x_k$ for the first principal component.

The procedure yielded a wealth index for every sampled household in the project area and the non- project area. Using the calculated wealth index, households were categorized into quintiles of wealth where quintile 1 = Very poor household, 2 = Somehow poor, 3 = Middle, 4 = Wealthy and 5 = Very wealthy household.

## Results and discussions

The household wealth indicator variables included for the study were whether household owned assets such as bicycle, boat or car, cattle, dairy goats, donkeys, goats, improved cattle, land, mobile phone, motorcycle, poultry, a radio set, sheep and a television set. The materials used on the floor, roof and walls of the household dwelling were also included as indicators of wealth in the study area. All the variables were first dichotomized as 1=Yes and 0=No as suggested by Vyass and Kumaranayake (2006) to indicate the ownership of each household asset.

## Livestock ownership

It was found that 64% of the households owned indigenous cattle while the remaining percent did not. Of all the households interviewed, only 3% had improved cattle compared to 97% who did not have. When asked about ownership of donkeys, 25% of the households owned donkeys while the remaining 75% did not have. On the ownership of indigenous goats, the study found that 50% owned indigenous goats while the remaining 50% did not have. It was found that 3% of the households had dairy goats as opposed to the remaining 98% who did not have. Households were asked whether they owned poultry or not; in response 48% said they owned poultry while 52% did not own poultry. Finally the study found that only 9% owned sheep while 91% did not. The results are presented in Table 2.

**Table 2:** Livestock ownership in Pate, Amu and Hindi divisions of Lamu County

| Type of livestock | Ownership of livestock | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| Indigenous Cattle | No | 193 | 36.0 | 36.0 |
| | Yes | 343 | 64.0 | 100.0 |
| | Total | 536 | 100.0 | |
| Improved cattle | No | 520 | 97.0 | 97.0 |
| | Yes | 16 | 3.0 | 100.0 |
| | Total | 536 | 100.0 | |
| Donkeys | No | 403 | 75.2 | 75.2 |
| | Yes | 133 | 24.8 | 100.0 |
| | Total | 536 | 100.0 | |
| Indigenous Goats | No | 270 | 50.4 | 50.4 |
| | Yes | 266 | 49.6 | 100.0 |
| | Total | 536 | 100.0 | |
| Dairy goats | No | 522 | 97.4 | 97.4 |
| | Yes | 14 | 2.6 | 100.0 |
| | Total | 536 | 100.0 | |
| Poultry | No | 280 | 52.2 | 52.2 |
| | Yes | 256 | 47.76 | 100.0 |
| | Total | 536 | 100.0 | |
| Sheep | No | 490 | 91.4 | 91.4 |
| | Yes | 46 | 8.6 | 100.0 |
| | Total | 536 | 100.0 | |

**Source:** Author: Household Livestock ownership survey report.

**Ownership of other assets**

The study's investigation on the ownership of other assets revealed that 17% of the households owned bicycles while 83% did not have; 7% owned either boat or car yet the remaining 93% did not; 79% owned agricultural land while 21% did not. Asked whether they owned mobile phones or not, 84% of the households said they had phones while 16% said they did not. The study further found that 69% of the households owned radio sets while 31% did not; 31% owned televisions while 69% did not and finally, only 14% owned motorcycles while 86% did not. The findings are presented in Table 3.

**Table 3:** Household ownership of other assets in Pate, Amu and Hindi divisions of Lamu County

| Asset | Ownership of asset | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| Bicycle | No | 445 | 83.0 | 83.0 |
| | Yes | 91 | 17.0 | 100.0 |
| | Total | 536 | 100.0 | |
| Boat or car | No | 499 | 93.1 | 93.1 |
| | Yes | 37 | 6.9 | 100.0 |
| | Total | 536 | 100.0 | |
| Land | No | 113 | 21.1 | 21.1 |
| | Yes | 423 | 78.9 | 100.0 |
| | Total | 536 | 100.0 | |
| Mobile phone | No | 85 | 15.9 | 15.9 |
| | Yes | 451 | 84.1 | 100.0 |
| | Total | 536 | 100.0 | |
| Radio set | No | 164 | 30.6 | 30.6 |
| | Yes | 372 | 69.4 | 100.0 |
| | Total | 536 | 100.0 | |
| Television set | No | 372 | 69.4 | 69.4 |
| | Yes | 164 | 30.6 | 100.0 |
| | Total | 536 | 100.0 | |
| Motorcycle | No | 462 | 86.2 | 86.2 |
| | Yes | 74 | 13.8 | 100.0 |
| | Total | 536 | 100.0 | |

**Source:** Author: Household ownership of other assets survey report.

**Materials used for household dwelling**

The study found that 39% of the households had the floors of their houses made of dust (earth floors) while the remaining 61% had floors made of cement; 52% of the households had roofs of their dwelling units made of naturally available materials such as *makuti* or grass thatch while 48% had their roofs made of iron sheets. Of all the households, 59% had the walling material for their dwelling units made of naturally available materials including mud, rough stones, lime or timber while 41% had the walls made of either bricks, quarry stones or cement. The results are presented in Table 3.

**Table 3:** Materials used on household dwellings in Pate, Amu and Hindi divisions of Lamu County

| Dwelling unit | Material used | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| Floor material | Dust | 209 | 39.0 | 39.0 |
| | Cement | 327 | 61.0 | 100.0 |
| | Total | 536 | 100.0 | |
| Roofing material | *Makuti* or grass thatch | 279 | 52.1 | 52.1 |
| | Iron sheets or tiles | 257 | 47.9 | 100.0 |
| | Total | 536 | 100.0 | |
| Walling material | Mud, rough stones, lime or timber | 220 | 41.0 | 41.0 |
| | Brick, quarry stones, cement | 316 | 59.0 | 100.0 |
| | Total | 536 | 100.0 | |

**Source**: Author: Characteristics of household dwelling survey report.

## Constructing the household wealth index

The response of households on the dichotomized wealth indicator variables was captured in the Statistical Package for Social Scientists (SPSS) and Microsoft Excel spread sheet. Principal Component Analysis (PCA) procedure was used to calculate the factor scores from the first principal component. The PCA assigns weights to different assets owned by the households giving rise to Relative Wealth Indices for all households both in the PATTEC project area and non-project areas.

***Quintiles of wealth in Pate Island, Amu and Hindi divisions of Lamu County***

Using the household wealth indices obtained from the PCA procedure, households were categorized into quintiles of wealth where quintile 1 = Very poor household, 2 = Somehow poor, 3 = Middle, 4 = Wealthy and 5 = Very wealthy household. The household quintiles of wealth were cross tabulated by whether household was in project area or not. The results of the cross tabulation revealed that 0.7% of households in the study area were very poor and found in the project area compared to 19.2% of households who were very poor and found in non-project area. It was also found that 16% of households in Lamu were categorized as very wealthy and found in the project area compared to 3.7% who were very wealthy and found in non-project area. The results of household quintiles of wealth are presented in Table 4.

**Table 4:** Quintiles of Wealth among farm households in Lamu County, Kenya

| **Household category** | | **Percentile Group of the HH wealth index** | | | | | **Total** |
|---|---|---|---|---|---|---|---|
| | | **Very Poor** | **Somehow poor** | **Middle** | **Wealthy** | **Very wealthy** | |
| Non-project households | Count | 103 | 85 | 54 | 20 | 20 | 282 |
| | % | 19.2 | 15.9 | 10.1 | 3.7 | 3.7 | 100.0 |
| Project households | Count | 4 | 21 | 55 | 88 | 86 | 254 |
| | % | 0.7 | 3.9 | 10.3 | 16.4 | 16.0 | 100.0 |
| Total | Count | 107 | 106 | 109 | 108 | 106 | 536 |
| | % | 20.0 | 19.8 | 20.3 | 20.1 | 19.8 | 100.0 |
| Mean Wealth index | | -1.5103 | -0.5992 | 0.1368 | 0.73014 | 1.23921 | 0 |

**Source:** Author: Household wealth index report

***The Propensity Score Matching (PSM) estimator***

The Project households and non-project households were matched on their propensity scores calculated using pre-project underlying covariates which included age of the household head, sex of the household head, ownership of land, other major source of livelihood for the household, and years of education of the household head. The steps of calculating the PSM estimator were followed as suggested in literature (Stuart & Rubin, 2007; Caliendo & Kopeinig, 2008; Rosenbaum & Rubin, 1985, Lechner, 2001). One to one matching algorithm was applied to come up with 140 project households and 136 non-project households.

The mean wealth index for households that did not participate in the tsetse and trypanosomiasis control project was subtracted from that of project households. The mean wealth index for project households was 0.698793 (Std. Err. = 0.0476051) compared to -0.745156 (Std. Err. = 0.0772896) for the non-project households resulting to a PSM estimator of 1.4439. These results are presented in Table 5.

**Table 5**: Mean Household wealth index in project and non-project areas

| Household category | Number of households | Mean Household Wealth Index | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| Project households | 140 | 0.698793 | 0.5632709 | 0.0476051 |
| Non-project households | 136 | -0.745156 | 0.9013444 | 0.0772896 |
| PSM Estimator | | 1.443949 | | |

**Source:** Author: Mean household wealth index report

### Comparison of mean household wealth index

Using an independent samples t-test, the mean wealth index for project households was 0.698793 (Std. Err. = 0.0476051) compared to -0.745156 (Std. Err. = 0.0772896) for the non-project households. The wealth indices of the two categories of household were found to be significantly different at F=28.395. This suggests that the tsetse and trypanosomiasis control activities that were carried out in Pate Island led to an increase in household wealth. The t-test results are indicated in Table 6.

**Table 6**: Independent Samples Test

| Levene's Test for Equality of Variances | | T-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|
| F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | Lower | Upper |
| 28.395 | .000 | 16.009 | 274 | .000 | 1.44 | .090 | 1.27 | 1.62 |
| | | 15.907 | 225.359 | .000 | 1.44 | .091 | 1.27 | 1.62 |

**Source:** Author: T-test report

### Discussion

The PSM estimator obtained in this study means that there was a rise in household wealth index by 1.4439. This suggests that the tsetse and trypanosomiasis control activities that were carried out in Pate Island led to an increase in household wealth. The durable assets such as bicycle, boat or car, land, mobile phone, radio set, television set, motorcycle was a proxy for the medium to long term stream of income in the households during the project period. The control of tsetse flies and the elimination of disease transmission in Pate Island may have resulted to increased livestock numbers and quality.

### Conclusion and recommendations

### Conclusion

The proportion of very wealthy households of Lamu County was higher in the project areas than in non-project areas resulting in a rise in Wealth Index among Pate Island households implying that the households

had higher incomes conserved over time in durable assets such as livestock, bicycles, boats or cars, land, mobile phones, radio sets, television sets, motorcycles and in improved living conditions.

## Recommendations

1. Mobilize resources among governments and development partners to eradicate tsetse and trypanosomiasis in vast land areas of Africa which are still heavily infested by Tsetse flies. This study has demonstrated that investments in tsetse and trypanosomiasis control pays off. The findings can be used for resource mobilization to enable implementation in other areas affected by tsetse flies hence poverty alleviation among beneficiary communities.
2. Design studies to assess impact of tsetse and trypanosomiasis control in areas which are not geographically isolated. The pate Island study was a case of an intervention area surrounded by water serving as a natural barrier. This was an ideal situation separating the treatment group from the control group of households' hence minimal infiltrations of project output into the non-project area.
3. Governments, public agencies and non-governmental organizations (NGO) to design tsetse eradication activities according to existing needs and constraints.

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# Risk factors associated with cow-lameness in zero-grazed and pasture grazed dairy systems in Kenya

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## Abstract

Cases of lameness in dairy cattle is indicative of welfare problems and results in production-limiting in the herd. The objective of this work was to compare risk factors associated with cow-lameness in smallholder dairy farms. Randomly selected farms in Nakuru County were visited in the morning to examine cows during milking. A total of 485 dairy cows were examined on 172 smallholder farms, which were either predominantly zero-grazing in Bahati and Njoro areas or pasture grazing in Lare area. Cows in zero-grazed had higher odds of lameness than those in pasture grazed (OR= 1.786 for Friesian and Ayrshire, and 1.751 for other breeds). Odds were lower for younger parity in zero-grazing than pasture (OR=0.529), while older parities had higher odds of lameness in zero-grazing than pasture (OR=2.042). Wet bedding (OR=1.542) had higher odds in zero-grazed compared to pasture, while earth floor type (OR=3.390) had higher odds in zero compared to pasture grazing system. Knowledge of the risk factors and relative economic loss was relevant for preventive management of lameness. Key words: Dairy cow, lameness, feeding management, welfare

## Introduction

Increased cases of cow-lameness manifesting as an abnormal gait or animal limping when walking or claw disorders is a cause of worry to dairy producers. Multiple risk factors have been identified for cow-lameness in developed countries including environmental, management, behavioral, nutrition, infection, and conformation or genetics (Solano *et al*., 2015). Environmental aspect of cow-lameness includes housing types, floor quality and cubicle design (Haskell *et al*., 2006). Management routines include claw trimming (Espejo *et al*., 2007) and overcrowding (Leonard *et al*., 1996). A common characteristic of these dairy systems is intensive dairying in which cows are fed confined in housing units. Zero-grazing units in smallholder dairy farms in Kenya are similar to those systems with about half (44%) of such farms found in the Kenya highlands (Bebe *et al*., 2003). Studies of cow-lameness are few in Kenya, but they suggest increased incidences with the shift from pasture to zero grazing and over the years, Gitau (1999) reported cow-lameness prevalence of 0.76% per month in cattle kept in pasture 24 hours a day and 2.14% in cows housed 24 hours a day in Kiambu farms. Mbuthia *et al*. (2007) performed a radiographic examination of 318 abattoir obtained claw samples and found 35% subclinical and 21% chronic laminitis cases with 44% experiencing extreme deformities. Although empirical evidence of lameness prevalence in Kenya has been provided, there is little on risk factors. This study aimed at filling the knowledge gap with an empirical study of the risk factors associated with cow-lameness in smallholder farms which could inform management interventions for improved animal welfare and herd productivity.

## Materials And Methods

### Study site

The study was carried out on smallholder dairy farms practicing zero and pasture grazing in Bahati, Njoro and Lare regions of Nakuru County in the Kenya Highlands. Elevation is ≥ 1000 m above sea level, annual mean temperature 10-18$^{o}$C and rainfall has bimodal pattern with > 800 mm annually (Jaetzold and Schmidt,

1983). Zero grazed dairy herds dominate in Bahati and Njoro regions while pasture grazed dairy herds dominate in Lare region.

### Sampling procedure

A random sampling procedure was used for the study, where Bahati and Njoro areas represented the zero-grazing and Lare the pasture grazing. Farms within each area were randomly selected based on a list of farmers provided by the staff of animal production directorate in Bahati, Lare and Njoro Sub Counties. Smallholder dairy farms with 1 to 5 adult cows were selected for the study for a total of 70 farms in Bahati, 45 in Njoro and 57 in Lare.

### Data collection

Data was obtained through observation and administering questionnaires. Farms were visited in the morning and observations were made for risk factors. A total of 485 cows in 172 farms and kept under zero-grazing and pasture grazing systems were examined. Data on risk factors included: reproduction status, stage of lactation, parity, breed, housing confinement, floor type, bedding condition, feed bunk space.

### Statistical analysis

Individual animal and herd level risk factors were assessed for their association with lameness using logistic regression model:

$$\text{Logit } Yi\ (\pi) = \alpha + \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon$$

Where Y = lameness prevalence, α = the intercept, βs = regression coefficients, Xs= Risk factors, E= error term.

### Result

### Description of the sample grazing systems

The results of this study show that a total of 485 dairy cows were observed from 172 smallholder farms. Seventy three cows were lame in zero grazed and thirty four cows in pasture (Table 1).

**Table 1:** Description of the sampled herds

| Grazing systems | No. of Farms | No. of cows | Proportion of lame cows | Herd size |
|---|---|---|---|---|
| Zero-grazing | 109 | 317 | 23.0% | 2.9±1.2 (1.00 - 5.00) |
| Pasture | 63 | 168 | 20.2% | 2.7±1.2 (1.00 - 5.00) |
| Total | 172 | 485 | 21.1% | 2.8±1.8 (1.00 - 5.00) |

Mean ±SD (minimum-maximum)

### Individual cow level risk factors

Cows in early and mid-lactation, higher parity had higher odds of lameness in zero grazing than in pasture grazing system (Table 2).

**Table 2.** Comparison of cow level risk factors in smallholder zero and pasture dairy cow

| Variables | Level | Production systems | Number of cows | Proportion lame cows % | OR | 95% CI | P valve |
|---|---|---|---|---|---|---|---|
| Breed | Friesian/ Ayrshire | Zero | 251 | 16.7 | 1.786 | (0.511-6.241) | 0.36 |
| | | Pasture | 66 | 11.7 | Ref | | |
| | Others | Zero | 77 | 47.0 | 1.751 | (1.014-3.024) | 0.0444 |
| | | Pasture | 91 | 27.5 | Ref | | |
| Reproductive status | Lactating | Zero | 230 | 26.5 | 1.473 | 0.870-2.493 | 0.1496 |
| | | pasture | 127 | 19.7 | Ref | | |
| | Non-lactating | Zero | 87 | 13.8 | 0.569 | 0.218-1.483 | 0.2486 |
| | | Pasture | 41 | 22.0 | Ref | | |
| Stage of lactation | Early/ mid | Zero | 187 | 30.1 | 1.488 | 0.843-2.627 | 0.1707 |
| | | Pasture | 98 | 22.4 | Ref | | |
| | Late | zero | 44 | 11.1 | 1.042 | 0.229-4.743 | 0.9581 |
| | | Pasture | 28 | 10.7 | Ref | | |
| Parity | 0-2 | Zero | 178 | 10.6 | 0.529 | 0.259 – 1.082 | 0.0813 |
| | | Pasture | 97 | 17.5 | Ref | | |
| | >3 | Zero | 139 | 29.1 | 2.042 | 1.073 – 3.886 | 0.0296 |
| | | Pasture | 71 | 23.9 | Ref | | |

## Herd level risk factors

Results indicate that wet bedding condition and Earth floor type (OR=3.390, P=0.0001) have high chance of being associated with cow-lameness in zero grazed than pasture grazed dairy cows (Table 3).

**Table 3:** Comparison of the herd level risk factors for cow lameness in smallholder zero and pasture dairy cows

| Variables | Level | Production systems | No of cows | Proportion lame cows (%) | OR | 95% CI | P-value |
|---|---|---|---|---|---|---|---|
| Bedding condition | Dry | Zero | 140 | 15.0 | 999.999 | 0 | 999.999 |
| | | Pasture | 8 | 4.8 | | | |
| | Wet | Zero | 177 | 29.4 | 1.542 | 0.937-2.537 | 0.0885 |
| | | Pasture | 160 | 21.3 | Ref. | | |
| Feeding space | Adequate | Zero | 229 | 16.2 | 0.759 | 0.454-1.271 | 0.2953 |
| | | Pasture | 168 | 20.2 | Ref | | |
| | Not adequate | Zero | 88 | 40.9 | -- | -- | -- |
| | | Pasture | 0 | 0 | | | |
| Floor type | Concrete | Zero | 233 | 14.6 | -- | -- | -- |
| | | Pasture | 1 | 0.6 | | | |
| | Earth | Zero | 84 | 46.4 | 3.390 | 1.916-5.999 | 0.0001 |
| | | Pasture | 167 | 20.4 | Ref | | |

## Discussion

The importance of lameness in dairy cattle has been increasingly recognized in the last two decades (Rushen, 2001). Regardless of production system, dry bedding had lower risk of lameness compared to wet bedding (OR=0.483, p=0.02). This had higher effects in zero grazing where wet bedding was associated with higher lameness risk than pasture grazing system (OR=1.542, p=0.09). This could be because cows in zero-grazing were confined, standing longer period in a wet environment which increased claw moisture content and softening leading to ease of foreign material penetration and thus lameness. Greenough, (2007) reported that wet conditions could increase spread of infectious bacteria, potentially invading the hoof to cause infection, while Sanders *et al.*, (2009) reported that higher incidence and prevalence of lameness was documented in dairy cows in wet environments**.** Adequate feeding space had lower risk of lameness than inadequate (OR=0.315, P=0.04). In zero grazing system, farms with inadequate feeding space had high proportion of lameness (41%), while those with adequate feeding space had only 16%. In zero-grazing system, earth floor resulted in more cases of lameness (46.4%) than concrete (14.6%). These floors are hard to maintain and retain humidity for a long period of time, also expose cows foot to manure slurry and moisture which increases chances of lameness. In agreement, Somer *et al.*, (2003) reported cows raised on earth floor surfaces often had overgrown claws that inevitably become over loaded at specific zones, thus being highly predisposed to claw-horn lesions.

All the cow level risk factors were not significantly associated with cow-lameness at 95% in zero grazed, except parity 3 and above, other breeds. The odds of lameness significantly increased for Friesian-Ayrshire, lactating cows, early-mid lactation, parity 3 + and other breeds in zero grazed compare to pasture. This is in agreement with Amory *et al.* (2008) found that high yielding cows were more likely to develop non-infectious causes of lameness. Early and mid-lactation in zero grazed had 30.1% lameness compared to pasture 22.4%. This is in line with Bicalho *et al.* (2008) and Barker *et al*., (2010) who indicated that high yields in early lactation was a risk factor for lameness. Third or higher parities was by far the factor posing the greatest risk for development of lameness, this is in agreement with Sogstad *et al.*, (2005) that most lameness is generally associated with third or higher parities. Sarjokari *et al*., (2013) observed an association between lameness and parity and argued that older cows are bigger, are predisposed to relapse with certain foot lesions and have been exposed for a longer interval to the housing environment than young ones.

## Conclusions and Recommendations

Breed, older parities (3+), wet bedding condition, and earth floor, early and mid-lactation were by the most important risk factors associated with the occurrence of cow-lameness. These factors had higher influence on lameness in zero grazed compare to pasture grazed dairy cows. There is a need for farmers in zero grazing system to manage important risk factors that are associated with increased lameness and reduced the risks.

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# Dairy Goat production: an option for poverty alleviation and food security in Kenya

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## Abstract

Livestock plays an important economic and socio-cultural role among many Kenyan communities. The livestock sub sector contributes to the food and cash needs of the farmers, and provides employment to about 10 million people, contributes 7 per cent to the Gross Domestic Product and 17 per cent to the Annual GDP, and provides 50 per cent of the agricultural labour. Small Ruminants, such as goats, fit well into smallholder farming systems. Demand for dairy goats and their products have been increasing tremendously since their introduction. The major exotic dairy goat breeds in Kenya are the German (Kenyan) Alpines, Toggenburg and Saanen and are found mainly in the high and medium potential rainfall areas of Kenya. The increasing human population is leading to increased land pressure, the smaller land sizes unable to support dairy cattle, making the dairy goat a better option. As a nation, promoting dairy goats' production will alleviate extreme poverty and hunger. The high quality of goat's milk addresses malnutrition at the household level. Development of dairy goats in Africa is constrained mostly by ignorance of their importance, lack of resources earmarked for them, desperate lack of; breeding stock, information, infrastructure, market linkage and skilled manpower. For the dairy goat production to be used for food security in developing countries, attention should be focused to the key factors that influence its success. These include community participation, comparative advantage, socio-economic and cultural aspects, positive impacts, economic implications, environmental factors, institutional aspects and extension services. How these are addressed or how some will manifest themselves will determine the success of dairy goat production.

## Introduction

Livestock plays an important economic and socio-cultural role among many Kenyan communities. It contributes 7 per cent to the Gross Domestic Product and 17 per cent to the Annual GDP and provides 50 per cent of the agricultural labour (FAOSTAT 2010). Domestic animals have, for many years, contributed to human needs for food and agricultural products. It also plays an important economic role as capital and for social security. The value of livestock has also been clearly demonstrated for soil nutrient management, especially in soils in rapidly intensifying crop-livestock systems (Tarawali et al., 2004) and in those already intensified (Olson, 1998; Olson et al., 2004). Integration of livestock into crop systems enhances smallholder farm productivity and profitability (Peden et al., 2007). Small Ruminants, such as goats, fit well into smallholder farming systems. They are easier to work with than large ruminants and are cheaper to buy and maintain (Ogola et al 2010a). Goats did not occur wild in Africa, it is agreed that the ancient and recent goats of the continent were introduced from Asia (Epstein, 1971 FAOSTAT 2010). The world population of goats stood at 861.9million (FAO STAT, 2008). The largest number of goats are found in Asia (59.7%) followed by Africa (33.8%) both accounting for 93.5% of the total number of goats in the world (Olivier *et al*., 2005; Aziz, 2010). They have served mankind longer than cattle or sheep (Kosgey 2004; FAOSTAT 2010; Ogola et al 2010a). Dairy goats occupy a unique and significant niche in resource-limited smallholder farmers in the high potential areas of the tropics and subtropics and are being increasingly adopted.

## Dairy Goat Industry in Kenya

Kenya is reputed to have the most developed and a thriving dairy industry in East Africa. Dairy is one of the agricultural sub-sectors experiencing high growth, estimated at 3 to 4 % annually (National Livestock Policy, 2008). Its contribution to national GDP is estimated at 3.8%, which is part of the 10 to 12% from livestock and 40% from agriculture. Goat production is important in marginal agricultural land, especially in the arid and semi-arid areas (Rege and Lebbie, 2000; Kosgey, 2004; GOK 2009). They play a vital role in food security and income generation for the resource-poor farmers. The percentage contribution of dairy goat milk to GDP is not known since their introduction in the 1980s. The aim was to improve livelihoods largely through provision of milk for home consumption and surplus for sale to raise income and alleviate poverty (Ogola *et al*., 2010a). Demand for dairy goats and their products have been increasing tremendously since their introduction. The drastic increase in human population pressure, land scarcity and diminishing production resources (Bett *et al*., 2009) have also stimulated the use of dairy goats in rural development efforts (Josserand, 1984; FAO, 2005; Ahuya et al 2005).

## Breeds and breeding

The major exotic dairy goat breeds in Kenya are the German (Kenyan) Alpines, Toggenburg and Saanen. They are found mainly in the high and medium potential rainfall areas of Kenya. Dairy goats reach sexual maturity at 4 to 5 months of age. Young does should be bred at a body weight ranging from 31 to 36 kgs, which usually is at an age of 7 to 10 months. The gestation period ranges from 145 to 155 days with an average length of 149 days. Does normally kid between one and three kids per year (single-born kids weigh approximately 3 to 4.5 kgs at birth). Does giving birth to twins produce more milk and have greater total kid weight per maintenance doe unit. Daily weight gains after birth range from 50 to 150 grams per day (0.1 to 0.33 pound per day), but meat goat crosses can exceed 250 grams per day (0.55 pound per day).

## Exotic Breeds

**Saanen:** This is the milk queen in the goat world and originated from Switzerland. It's all white or creamy coloured with pink skin pigmentation. The face is straight, the ears are upright and alert (pricked) the hair is short and fine and the body is long (Plate 1). Under good management it produces 3-5 litres of milk per day depending on management. They are prolific and have high twinning rate. Sometimes the kids are born with both male and female organs (hermaphrodite). This has been observed on polled goats. Mature male weighs 70-100 kg and mature female weighs 50-70 kg. Udders are usually shapely and well attached.

Saanen

Toggenburg

Alpine

**Plate 1; The Saanen, Toggenburg and Alpine dairy goats.**

**Toggenburg:** There are two breeds of Toggenburg, one originating from Switzerland and the other one from Britain. The British breed is bigger than the Swiss breed with the female of the British type weighing up to 70kg and bucks up to 100 kg. With Swiss type, the female weights are in the range of 50kgs with

bucks up to 70 kg. They are brown or greyish brown in colour with distinctive white stripes on the face and legs. They may be horned or naturally polled. Horns in male are long and curving back. They may have toggles (tassels) or not (Plate 1). They are very gentle and quiet in temperament. They are easily handled and can be trained. They have a long body and seem bony. They are bred for milk with average milk yield of 1-3lts per day depending on management. The breed is suited for the higher cooler regions where heat stress is not a problem and good quality fodder is freely available.

**Alpine**: The breed originated from French Alps. They are medium to large in size and are hardy and adaptable animals thriving in many climates. They have a varied coat colour with shades of grey, brown, black, redbuff and combinations (Plate 1). They have a pronounced mane in both male and female. They may or may not have horns. The goat is bred for milk with average milk yield ranging from 2.5-4lts subject to levels of management. The female weighs from 50-60kgs while bucks weigh 65-80kg.

**Milk production:** Over the past 20 years, a new and growing interest in goat milk and goat milk products has occurred everywhere in the world (Dubeuf ***et al.,*** 2003). Goats form the most important group of milk producing animals after dairy cattle in both temperate and tropical agriculture (Farnworth, 2002). The demand of dairy goats' milk is increasing because of the growing population, the increasing awareness of medicinal and nutritional status associated with goat milk and also the special interest in goat milk products, especially cheeses and yoghurt, in many developed countries which has led to increasing levels of disposable incomes (Haenlein, 2004; Epitaufik, 2007; FAO STAT, 2008).

**Milk production from different breeds:** The three major dairy goat breeds in Kenya are the Saanen, Toggenburg, and Alpine. The lactation period for dairy goats averages 204 days, with peak production usually occurring 4 to 6 weeks after kidding. Representative production data for the various goat dairy breeds is shown in Table 1 below.

**Table 1**. Milk production by dairy goat breeds (2003 DHIR data).

| Breed | Average production (lbs/lactation) | Production range (lbs/lactation) | Milk fat (%) | Milk protein (%) |
|---|---|---|---|---|
| Alpine | 2,266 | 790-5,470 | 3.4 | 2.9 |
| Saanen | 2,577 | 610-5,490 | 3.3 | 2.9 |
| Toggenburg | 2,115 | 940-4,380 | 3.2 | 2.7 |

**The value of goat milk:** Goat milk differs from that of the cow in amino acid content and composition of the proteins (Table 2) (Quiles *et al*., 1994). It is composed of small suspensions of fat globules, making it easier to be assimilated and, therefore, have particular benefits in the diet of children and adults who show sensitivity or allergic reactions to cow's milk. It has also been found to be beneficial to HIV/AIDS victims as its high protein molecules are better absorbed than other proteins and strengthen antibodies. Also for mothers who opt not to breast feed, goat milk is an ample substitute. Goat milk is associated with alleviating or controlling some diseases (Haenlein, 2004). It has particular benefits in the diet of children and adults who show sensitivity or allergic reactions to cow's milk. Goat milk contains the precursor to vitamin A in the milk fat that allows it to be readily available for use by the body (Park, 1994).

**Table 2** Comparison of average milk composition

| Nutrient | Human | Cow | Goat |
|---|---|---|---|
| Data from the American Dairy Goat Association | | | |

| Abbreviations: kcal/100 ml is a measure of energy content. 1 kcal = 1,000 calories; IU = international unit, a measure of vitamin potency; µg = microgram, 1/1000 milligram | | | |
|---|---|---|---|
| Energy (kcal/100 ml) | 68.00 | 69.00 | 70.00 |
| Lactose (%) | 7.30 | 4.70 | 4.10 |
| Protein (%) | 1.10 | 3.50 | 3.20 |
| Fat (%) | 4.00 | 3.60 | 3.80 |
| Cholesterol (mg/100 ml) | 20.00 | 15.00 | 12.00 |
| Ash (%) | 0.20 | 0.70 | 0.80 |
| Calcium (%) | 0.04 | 0.18 | 0.19 |
| Phosphorous (%) | 0.06 | 0.23 | 0.27 |
| Iron (%) | 0.20 | 0.06 | 0.07 |
| Vitamin A (IU/g fat) | 32.00 | 21.00 | 39.00 |
| Vitamin D (IU/g fat) | 0.30 | 0.70 | 0.70 |
| Vitamin C (mg/100 ml) | 3.00 | 2.00 | 2.00 |
| Thiamin (µg/100 ml) | 17.00 | 45.00 | 68.00 |
| Riboflavin (µg/100 ml) | 26.00 | 159.00 | 210.00 |

**Source.** *http://www.ADGA.org*

**Advantages and disadvantages of keeping goats.**

Goats are relatively cheap and are often the first asset acquired, through purchase or customary means, by a young family or by a poor family recovering from a disaster, such as drought or war. The advantages and disadvantages of goats relative to resource-poor people are shown below.

**Advantages:** They are able to use fibrous feeds, especially browse efficiently, use of marginal land, water and wide climatic adaptation. They are also relatively cheap to purchase. They are suitable to small farms and relatively drought tolerant. The fast reproductive rate quickly builds up herd and ensures early returns on investment and enables early credit repayment. Their small size enables easy and quick movement of households in emergencies, and allows easy home slaughter. They are also easy for women and children to handle.

**Disadvantages:** They are **s**usceptible to predators and thieves, their small value often makes formal credit systems uneconomical, their small value makes formal insurance systems difficult to administer. Food preferences and dental set-up makes goats capable of inducing severe damage to vegetation (trees and brush) compared to other ruminants.

## The Role of Dairy Goats in Promoting Food Security

Goats are deeply embedded in almost every African culture and are true "friends" to the rural poor in particular. They can therefore play a vital role in supporting food security of a household (GOK, 2009). Goat is often the only asset possessed by a poor household. In times of trouble, such as crop failure or family illness, goats can be sold and food or medicine could be purchased. It is well established that goats can survive and indeed flourish in areas where cattle and sheep struggle to survive. Goats are a viable option in improving the household cash flow of rural people and assisting in resolving the issue of food security (Kooster, 1986).

In the rural, economically deprived regions, goats are a ready source of cash income, food and social security. It is much easier for small scale farmers, with no land or only small land sizes, to farm with goats than with cattle, because ten goats could be kept instead of one cow (ILCA, 1990).

One of the main reasons for animal domestication, which started some 10,000 years ago, was to reduce the problem of unpredictability of food supply associated with unpredictable weather. Goats can assist in poverty eradication as landless people who cannot grow crops can keep goats (World Bank, 2001). Goat

production is less influenced by weather compared to crop production and the milk and meat produced by the goats are of high quality in most if not all aspects as protein, minerals and vitamins (Peacock, 2005). Smaller animals as goats are more prolific, have lower requirements in terms of capital and maintenance costs and are less risky to keep. They are also easier to sell when cash is needed for school fees or other purposes. In addition, small ruminants generally perform better under conditions where food availability is scarce compared to cattle (World Bank, 2005).

## Challenges of the Goat Sector throughout the World

Milk goats are present in all countries but they are less supported by government and academic and research institutions than other animal production sectors. There is still a great deal of prejudice and ignorance of importance of goats to farmers in rural areas. Contribution of goats to the rural economy is universally underestimated due to largely informal, mostly untaxed, nature of most goat and goat product marketing. Ignorance of their importance, lack of resources earmarked for them, desperate lack of; breeding stock, information, infrastructure, market linkage and skilled manpower has led to slow adoption in Africa (Peacock, 2005).

## Way forward

**Involvement of stakeholders:** Development strategies for animal genetic resources would likely have the greatest impact when there is community involvement (stakeholders), and integrating traditional practices, knowledge, and innovations with modern livestock breeding and management practices

**Proper breeding strategy:** Having a proper breeding strategy in place to address both short- and long-term concerns through proper planning is essential in ensuring dairy goats production in Kenya succeeds. Use of AI can increase the genetic diversity and productivity.

**Exploitation of comparative advantage:** There are areas where dairy cows are more popular and raised in greater numbers than introduced dairy goats such that dairy goat milk only supplements cow's milk and receive low prices. Places like these could alternatively be used as breeding or as multiplication zones to provide goats for areas with land pressure (which now became markets for the latter) where the demand for dairy goats is high but not available and dairy goat milk demand is high.

**Incorporating institutional aspects:** Institutional factors like support services in input supply, policy, research, extension and training, processing, marketing and credit could lead to achievement of efficiency by linking production and post production components to efficient services and marketing schemes. Livestock breeding programs and the policies promoted by the government in the sector must be seen to be complementary to each other and to promote both more food and other livestock commodities, and to improve resource utilization and livelihood of the livestock owners.

**Role of extension services and extension research linkages:** Continual training of the farmers, and monitoring and evaluation is required to guide and entrench introduced technologies with farmers. To involve farmers, it is advisable to back the breeding programmes that are in place with an effective extension service for maximum effect.

**Conclusion;** For the dairy goat production to be used for food security in developing countries, attention should be focused to the key factors that influence its success. These include community participation, comparative advantage, socio-economic and cultural aspects, positive impacts, economic implications, environmental factors, institutional aspects and extension services. How these are addressed or how some will manifest themselves will determine the success of dairy goat production.

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# Morphological **characteristics of two strains of helmeted guinea fowl (Numida meleagris) in Bungoma County**

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Animal production KALRO Kitale

## Abstract

Three hundred and twenty four eggs from the Pearl and White guinea fowl genotypes were purchased from farmers in Kimaeti, Kanduyi and Webuye regions of Bungoma County. Nine guinea fowl farmers were selected from each region and given twelve eggs; six pearl and six white. The eggs were incubated and hatched by the indigenous chicken hens. The data for keets was taken on first day, followed by $4^{th}$ , $8^{th}$, $12^{th}$ and $16^{th}$ weeks for Body Weight9(g), Body Girth (cm), Body Length (cm), Shank Length (cm), Neck Length (cm) and Wing Length ((cm). The White genotype had superior body weight and girth than the Pearl at hatching until the $4^{th}$ week. However, the Pearl overtook the White from the $8^{th}$ week up to the end of the experiment. The body, neck and the Shank lengths did show any significant differences between the genotype. Kimaeti showed better body weights for both genotypes than Kanduyi and Webuye regions because of better availability of feed resources. The Pearl had better mature weight than the White genotype.

**Key Words**: Guinea fowl, Keets, Pearl, White, morphology and genotypes

## Introduction

Guinea fowl (*Numida meleagris*) is a poultry species suitable for use in meat production to expand and diversify of the local poultry industry due its consumer acceptance, resistance to common diseases and tolerant to poor management condition (Arguelles, *et al*, 2004). They are also useful ornamental bird. The shell of the guinea fowl egg is thick and less porous with better keeping quality than chicken eggs (Teye & gyawu, 2002; Koney, 1993; Apiiga, 2004: Dei and Karbo, 2004). In Zimbabwe like other parts of Africa, guinea is now being perceived as a potential driver of poverty reduction in rural areas, a strategy already operational in the republic of Ghana (Zakari, 2007, Ghanadot, 2009). They provide good opportunity for better utilization of water and feed resources to generate additional food and income for rural communities (Kusina, *etal*, 2012). This is through use of alternative natural feed resources such as grass, insects and water plants (Ayorinde, 1990).

In Kenya, guinea fowl is largely a wild bird roaming in the arid and semi-arid areas. It has been domesticated in Kenya for food and income generation as well as pet and hobby. Guinea fowl is one of the emerging livestock that has not received adequate attention in terms of research and development (Kiptarus, 2005). They are common on farms around Nairobi, Coast, Rift Valley and Western regions (Emmanuel, 2013). There is limited large scale production in Kenya as is for chickens (Omiti & Okuthe, 2009). In Kenya, domesticated guinea fowls are mostly reared in small backyard units in small scale numbers (Nyaga, 2007). Farmers in the country keep three main genotypes, namely, the pear, white and lavender. Birds of the same strains are mainly differentiated by the colour of their plumage.

Despite the potential and tremendous advantages of guinea fowl, there is limited data and information on their production, in contrast to indigenous chicken where extensive research is available (Kusina & Kusina, 1999; Maphosa, *et al*, 2004; Muchadeyi, *et a*l, 2004; King'ori, *et al* 2010). In addition, morphological characterization of common domesticated guinea fowl in Kenya has not been carried out. Therefore, this study aims at characterizing the domesticated guinea fowl in Bungoma County using morphological indices.

## Materials and Methods

### Site description

The study was carried out in three sites namely; Kimaeti, Kanduyi and Webuye Sub-Counties in Bungoma county. These sites are chosen because of high guinea fowl concentration. Kimaeti is located on the extreme western part of the County bordering Busia County. The agro-ecological zone (AEZ) is mainly LM3 with rainfall ranging from 1200mm to 1400mm. It is a low altitude area with relatively low rainfall and high temperature. The main crops grown in the area are maize, cotton, cassava, millet, ground nuts and tobacco.

Webuye is located on the eastern part of Bungoma County. It is a medium altitude area with high bimodal rainfall ranging between 1600 to 1800mm annually in Agro-ecological Zone (AGZ) $LM_1$. The crops grown in the area include maize, beans, sugar cane, bananas and sweet potaoes. Kanduyi/ Chwele location lies in Bungoma west on the southern foot of Mount Elgon, 20 Km north of Bungoma town. Its average annual rainfall ranges between (1600-1900mm). The area is high potential for coffee, Maize, Horticultural crops and other food crops in UM2 (Jaetzold, 1984).

### Morphological data collection

Twenty seven (27) guinea fowl farmers (9 from each site) were selected. These farmers were identified from the 71 guinea fowl keepers who participated in the survey. Some 324 guinea fowl eggs were purchased from farmers in the three regions. Each farmer received 12 eggs (6 for white and 6 for pearl breeds). The farmer used the indigenous chicken hen as surrogate mother to hatch and take care of the Keets. Management of the birds was done by the farmer under free range system of production. Health management was done in collaboration with the research team. Once the Keets were hatched, 6 keets were randomly selected from each clutch, tagged and weighed. The keets were weighed on first day and feeding was done by free range system with minimal supplementation, prevalent on smallholder farms in Bungoma County.

The morphological features of the guinea fowls' body parts were captured on day 1, then $4^{th}$, $8^{th}$ $12^{th}$ and $16^{th}$ weeks. The morphological measurement included; body weight, body girth, body length, shank length, wing length, wattle length and width length. The external measurements were obtained as described by Fajemilehin, (2010) as defined below:

- Body weight: The birds was put in an empty box and measurement taken on portal electronic weighing scale
- Body girth: Taken as the circumference of the body around the breast region using flexible measuring tape.
- Body length: The distance between the posterior end of the phygostyle and the anterior of the nasal opening using flexible measuring tape
- Shank length: Distance between the footpad and the hock joint
- Wing length: The distance between the tip of the phalanges and the carocoid-humerous joint using flexible measuring tape.
- Wattle length: The distance between the middle point of attachment of the wattle on the head and the tip end.

### Data analysis

Data was subjected to analysis of variance (ANOVA) based on block design. For further analysis, Fischers LSD was used to verify differences among treatment means at 5% level.

## Results

**Table1:** Means of genotypes on guinea fowls body weight (grams) at different stages of growth up to 16 weeks of age

| Week | Genotype | |
|---|---|---|
| | Pearl | White |
| 0 (Day old) | 23.1 | 24.65 |
| 4 | 116.9 | 121.67 |
| 8 | 471.5 | 469.1 |
| 12 | 974.1 | 951.5 |
| 16 | 1210.2 | 1206.8 |

The results show the pearl keets hatched with lower body weights than the white genotype as shown in Table 1. The low body weights of the pearl guinea fowl are recorded until the 4$^{th}$ week. However, growth rates of the pearl keets overtake the white from the 8th up to the end of the experiment (16$^{th}$ week).

**Table2**: Means and standard errors of location on body weights (grams) of guinea fowls at different stages of growth up 16 weeks of age

| Week | Region | | |
|---|---|---|---|
| | Kimaeti | Kanduyi | Webuye |
| 0(Day old) | 24.3 | 24.2 | 24.2 |
| 4 | 125.3$^{A}$ | 119.4$^{AB}$ | 114.5$^{B}$ |
| 8 | 476.6$^{A}$ | 472.3$^{A}$ | 462.1$^{B}$ |
| 12 | 955.9$^{A}$ | 955.5$^{A}$ | 946.5$^{B}$ |
| 16 | 1211.8$^{A}$ | 1208$^{B}$ | 1204.4$^{C}$ |

Table 2 shows that the keets hatching weight did not exhibit any significant difference (p>0-05) irrespective of the region. From the fourth week onwards, birds in Kimaeti had superior body weights to those in Kanduyi and Webuye although significant differences (p<0.05) was only recorded in Webuye birds.

**Table 3**: Means and standard errors of the location and breed on the weight of two guinea fowls genotypes up to 16 weeks of age

| Age (weeks) | Breed | Number | Kimaeti | Kanduyi | Webuye |
|---|---|---|---|---|---|
| 0 | P | 27 | 23.960±0.0889 | 23.66±0.01 | 23.711±0.034 |
| | W | 27 | 24.337±0.0893 | 24.67±0.02 | 24.589±0.050 |
| 4 | P | 27 | 122.885±1.5053 | 116.80±1.90 | 111.211±0.81 |
| | W | 27 | 126.955±1.1066 | 122.06±2.02 | 116.019±0.65 |
| 8 | P | 27 | 478.456±4.789 | 472.14±5.28 | 463.951±4.55 |
| | W | 27 | 474.481±4.911 | 471.12±5.26 | 462.944±4.59 |
| 12 | P | 27 | 958.703±8.852 | 955.71±9.12 | 953.704±8.64 |
| | W | 27 | 946.385±8.184 | 954.27±9.050 | 946.385±8.18 |
| | P | 27 | 1212.596±9.431 | 1208.90±10.26 | 1206.815±9.85 |
| 16 | W | 17 | 1209.537±9.231 | 1208.25±10.04 | 1203.052±9.53 |

**Table 4:** Means and standard errors of location and genotype on the body girth (chest circumference) (cm) of guinea fowl up to 16 weeks

| Week | Number | Genotype | Kimaeti | Kanduyi | Webuye |
|---|---|---|---|---|---|
| 0 | 27 | P | 8.68±0.02 | 8.69±0.02 | 8.70+0.03 |
| | 27 | W | 8.73±0.02 | 8.72±0.02 | 8.72±0.02 |
| 4 | 27 | P | 15.31±0.07 | 14.95±0.07 | 14.32±0.04 |
| | 27 | W | 15.56±0.05 | 15.53±0.05 | 15.56±0.05 |
| 8 | 27 | P | 22.51±0.05$^{A}$ | 22.51±0.05$^{A}$ | 21.94±0.08$^{B}$ |
| | 27 | W | 22.39±0.04$^{A}$ | 22.54±0.12$^{A}$ | 21.86±0.08$^{B}$ |
| 12 | 27 | P | 28.74±0.09 | 28.80±0.10 | 28.76±0.40 |
| | 27 | W | 28.44±0.09 | 28.52±0.09 | 28. 47±015 |
| 16 | 27 | P | 30.86±0.14 | 30.27±0.27 | 30.53±0.18 |
| | 27 | W | 30.54±0.16 | 29.95±0.40 | 30.35±0.16 |

Table 4 showed that the white genotype had larger body girth than the pearl from hatching to the 4$^{th}$ week. However, from the 8$^{th}$ week onwards, the pearl genotype had higher body girth than the white with significant difference ($p>0.05$). Birds in Kanduyi gave slightly superior body girth than Kimaeti and Webuye between 4$^{th}$ and 12$^{th}$ week without significant differences ($p>0.05$).

**Table 5**: Means and standard errors of location and genotype on body length (cm) of guinea fowl up to 16 weeks

| Week | Number | Genotype | Kimaeti | Kanduyi | Webuye |
|---|---|---|---|---|---|
| 0 | 27 | P | 10.69±0.02 | 10.68±0.03 | 10.70±0.02 |
| | 27 | W | 10.67±0.03 | 10.70±0.02 | 10.67±0.08 |
| 4 | 27 | P | 19.76±0.08$^{A}$ | 18.09±0.17$^{B}$ | 17.53±0.10$^{C}$ |
| | 27 | W | 19.85±0.05$^{A}$ | 17.41±0.11$^{B}$ | 17.81±0.05$^{B}$ |
| 8 | 27 | P | 32.43±0.65$^{B}$ | 33.44±0.16$^{A}$ | 33.12±0.22$^{AB}$ |
| | 27 | W | 33.43±0.17$^{A}$ | 33.38±0.18$^{A}$ | 32.96±0.22$^{B}$ |
| 12 | 27 | P | 41.08±0.10$^{A}$ | 40.81±0.15$^{AB}$ | 40.63±0.11$^{B}$ |
| | 27 | W | 40.95±0.19$^{A}$ | 40.66±0.14$^{B}$ | 40.53±0.17$^{B}$ |
| | 27 | P | 42.53±0.17 | 42.77±0.18 | 42.50±0.17 |
| 16 | 17 | W | 42.15±0.89 | 42.42±0.16 | 42.05±0.13 |

Table 5 showed that body of both genotypes had no significant difference (p>0.05) and was not affected by the location or region where they are kept. The birds from Kimaeti area had slightly higher body lengths than Kanduyi and Webuye. The length of the birds did not show any distinct pattern between the breeds and between the locations other than it increases with advancement of age in both breeds.

**Table 6**: Means and standard errors for genotype and location for shanks of guinea fowl up to 16 weeks.

| Week | Number | Genotype | Kimaeti | Kanduyi | Webuye |
|---|---|---|---|---|---|
| 0 | 27 | P | 2.296±0.020 | 2.304±0.023 | 2.278±0.023 |
| | 27 | W | 2.313±0.020 | 2.304±0.017 | 2.289±0.022 |
| 4 | 27 | P | 4.607±0.037$^{B}$ | 4.793±0.082$^{A}$ | 4.500±0.026$^{C}$ |
| | 27 | W | 4.646±0.028$^{B}$ | 5.193±0.084$^{A}$ | 4.637±0.035$^{B}$ |
| 8 | 27 | P | 6.585±0.067$^{A}$ | 6.392±0.043$^{B}$ | 5.896±0.139$^{C}$ |
| | 27 | W | 6.354±0.047$^{B}$ | 6.470±0.048$^{A}$ | 6.137±0.198$^{C}$ |
| 12 | 27 | P | 8.500±0.043$^{A}$ | 8.387±0.051$^{B}$ | 8.160±0.024$^{C}$ |
| | 27 | W | 8.430±0.036$^{A}$ | 8.230±0.044$^{B}$ | 8.081±0.017$^{C}$ |
| 16 | 27 | P | 8.615±0.037 | 8.681+0.044 | 8.604±0.066 |
| | 27 | W | 8.462±0.039$^{A}$ | 8.474±0.051$^{A}$ | 8.326±0.068$^{B}$ |

The pattern of growth in the shank of the two genotypes investigated were statistically similar (p>0.05) in all age groups of guinea fowls.

**Table 7.** Means and standard error for guinea fowls wing span up to 16 weeks

| Week | Number | Genotype | Kimaeti | Kanduyi | Webuye |
|---|---|---|---|---|---|
| 0 | 18 | P | 3.944±0.03 | 3.878±0.0353. | 715±0.088 |
| | 18 | W | 3.948±0.05 | 3.889±0.038 | 3.650± 0.084 |
| 4 | 18 | P | 8.083±0.17 | 6.878±0.333 | 7.603±0.043 |
| | 18 | W | 8.422±0.11 | 7.670±0.176 | 7.788±0.040 |
| 8 | 18 | P | 16.444±0.04 | 16.530±0.053 | 16.174±0.102 |
| | 18 | W | 16.250±0.07 | 16.552±0.126 | 16.033±0.114 |
| 12 | 18 | P | 20.530±0.08 | 20.430±0.057 | 19.800±0.354 |
| | 18 | W | 20.430±0.03 | 20.310±0.048 | 19.980±0.515 |
| 16 | 18 | P | 26.589±0.17 | 26.362±0.078 | 26.033±0.601 |
| | 18 | W | 26.501±0.09 | 26.288±0.092 | 26.002±0.044 |

The wing span at hatching was significantly higher in Kimaeti than in other regions for both genotypes ($p>0.05$). The White genotype had longer wingspan than the pearl up to the 4$^{th}$ week old (Table 7).

## Discussion

Table 3 shows that the pearl keets were smaller in weight at day old than the white keets, though with statistical insignificance ($p>0.05$) difference. However, the disadvantage of small body weight of the pearl keets was overcome within the first eight weeks of age compared with the white genotype. Fajemilehin, (2010), reported the same scenario when working with the pearl, black and ash genotype in Nigeria. However, contrary to the current study, overtaking of the black and ash by the pearl genotype took place in the first 6 weeks. Thereafter, by the end of the experiment, the pearl genotype showed consistent higher body weight than the white.

Generally, there was significant difference between the two genotypes at the same time of growth ($p>0.05$). However, the birds recorded lower body weights at all stages of their growth compared with birds reported by Samuel and Moreki (2013). Ayorinde and Ayeni (1983) reported that a guinea fowl tend to grow slowly, less than 1kg at 8 weeks of age compared with broiler chicken which attained 1.5 to 2 kg in 6-8 weeks. Fajemilehin (2010) reported very low live weight of 510.41g for the pearl genotype at 12 weeks of age compared with this study which reported 973.6g on the individual birds at the same age.

The results show that body weight of the two local guinea genotypes were moderate at 1210.2 and 1206.8 for the Pearl and White genotypes respectively at 16 weeks old, contrary to Ayorine (1988) and Fajemilehin, (2010). It is suggestive that guinea fowls reared in Bungoma County are medium size strain type and are likely suitable as dual-purpose breed suitable for both meat and egg production.

For improvement to increase body weight and reduce the slaughter age to be achieved, breeding of indigenous guinea fowl should be undertaken by crossbreeding with exotic heavy breeds (Fajemilehin, 2010). Breed improvement is possible given that the heritability estimate for body weight for indigenous guinea fowl ranges from 35% at day old to 40% at 16 weeks (Ayorinde *et al*. 1988) and there is large phenotypic variation in the traits (Nahashon, et al 2006a). Sanjeev *et al* (1997) reported higher heritability.

Difference in body weight of guinea fowls in different regions in the current study may be due to environmental conditions. Kimaeti region showed higher live weight at all stages followed by Kanduyi and lastly Webuye, which was highly attributed to variability in available feed resources in the regions. Abundance of food crops especially energy food is available to the birds during scavenging; this includes maize, sorghum, millet, ground nuts, cassava and sweet potatoes. It seems as if Kimaeti has more favourable

conditions for guinea fowls in Bungoma County due to relatively sparse population with larger land sizes under food crops than Webuye that is non-food crops region. Apart from diversity of food crops growing in the region, another advantage of keeping guinea fowls in Kimaeti is the fact that farmers have been keeping guinea fowl for long period of time. Most guinea fowl keepers in Webuye are beginners and lack necessary experience and skill in rearing the birds. Ayorinde and Oke, (1995) indicated that body weight within a flock can be attributed to environmental factors. As indicated in table 4, the body girth for the pearl at 16 weeks old was higher than the white genotype. Fajemilehin (2010) reported less body girth than the present study. The body girth or chest circumference of guinea fowls generally increased with age advancement. This finding is in agreement with Samuel et al (2013) with studies on guinea fowl fed on yellow maize, sorghum and millet sources of energy in Botswana. Kasperska *et al* (2011) suggested that the increase in body girth indicate normal body growth and good development of internal organs. The body girth taken around the chest region also indicates breast development. The breast development is a good measure of meatiness in poultry (Fajemilehin, 2010). It is one of good predictors of body weight in guinea fowls with positive correlation of 0.78 (Ogah, 2013).

The genotypes did show any significant difference ($p<0.05$) in their lengths at any stage of their lives. The difference was only noticed in locations, whereby Kimaeti birds were longer than Kanduyi and Webuye. The body length can positively influence the body weight of birds. Birds with long bodies like vulturine guinea fowl (*Acryllium vulturine*) tend to have high body weights (Nsoso *et al* 2006). In addition, the body length can significantly contribute to the height of the bird. The long birds have an advantage in noticing the predator fast than short ones.

There was progressive increase in length of the shank of the birds as they grew until 12$^{th}$ week when growth slowed down. This shows that the shank growth is controlled by a gene that is active at early life of bird but becomes inactivated at some time in life. The white guinea fowl exhibited long shanks from day old to the 4$^{th}$ week but the pearl guinea fowl over took them from the 8$^{th}$ week to the end of the experimental period. The shank length increases as the birds grow and therefore has a direct bearing to the weight of the birds since they are ones that carry the weight of birds.

We conclude that neck length is an early maturing trait in both genotypes of the guinea fowls. This is necessary to enable birds to have a good view of their surrounding or detect any danger or predators in advance (Nzoso *et al*, 2006).

The wing span or stretch length was not affected by the genotype or region. In this study, wing span values were higher than those reported by Nzoso *et al*, (2006) and Fajemilehin, (2010) in Nigeria for pearl ash and black genotypes. Ogah, (2010) also recorded lower values of 19.28cm$\pm$0.08 as compared to the current study of 26.123cm and 26.210cm for pearl and white genotypes. Wing span is considered a late maturing trait in poultry (Fajemilehin, 2010) which are a physiological advantage to guinea fowls as they are for flight and can revert easily to feral conditions (Nzoso, et al, 2006).

## Conclusion

The result of this study indicates that the Pearl guinea fowl manifested superiority in adult body indices particularly in body weight and chest circumference which have direct bearing on meatiness in poultry. This ecotype is recommended for meat production in Bungoma County. Additionally, the white ecotype demonstrated better linear measurements and can be used to address the problem of low hatching weights and high keet mortality arising from low hatching weights in guinea fowl production.

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# Inclusion of mastitis resistance in the dairy cattle breeding goal to optimize response to selection

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## Abstract

The current study aimed at deriving the economic value of mastitis resistance and estimation of its response to selection when it is included in the dairy breeding goal. Simulation of breeding schemes resembling those used in pasture-based dairy cattle production systems was made. Selection index methodology (SIP) was used to derive the economic value of somatic cell count (SCC) as an indicator trait for mastitis resistance (MR). Matching the breeding goal to the expected responses to selection for milk yield achieved the derivative. The ZPLAN was used to model the breeding program and compute the response to selection for traits in the breeding goal. Two breeding goals, current and alterative were modeled. The alternative breeding goal accounted for resistance to mastitis while the current breeding goal assumed it. The study findings indicated that the response to selection for MY was maximized when the economic value for SCC was KES -2364.00. At this economic value, the response to selection for MY was KES 6600.00. When SCC was included in the breeding goal, the response to selection increased by 0.23, 0.13 and 0.16%, for annual genetic gain, returns and profitability per cow per year, respectively. Milk yield increased by 0.02%. The implication of these findings is that breeding schemes that breed for mastitis resistance optimizes response to selection.

**Key words**: Breeding goal, Milk quality, Simulation, Somatic cell count.

## Introduction

Mastitis is the most costly disease in dairy cattle production resulting in heavy economic losses annually (Berry *et al.*, 2011). In the tropics the losses have been valued at $38.00 per cow per lactation (Mungube *et al*., 2005). The disease incidence in Kenya is extremely high with over 60% of dairy cows in smallholder production systems producing milk with somatic cell count (SCC) greater than 250 x $10^3$ cells/ml (Omore *et al.*, 1999; Kashongwe *et al.*, 2017). This implies that most smallholder farms encounter huge losses attributed to reduced milk yield and quality, discarded milk during the withdrawal period, high veterinary costs, increased rate of culling and occasionally mortality. Previous attempt to overcome these challenges through conventional strategies such as clean udder hygiene and treatments have not been successful (Omore *et al.*, 1999). There is therefore need for alternative strategies. Breeding for resistance to mastitis has been proposed as an alternative for different reasons. First, animals resistant to mastitis may not easily contract the disease and therefore no economic losses attributed to withdrawal period during treatment. Second, breeding for resistant animals ensure animal welfare concerns and prevent traces of drugs residues in milk. Lastly, disease resistant animals are able to pass the genes to their offspring and therefore the improvement is progressive and cumulative after each generation. Breeding for resistance require inclusion of the disease indicator trait in the breeding goal (Pfeiffer *et al.*, 2015). The current dairy cattle breeding goal in Kenya (Kahi & Nitter 2004), however, does not account for mastitis resistance. The first pre-requisite in inclusion of mastitis resistance in the breeding goal is the estimation of its economic value. Using the dairy cattle breeding program in Kenya as a model, the objective of the current study was to derive the economic value of mastitis resistance and estimate response to selection when it is included in the breeding goal.

## Methodology

### Procedure

The Selection Index Program (SIP) (Hazel, 1943) and ZPLAN (Williams *et al* 2008) were used to estimate the economic value of mastitis resistance and estimate response to selection, respectively. A breeding scheme utilizing Multiple Ovulation and Embryo Transfer with conventional semen (MOET-CS) was adopted. This scheme realized higher response to selection compared to an Artificial Insemination scheme of the same size (Sagwa *et al*., 2018).

### Input Parameters

Input parameters such as the genetic, phenotypic and economic parameters used in the current study were obtained from studies carried out in Kenya (Kahi *et al*., 2004; Kahi & Nitter, 2004: Okeno *et al*., 2010ab). Where such variables were missing they were obtained from studies conducted in the tropics which experience similar production conditions as Kenya (Pfeiffer *et al*., 2015).

### Breeding goal and Selection criteria

Two breeding goals were compared. First was the current breeding goal as defined by Kahi and Nitter (2004). This breeding goal does not account for mastitis resistance. Second was an alternative breeding goal. This breeding goal accounted for mastitis resistance in addition to all the traits in the current breeding goal (Kahi and Nitter 2004). Somatic Cell Count (SCC) was used as an indicator trait for mastitis resistance in the alternative breeding goal. The SCC has been demonstrated to have high and positive genetic correlation with mastitis (0.7) (Carlen *et al*., 2004).

### Traits in the breeding goal

There were two breeding goals which were defined and differed based on whether Mastitis resistance (MR) was included in the breeding objective or not. Pedigree selection was assumed in all the breeding goals. Breeding goal 1 was assumed to be the base scenario upon which the alternative breeding goal was compared. The breeding goal is similar to the current dairy cattle breeding goal in Kenya. The criteria included measurement of MY, FY, AFC, CI, LW, DG, PDG, PSR, PWR and PLT. Scenario 2 was similar to 1 but included MR in the breeding objective. Somatic cell count (SCC) was used as an indicator trait for mastitis resistance. Selection was based on the best index of available criteria in both breeding objectives.

### Breeding Scheme

A two tier closed nucleus breeding scheme was modeled. The first tier represented the nucleus where elite animals are raised and selected for breeding. The superior offspring are used as replacement stock in the nucleus, while the second best are used for breeding in the second tier (commercial). The nucleus depicts large scale farms in Kenya, whilst the commercial tier represented the smallholder dairy farms.

### Population structure

A simulated population of 50,000 cows distributed in two tiers was considered. The nucleus consisted of 5% of the highest ranking cows in the population while the remaining 95% constituted the commercial population. Truncation selection based on estimated breeding values was used to select top ranking males and females for breeding in the nucleus. Candidates not selected for breeding culled and sold for meat.

### Estimation of economic value for mastitis resistance

Economic value is the change in profitability of a production system due to a unit change in genetic gain of a given trait independent of the other traits in the breeding goal (Groen, 1990). The economic value for mastitis resistance was estimated based on the model described by Nielsen *et al* (2005). In that model selection index methodology (Hazel, 1943) is used to match the breeding goal to expected responses to selection in a production trait. The response to selection of the production trait is thereafter optimized relative to overall gain. In the current study the production trait used was milk yield (MY). This is because mastitis has direct impact not only on the quantity of milk produced but also on quality. The economic value of SCC was computed as;

$$SR_T = \frac{\sigma IT}{\sigma I} \times i \tag{1}$$

where $SR_T$ is total selection response in monetary units, **σIT,** the covariance between index and trait **T,** *i* the selection intensity and σI, the standard deviation of the index.

### Prediction of response to selection

All the breeding values were predicted using best linear unbiased prediction (BLUP) by fitting a multivariate animal model to the phenotypes. The model was computed as:

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Za} + \mathbf{e} \tag{1}$$

where **Y** is the vector of phenotypes, a vector of fixed effects, **a**, a vector of random animal effects, **e**, a vector of residual errors, and **X** and **Z** the incidence matrices. The breeding values were computed using (co)variance matrix presented below:

$$\begin{pmatrix} \mathbf{a} \\ \mathbf{e} \end{pmatrix} \sim \mathrm{N}\left(0; \begin{bmatrix} \mathrm{G} \otimes \mathrm{A} & 0 \\ 0 & \mathrm{R} \otimes \mathrm{I} \end{bmatrix}\right) \tag{2}$$

where the matrix **A** is the numerator relationship matrix among all animals, and the matrix **G** is the additive genetic (co)variance matrix of traits in the breeding goal. The matrix **R** is the (co)variance matrix for residual effects.

The of rate of genetic gain for each cow was predicted as linear regression of true breeding values for each trait in the breeding goal weighted by its corresponding economic values and expressed per year.

The economic returns were determined based on profitably per cow in each breeding scheme. The profitability per cow was estimated as:

$$\pi = \sum_{t=0}^{T} \left( \frac{R_t - c_t}{(1+r)^t} \right) \tag{3}$$

where *T* is the evaluation period (25 years), $R_t$ the annual benefits of genetic improvement calculated as realized genetic gain per cow per year, $c_t$ the costs of genetic improvement which includes fixed and variable costs and *r* the discounting rate. The discounting rate of 5% has been recommended when evaluating animal breeding programs (Bird & Mitchel, 1980).

### Data Analysis

Selection index (Hazel 1943) was used to derive economic value for mastitis resistance. On the other hand ZPLAN (William *et al.,* 2008) was used to model the breeding schemes and predict response to selection.

## Results and Discussion

### *Economic value for mastitis resistance*

Our findings indicate that the response to selection for MY was maximized when the economic value for SCC was KES -2364.00. At this economic value, the response to selection for MY was KES 6600.00. An increase or decrease in the economic value for SCC beyond or below the KES -2364.00 resulted to a decline in response to selection for MY. This implies that the negative economic value for SCC found in the current study is desirable for maximization of MY in the breeding goal. Our findings falls within the rage of ZAR -178.65 - -419.48 found in South African Jersey and Holstein dairy cattle breeds at the current exchange rates (Banga *et al.*, 2014).

### *Response to selection*

The annual genetic gain, returns, costs and profit per cow of the evaluated breeding goals are presented in Table 1. Our findings demonstrate that including mastitis resistance in breeding goal increases response to selection. This is evident in Table 1 as the annual genetic gain, returns, and profit per cow per year increased by 0.23, 0.13 and 0.16%, respectively, in the alternative compared to current breeding goal. This increase could be attributed to 0.02% increase in MY observed in response for individual traits (results not presented).

**Table 6**: Genetic gain, returns and Profit (KES) per cow per year realized in the current and alternative breeding goal of dairy cattle in Kenya

| Parameter | Breeding goals | |
|---|---|---|
| | Current breeding goal | Alternative breeding goal |
| Annual genetic gain | 244.01 | 244.57 |
| Returns per cow | 1155.48 | 1157.02 |
| Costs per cow | 181.15 | 181.15 |
| Profit per cow | 974.32 | 975.86 |

The observed increase in milk production could be explained by reduction in response to selection in SCC. This could be attributed to antagonistic relationship between MY and SCC. Therefore, as the SCC decreases, the MY increases. This confirms that the economic value for SCC we found in the current study, optimizes response to selection. Although the effect is small, it is worth noting that genetic gains are cumulative (Müller *et al.*, 2017) and therefore inclusion of mastitis resistance in the breeding goal of dairy cattle may increase MY over generations.

## Conclusion

Study findings demonstrate that, inclusion of mastitis resistance in the breeding goal for dairy cattle optimizes response to selection. Although the increase is less than 1 percent the economic value for SCC found in the current study was desirable and therefore should be considered when including mastitis resistance in the current dairy cattle breeding goal.

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# Donkey uses for food and nutritional security, employment creation, increased export earnings and national development: A review

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## Abstract

In Kenya donkeys numbering 1.83 millions are used for pack, transport and traction. Pastoralists use donkeys to move kraal gear, carry the elderly, the sick and children. Donkeys are used to transport crop harvest, manure, wood and water and in high rainfall areas they are used to pull carts to enable them carry heavier load. They are important in water vending in such municipalities as Limuru and Naivasha. Donkey transport and traction have created employment and reduced drudgery in agriculture particularly among women. Donkeys perform land preparation, planting and weeding in Ithanga, Kibwezi, Kitui, Machakos and Mwea. They produce meat and milk and among Pokot and Turkana donkey meat consumption is common. Donkey meat is widely consumed elsewhere in the world including Mediterranean countries, China, Botswana, Lesotho and West Africa. Where donkey meat is not routinely consumed it is exported to earn foreign exchange as Botswana has thriving export business with China. Entrepreneurs can set up donkey meat processing facilities to produce pet and captive animal food. Donkey milk is consumed among Maasai, Pokot and Turkana as children medicine and survival milk for orphaned infants. Donkey milk is widely consumed in Mediterranean countries, Southern Europe and China. Milk is used in cosmetics because of its abundance in polyunsaturated fatty acids. Donkeys are used for sports for example the Lamu Annual Donkey Derby. Donkeys survive, reproduce and produce meat and milk in harsh environmental conditions. They tolerate endo-ecto and haemoparasites burdens, have better fibre digestion compared to other farm livestock and have low dry matter and water requirement enabling them to survive in arid and semi arid areas. Hence production of donkey meat and milk will open up remote marginal areas of Kenya such as mountainous areas, arid and semi arid areas where even the camel may not tolerate. Elsewhere donkey ranching is popular and Kenya can learn from such enterprises. Hence research and advocacy on the donkey are needed to increase their contribution to national development, employment creation, food and nutritional security and increased export earnings.

## Introduction

Donkeys have not received adequate attention in research, production and commercialization of their products in Kenya and is mainly used for transport as pack animals or pulling carts (Mutua, 2000; Twerda et al., 1997; Pearson et al., 1999). Among the pastoralists the donkey is used to move kraal gear, carry the elderly, the sick and children (Twerda et al., 1997; Aganga et al., 2003; Kohler-Rollefson and Wanyama 2003). The donkeys are also used to transport crops, crop byproducts, manure, wood and water (Mutua, 2000; Ndlovu et al., 2000; Swai and Bwanga 2008). Good examples in Kenya are Elburgon, Kericho and Molo where donkeys are extensively used to transport farm inputs, crop harvest and marketing and maize meal to and from *Posho Mills*. In high rainfall areas donkeys are used to pull carts to enable them carry more load including household and construction materials, farm produce and water (Fernando and Starkey 2000). They play major roles in water vending in such municipalities as Limuru and Naivasha. The donkeys and their carts are also hired out for commercial purposes (Fernando and Starkey 2000). The donkeys are used in land preparation, planting and weeding (Ndlovu et al., 2000; Ariaga-Jordan et al., 2005; Swai and Bwanga 2008). In Kenya donkeys are also used for land preparation, planting and weeding in Ithanga, Kibwezi,

Kitui, Machakos and Mwea where. donkey owning households cultivate larger fields (Fernando and Starkey 2000; Kumwenda 2000; Ndlovu et al., 2000). Other products from the donkey include meat and milk. Among the Pokot and Turkana consumption of donkey meat is common (Kohler-Rollefson and Wanyama 2003). Some Kenyans in Limuru, Nairobi and Naivasha have unknowingly consumed donkey meat sold in the butcheries. Donkey meat is widely consumed elsewhere in the world including the Mediterranean countries, China, Botswana, Lesotho and West Africa (Patrick et al., 2000; Polidori et al., 2008; Marino et al., 2009; Nwokwa, 2011). Where donkey meat is not routinely consumed it can be exported to earn foreign exchange as Botswana has thriving export business with China (Patrick et al., 2000; Chinese Embassy 2003). Entrepreneurs set up donkey meat processing facilities for the production of pet and captive animal food (Patrick et al., 2000). Donkey milk is also consumed among Maasai, Pokot and Turkana mainly as children medicine and survival milk for orphaned infants (Twerda et al., 1997; Kohler-Rollefson and Wanyama 2003). Elsewhere in the world donkey milk is widely consumed including Mediterranean countries, Southern Europe and China (Polidori et al., 2008; Marino et al., 2009; Salimei et al., 2012). Milk is also used in the cosmetics industry because of its high content of polyunsaturated fatty acids (Salimei et al., 2012).Donkeys are also used for riding by children, women, the sick and the elderly among the pastoralists (Aganga et al., 2003; Kohler-Rollefson and Wanyama 2003; Swai and Bwanga 2008). Donkeys can be used for sports for example the Lamu Annual Donkey Derby. They can also be used as pets in Europe (Cox et al., 2010) and for prestige in Africa (Fernando and Starkey 2000; Kumwenda 2000; Swai and Bwanga 2008).

## Donkey transport and traction

The major advantages in the use of donkeys in transport and traction include the fact that there is abundant traditional knowledge about donkey utilization and management (Twerda et al., 1997; Fernando and Starkey 2000; Kohler-Rollefson and Wanyama 2003), availability of a huge donkey population and cheaper to buy and use than oxen (Fernando and Starkey 2000; Mutua, 2000; Mushi, 2003). There are over 1.83 million donkeys in Kenya with 988.7, 382.4 and 304.3 thousand distributed in the Rift Valley, North Eastern and Eastern Provinces respectively (KNBS, 2009). The donkeys provide cheap and readily available transport (Aganga et al., 2003; Fernando and Starkey 2000; Mushi, 2003). Donkeys are docile lending them easy to train and convenient handling by women and children and can be effectively handled by one person (Fernando and Starkey 2000; Mushi, 2003; Swai and Bwanga 2008). They are economical for small scale farming (Fernando and Starkey 2000; Olupot and Sseruwo, 2000; Mushi, 2003) and hardy for countries with diverse terrains, harsh climatic conditions, poor infrastructure and veterinary attention (Aganga et al., 2003; Mushi, 2003; Swai and Bwanga 2008). Donkeys tolerate endo-ecto and haemoparasites burdens relatively well (Aganga et al., 2003; Mushi, 2003; Swai and Bwanga 2008). They have better fibre digestion compared to other farm livestock (Pearson et al., 2000; Aganga et al., 2003; Smith and Pearson, 2005) and their small body size, low DM and water requirement enable them to survive in arid and semi arid areas (Kohler-Rollefson and Wanyama 2003; Smith and Pearson, 2005; Swai and Bwanga 2008). Donkeys are efficient and economical in water use (Aganga et al., 2000; Smith and Pearson, 2005). They are stronger than oxen of similar size and withstand drought better without need for supplementation (Fernando and Starkey 2000). Donkeys are rarely stolen due to their low value and traditional believes (Fernando and Starkey 2000).

Some of the disadvantages in donkey transport and traction are that due to the small size, the donkey generates low power suitable only to carting and light field work such as carrying light load, ploughing and weeding (Kumwenda, 2000; Pearson et al., 1999; Aganga et al., 2003). Donkeys are unsuited in tsetse areas and those with high tick borne diseases challenge (Pearson et al., 2000; Wold, 2000; Swai and Bwanga 2008). They have low status in livestock ranking (Kumwenda, 2000; Mutua, 2000; Kohler-Rollefson and Wanyama 2003) and communities harbour negative attitude towards donkeys (Fernando and Starkey 2000; Olupot and Sseruwo, 2000). Donkey salvage value is low as many communities do not slaughter them for meat unlike the case with oxen (Kumwenda, 2000; Ladeinde and Ademiluyi, 2000; Pearson et al., 1999). Donkey theft can be major menace particularly where demand outstrips supply mainly during peak land preparation and harvest season (Pearson et al., 1999). In Kenya donkeys can be categorized according to

their work types, terrain of their region and weight of their load according to the programme '*Heshimu Punda*' within the Kenya Network for Dissemination of Agricultural Technologies (KENDAT). Tillage donkeys are mainly used for land tillage purposes. They pull ploughs and other farm implements and in some areas they are used together with other livestock especially oxen. In Kenya such donkeys are found in Ithanga, Kibwezi, Kitui, Machakos and Mwea. Donkey owning households can cultivate larger fields, plant and weed timely with resultant higher crop yields (Fernando and Starkey 2000; Kumwenda 2000; Ndlovu et al., 2000). These contribute to food and nutritional security, increased incomes and savings that enhance national development. Donkey transport and traction have created employment and reduced drudgery in agriculture particularly among women. Donkeys categorized in Transport by cart (TGC) are used to transport load by cart and are mainly used in urban and peri-urban areas for commercial purposes. Another category of donkeys are those that transport by pack (TGP) which are mainly used in pastoral areas and in hilly terrains and transport light load. The pack load is placed in the middle of the donkey's back. Foals and old donkeys include donkeys that are either too young to work (foals) or too old to work (retired donkeys) can be sold to provide farmers' income.The foals can be sold for rearing by other farmers and retired donkeys sold for slaughter to produce pet and captive animals' food or meat exported to such countries as China to increase export earnings in Kenya. An individual donkey can carry a load which is more than one third of its body weight which is approximately 40 to 80 kg load. The donkey pulling strength is mainly the chest, breast and shoulder region in contrast to the oxen whose strength is in the neck region. KENDAT has focused on donkeys categorized as Transport by cart (TGC) which are used to transport load by cart and are mainly used in urban and peri-urban areas for commercial purposes. In their '*Heshimu Punda*' programme in urban and peri-urban areas, KENDAT reported that out of the 11,985, 9,962, 7,860, 7,235 and 3990 reared in Kiambu, Nairobi, Nyandarua, Meru and Kirinyaga, 98, 100, 95, 95 and 99 were used to transport goods by cart. The remaining donkeys predominantly transported their loads by pack. This was in contrast to Embu where 80 % of the 3,791 donkeys transported their loads by pack as they were in the drier Mbeere District. These donkeys are used to generally transport produce to market especially in Kiambu where donkeys transported leaf vegetables, potatoes and milk whereas in Kirinyaga donkeys were greatly commercialized in transporting rice, farm produce, building materials, household goods and shop merchandise. These commercial transactions increase employment opportunities, increase citizens' income and contribute to national development.

## Donkey meat

Customers prefer meat that is tasty, rich in protein and low in lipids and cholesterol (Marino et al., 2009; Palidori et al., 2009; Palidori et al., 2011). Donkey meat has low fat and cholesterol and high protein and it is suitable for human consumption considering both its chemical composition, tenderness and ease of processing (Aganga et al., 2003; Nwokwa, 2011; Palidori et al., 2011) (Table 1).

**Table 1**: Mean composition of donkey meat

| Component | Mean | S.E. | Minimum | Maximum |
|---|---|---|---|---|
| Moisture, % | 373.7 | 3.26 | 70.1 | 77.8 |
| Fat, % | 2.02 | 0.61 | 1.18 | 2.81 |
| Protein, % | 22.8 | 2.63 | 20.3 | 23.7 |
| Ash, % | 1.01 | 0.22 | 0.89 | 1.23 |
| Energy value (MJ per kg) | 4.85 | 1.02 | 4.04 | 5.24 |
| Cholesterol (mg/100g) | 68.7 | 3.44 | 64.2 | 72.8 |

Source: Palidori et al., 2008

Donkey meat has high content of fatty acids with high concentration of polyunsaturated fatty acids (PUFAs) preferred in meat (Marino et al., 2009; Palidori et al., 2009). The meat also has high concentration of

essential amino acids (Palidori et al., 2008; Palidori et al., 2009; Palidori et al., 2011). High level of unsaturated fatty acids result in high ratio of unsaturated to saturated fat and the total amount of essential amino acids, exceeding 50 % of the total amino acids showing that donkey meat from a health point of view is a good alternative to traditional red meats (Aganga et al., 2003; Marino et al., 2009; Palidori et al., 2009). The red colour in meat indicates freshness and determines consumer purchasing decision and donkey meat colour is very similar to other red meats (beef, lamb) (Palidori et al., 2009). Donkey meat is rich source of macro and micro minerals (Aganga et al., 2003; Palidori et al., 2008; Nwokwa, 2011) (Table 2). The donkey also has high dressing percentage of 54.5 to 59.5 % (Aganga et al., 2003; Palidori et al., 2008; Nwokwa, 2011) and can increase the donkey value both for domestic use and export (Aganga et al., 2003; Chinese Embassy 2003; Palidori et al., 2008).

**Table 2**: Mineral composition of donkey meat

| Mineral (mg/100g) | Mean | S.E. | Minimum | Maximum |
|---|---|---|---|---|
| Calcium % | 8.65 | 2.13 | 6.12 | 11.5 |
| Magnesium | 24.8 | 6.71 | 18.5 | 33.6 |
| Potassium | 343.7 | 65.9 | 312.0 | 438.3 |
| Phosphorus | 212.9 | 56.7 | 185.5 | 334.5 |
| Sodium | 52.5 | 13.3 | 36.8 | 83.6 |
| Zinc | 3.67 | 0.78 | 2.99 | 4.71 |
| Iron | 3.80 | 1.01 | 2.86 | 4.77 |

Soucre: Palidori et al., 2008

Donkey meat production can be of interest to specific farmers and consumers (Palidori et al., 2008; Nwokwa, 2011; Palidori et al., 2011). For example donkey meat consumption is traditional in Southern Italy (Palidori et al., 2009). Mediterranean countries interest in donkey rearing increased due to nutritional properties of donkey meat. The meat is consumed fresh, cold matured or processed to produce salami, salted meat-based products and other kinds of ripened meat (Palidori et al., 2009; Palidori et al., 2011). Donkeys can survive, reproduce and produce meat and milk in hard environmental conditions (Kohler-Rollefson and Wanyama 2003; Marino et al., 2009; Salimei and Fantuz , 2012). Meat can be obtained at the end of donkeys' working life and from mature males, excess donkeys due to replacement by machinery and male foals used for meat production (Palidori et al., 2009; Palidori et al., 2011). In some countries donkey ranching has become popular (Chinese Embassy 2003; Palidori et al., 2011). The meat quality has become an important consideration to include such studies as the effect of different slaughter age on chemical composition and tenderness of donkey meat obtained from different breeds (Aganga et al., 2003; Palidori et al., 2008; Palidori et al., 2011). Unlike in Kenya, donkey meat is widely consumed elsewhere in the world including Mediterranean countries, China, Botswana, Lesotho and West Africa. Where donkey meat is not routinely consumed such as in Kenya, it is exported to earn foreign exchange as Botswana has thriving export business with China. Entrepreneurs can also set up donkey meat processing facilities to produce pet and captive animal food further increasing export earnings for Kenya. There will be a big impact on National Development, Employment Creation, Food and Nutritional Security and Increased Export Earnings if donkey ranching is popularized in the Rift Valley, North Eastern and Eastern Provinces where approximately 54, 21 and 17 % of donkeys are found in Kenya.

## Donkey milk

In Kenya donkey milk is consumed among Maasai, Pokot and Turkana mainly as children medicine and survival milk for orphaned infants (Twerda et al., 1997; Kohler-Rollefson and Wanyama 2003). Elsewhere in the world donkey milk is widely consumed including Mediterranean countries, Southern Europe; China and (Polidori et al., 2008; Marino et al., 2009; Salimei et al., 2012). The milk has been successfully used as

an alternative food for infants with food allergies which affects approximately 3% of infants below 3 years (Table 3).

**Table 3:** Composition and energy content of donkey milk

| Parameter | Horse | Donkey | Human |
|---|---|---|---|
| Total solids (g per kg) | 110.0 | 95.3 | 125.0 |
| Lactose (g per kg) | 61.0 | 65.8 | 64.4 |
| Total N x 6.38 (g per kg) | 21.4 | 16.5 | 12.5 |
| Fat (g per kg) | 14.0 | 7.6 | 34.6 |
| Ash (g per kg) | 4.5 | 4.1 | 1.9 |
| Gross energy(MJ per kg) | 2.10 | 1.76 | 2.60 |

Source: Salimei et al., 2012

It is commonly fed to orphan children as it resembles breast milk (Tadesse, 2010; Rathore, 2011; Salimei et al., 2012). The flavour and appearance of the milk have been found attractive to children, which is of particular importance to young consumers (Salimei et al., 2012). The milk and it's fermented derivatives are effective in immune recovery in elderly consumers due to their immunological activities. Such benefits require adoption of specific milking equipment and routine to achieve high quality products and economically feasible production. The milk is rich source of macro and micro minerals (Rathore, 2011; Salimei et al., 2012) (Table 4).

**Table 4.** Mineral composition of donkey milk

| Mineral (mg/L) | Horse | Donkey | Human |
|---|---|---|---|
| Calcium | 500 – 1300 | 330 - 1140 | 278 |
| Phosphorus | 200 – 1200 | 320 - 650 | 140 |
| Potassium | 300 – 800 | 240 - 747 | 530 |
| Sodium | 167 – 200 | 11 - 268 | 180 |
| Magnesium | 40 – 110 | 40 - 83 | 35 |
| Ca/P | 1.72 | 0.93 – 2.37 | 1.7 |
| Iron | 0.22 – 1.46 | 0.43 – 2.64 | 0.72 |
| Zinc | 0.9 – 6.4 | 1.23 – 3.19 | 1 - 3 |
| Copper | 0.2 – 1.0 | 0.08 – 0.30 | 0.2 – 0.4 |
| Manganese | 0.01 – 0.05 | trace | 0.003 – 0.006 |

Source: Salimei et al., 2012

Milk yield is proportional to body weight (2.5-3 kg per 100 kg) with donkeys producing 266 to 870 ml per milking, with a monthly persistence of 85 to 90 during the period 30 days to four months then stabilizing at 600 to 800 ml until the ninth month of lactation (Chiofalo et al., 2004; Polidori et al., 2009; Salimei et al., 2012). The colostrum milk and other milk are processed into special high value products in Europe (Salimei et al., 2012). Production of donkey milk will open up remote marginal areas of the Kenya such as arid and semi arid, mountainous areas in Rift Valley, North Eastern and Eastern Provinces where even camels may not tolerate. Production of donkey milk and popularization of its products will contribute to national development, employment creation, food and nutritional security. Milk is also used in cosmetics because of the polyunsaturated fatty acids and proteins described as important in natural active skin hydration and skin aging prevention (Salimei et al., 2012). Donkey milk use in such products will induce industrialization, further contributing to national development, employment creation and increased export earnings.

## Constraints to donkey uses

The Government needs to mainstream donkeys and their products in the livestock sector. There are few well trained personnel on modern donkey technology with the resultant little communication and transfer of knowledge. There is little collaboration among players in the donkey value chain. Donkey transport and traction tools, gear, carts, implements and equipment used are inappropriate as they are adaptations from those used by oxen. There are no specific management practices to allow donkeys to fully maximize their natural survival advantages due to poor management. Donkeys are subjected to inadequate feed, exposed to diseases and heat stress particularly during work season. Feed quality can be so poor that donkeys are unable to eat enough to meet energy requirement for work and loose weight in dry season hence leading to the traction potential not being fully utilized. There is need to determine the effects of frequency of watering on intake and digestibility of feeds and work output. In meat production there is need to determine the nutritional effects of different feeding strategies on meat quality. Studies should also determine the effects of different slaughter age on chemical composition and tenderness of donkey meat obtained from different breeds and their influences to protein and mineral content and meat toughness. Majority of Kenya citizens are unfamiliar with donkey uses as sources of transport, meat and milk and the minority who may be familiar harbour negative attitudes towards these products. Donkeys are ranked low in community animal wealth and are popular subject of ridicule. The community lacks evidence and awareness of the possibilities and benefits of donkey meat and milk production. There is little effort to demonstrate the donkey as an alternative option for infant nutrition. Hence there is need for advocacy to minimize the negative attitude and taboo associated with the donkey in general and donkey meat and milk in particular. Most quality parameters of meat and milk have not been adequately investigated particularly on nutritional, medicinal, microbiological and cosmetic value of donkey milk.

## Conclusion and recommendations

In Kenya donkeys are mainly used for transport as pack animals or pulling carts and among the pastoralists the donkey is used to move kraal gear, carry the elderly, the sick and children. The donkeys are also used to transport crops, crop byproducts, manure, wood and water. There is need to design and test appropriate tools, gear, carts, implements and equipment to improve efficiency and effectiveness in donkey transport, traction and as pack. There is need to develop and disseminate specific management practices to allow donkeys to fully maximize their natural survival advantages. Donkeys should be adequately fed, protected from diseases and heat stress minimized particularly during work season. Favourable Government policies should be formulated on donkeys and their products. More personnel should be trained on modern donkey technology with the resultant increase in effective communication and transfer of knowledge.

Donkey meat has low fat and cholesterol, high protein and essential micro minerals making it suitable for human consumption. The meat has suitable chemical composition, tenderness and ease of processing and the donkey has high meat dressing percentage. However, majority of Kenya citizens are unfamiliar with donkey use as a source of meat and the minority who may be familiar harbour negative attitudes towards donkey meat. Hence there is need for advocacy to minimize the negative attitude and taboo associated with the donkey in general and donkey meat in particular. The donkey milk has been successfully used as an alternative food for infants with food allergies which affects approximately 3% of infants below 3 years and it is commonly fed to orphaned children as it resembles breast milk. The milk and its fermented derivatives are effective in immune recovery in elderly consumers due to their immunological activities. However, the Kenyan community lacks evidence and awareness of the possibilities and benefits of donkey milk and there is little effort to demonstrate the donkey as an alternative option for infant nutrition. Hence there is need for advocacy to minimize the negative attitude and taboo associated with the donkey milk. The Government of Kenya needs to attract investors in donkey meat and milk production to invest in donkey ranching and donkey dairying particularly in the Rift Valley, North Eastern and Eastern Provinces.

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# Greenhouse Pollination of Cucumber, *Cucumis sativa* L, by Use of Honeybee, *Apis mellifera scutellata* Swarm

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## Abstract

Migrating or reproductive Honeybee swarms could be domesticated or conserved, in a Bee hotel, for utilization in pollination services. Cucumber, *Cucumis sativa* L, benefits from honeybee pollination. The crop was planted from seed in a greenhouse, 8x24 Meters in size. Drip irrigation was applied. *Apis mellifera scutellata* swarm, from a known bee conservation Hotel was introduced for pollination. The resultant flowers were tallied and compared with the resultant fruits, for productivity. The latter was compared with the plants on the outside plot, exposed to multiple pollinators. The greenhouse plants yielded more Cucumber and were straight in appearance, compared to the bend ones from the outside plot, clearly demonstrating pollination deficiency, due to the perimeter wall surrounding the area. The Cucumber in the greenhouse were effectively and efficiently pollinated by the single pollinator, the honey bee, *Apis mellifera scutellata* swarm. Aphid invasion was, however, notable in the greenhouse than on the outside plot. The sudden effect on the plant was adverse, requiring instant remedy as the aphids sucked juices from the Cucumber plant, leaving it to dry-up. It was recommended that the affected plant be uprooted and disposed of as soon as the infestation was manifest, to limit the rapid spread to neighbouring plants.

**Key words:** Honey bees, pollination, green house, Cucumber

# ROLE OF INFORMATION AND COMMUNICATION TECHNOLOGY IN LIVESTOCK REARING

## National/ County Dairy Baseline Data and Strategic Planning Framework Tool

**Dominic Menjo**

The current scenario of the dairy sector in Kenya is that of a very vibrant industry. This picture could be true to some extent but could also be better or worse. This is because most of the data used to paint the industry are based on sampled surveys, projections, and estimates. Players in the value chain have severally disputed the reliability of the above information. Kenya dairy processors Association (KDPA) have doubted the annual volume of milk produced in the country since their current capacity utilization is hardly 40%. The SDP study found substantial variation between official government statistics and available survey data in most areas surveyed, average SDP projections were four and three times higher than the official government numbers for improved breeds and local breeds, respectively.

The last livestock census was conducted in 1988; whatever figures that have been subsequently used for planning and other purposes were projections. The current official cattle population statistics come from the Ministry of Livestock and Development, through its field reports compiled by extension officials. An attempt was made during the Kenya National Population and Housing Census 2009 to include survey on livestock population but the enumerators were focused on human population and related information thus data obtained may not be accurately used for dairy planning.

There has been concern regarding the accuracy of these figures. Various grounds have been advanced to challenge the accuracy of the livestock population figures. The arguments are varied, some of which are valid though not verified. Among the grounds for dispute are: Culturally, many communities in Kenya are not inclined to disclose the number of animals they possess for fear of losing them and thus census clerks did not therefore carry out head counts to validate obtained figures. All livestock age groups were not taken into consideration eg in obtaining the number of chicken, it was common to give the number of adult birds and leaving out the chicks. The same applied to other livestock categories.

In recognition of lack of data in the dairy sector dairy stake holders led by Kenya dairy board (KDB), Kenya dairy processors association (KDPA) other dairy stakeholders have developed a harmonized tool that could guide the counties on data gathering and dairy strategic development.

The process involves: County introduction forum, County dairy stakeholder forum, Technical forum, County stakeholder forum 2, Documentation, Annual Data review.

Expected outputs: County dairy data (60%) accurate, County strategic plan framework, County dairy standard operating procedures, Strategic areas budgets, Dairy value proposition document to investors in all the participating counties, basis for actual farmer registration and cow registration process.

# Health Benefits of Camel Milk, Challenges and Future Prospects

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## Abstract

The Climate change has contributed towards the increased camels keeping system peri-urban due to abundance browses around the peri-urban centres. In the past, indigenous camel keepers i.e, Somali, Gabbra, Rendille, and Turkana were shunning areas around towns mainly due to challenges facing camel production such as, bad terrain, traditions believes, inadequate preferred feeds (poisonous plants like *Capris tomintosa*), diseases and tick loads. However, with increased demand for camel milk camel production in peri-urban is now viewed as new investment opportunity. Unlike cattle, camel is resistant to severe droughts and has potential to provide milk throughout the year. Camel long distance grazing area of 25km radius gives them comparative advantage over other livestock in provision of milk. Motor bikes, improved road infrastructure, improved camel milk market facilities like cold chains in centres has made camel milk trade an economic activity. There is need for value addition of camel milk and improved packaging to appeal to non- camel milk consumers. Promotion of camel dairy breeds such the Horr-Somali camel. More research work on the said medicinal and health benefits of camel milk need to be evaluated and if any positive be exploited.

## Introduction

Kenya has the fifth largest population of camels in Africa, after Somalia, Sudan, Mauritania and Ethiopia. The country has an estimated population of about 1.6 million camels (MoLD, 2010). They are mainly concentrated in former north Eastern (54%), Eastern (Marsabit, and Isiolo Counties (29%), Rift Valley (13%) and Coast regions (4%). The Arid and Semi-Arid lands (ASALs) hold about 80% of Kenyan camels**.** The camel's unique physiological, anatomical and ecological adaptations enable the camel to produce and supply milk to pastoral households throughout the year (Farah, 1996). In the face of recurrent droughts, more and more communities that were not traditional camel keepers are increasingly turning to camel rearing to ensure food and nutrition security. Additionally, camel rearing within peri-urban areas for the purpose of supplying milk to increasing human population within the centre. Isiolo per-urban camels send 1500-3000 lts. of milk to Nairobi Somali comities, presently there is no value addition on camel milk apart from packaging by vital camel milk in Nanyuki and a group a group of women in Isiolo who are makine ghee then adding perfume and using it as body lotion. There is milk has potential of doing a lot of natural health and beauty lines products. Camels don't produce as much milk daily as cows do, this makes to be quite rich in skin-loving ingredients like alpha-hydroxyl acids and vitamins, that'll leave your skin feeling soft and smooth. There are plenty of these products in camel keeping countries where we can learn from.

## Methodology

The study was undertaken in Isiolo (LMD area) and Churaa in marsabit county. Most of the information was collected from key informants and two women group who were producing and selling camel milk from the two sites. Desk top research was also undertaken to check if there is any information on the same.

## Result and Discussion

Most of camel keepers believes that camel milk has medicinal value but don't know what disease can be treated and what amount to be taken. Camel keepers do believe taking camel milk keeps them young and strong and allows for a long day work and trekking without extra food or water. Some research work has been done at kulamawe and mulango in Isiolo on provision of camel at different levels in reducing the levels

of dependence on insulin in diabetic patient. The problem is that the report is not yet out student work. Desk top research reviewed the following, that camel milk either aids or reliefs the following.

## Diabetes Treatment

Camel milk has a wealth of nutrients, including insulin, which is an essential component of human health. The balance between insulin and glucose is very important for the prevention of diabetes, making it a potential natural solution for diabetes. If a steady stream of camel milk is included in the diet, it will eliminate the need for insulin injections. If used as a preventative measure, it can also stop you from developing the disease in the first place.

A two-year study found that among type-1 diabetics who received 500 ml. of camel milk in addition to diet, exercise and insulin, there was an overall decrease in blood glucose and insulin levels compared to those patients who received only diet, exercise and insulin, while some completely eliminated the need for insulin.

## Boosts Immunity

There is a surprisingly high level of proteins in camel milk is protein 3.1%; fat 3.5%; lactose 4.4%; ash 0.79%, and total solids 11.9% (11–16) compare to 87.7% water, 4.9% lactose (carbohydrate), 3.4% fat, 3.3% protein, and 0.7% minerals (referred to as ash) in cow milk and other organic compounds in camel milk, some of which have powerful antimicrobial abilities. This means that it can help to boost the immune system and keep us healthy

## Autism Treatment

The high concentration of unique organic compounds has been known to have particularly powerful effects on the neurological system and can even prevent certain autoimmune disorders. Numerous case studies have shown that autistic symptoms have been lessened or erased completely when camel milk was taken regularly. The exact pathways are unknown, but this is a potentially invaluable new remedy for a tragic affliction.

## Allergic Reactions

Camel milk has been connected to reducing allergic reactions in those who regularly consume it. Furthermore, it does not cause the same sorts of lactose intolerance reactions of cow milk, as it has a significantly different chemical makeup

## Camel Milk Nutrition

Camel's milk is lower in calories and saturated fat than cow's milk. One glass of camel's milk is has 110 calories and 4.5 grams of fat, compared with 150 calories and 8 grams of cow's milk. Camel's milk also has less than half the saturated fat as cow's milk, 3 grams vs. 8 grams. Camel milk is substantially higher in vitamin B3, iron and vitamin C than cow's milk and also has less lactose in it, People who can't tolerate cow's milk have no issues digesting camel's milk.

## Cancer

Cancer is a very serious illness and studies show that camel milk actually improves chemotherapy treatment and reduces many of the negative side effects of the treatment. Dr. Hinkle recommends that patients go on a gluten-free/casein-free diet for a short period of treatment time, except for the camel milk. She also asks patients to avoid soy, food coloring and food additives, such as MSG, etc., while undergoing treatment. This

enables inflammation from the food to cease, and the body to use its resources to try and heal itself instead of fighting the allergic reactions to food. “It is very good to avoid any foods that you know you are allergic to when trying to heal the immune system,” states Dr. Hinkle. There are specific nutrients that can help cancer patients while undergoing treatment and recommends that all patients take a good quality brand of supplements that are not loaded with fillers.

## Hepatitis patients

Hepatitis patients whose liver enzymes have been normal for the first time in years while on the milk. One 80-year-old patient’s test results were normal after 40 years of elevated liver enzymes after being on the milk for only two weeks.

“The antiviral properties in the milk seem to dissipate the inflammation of the liver and the milk also provides many of the nutrients needed for healthy liver function”/

## Key constraints in camel milk production

1. Poor milk production from lactating camel 3-5 lts per day
2. Long trekking distance up to 25km thus reduce milk production.
3. High milk prices
4. Hygiene milk handling and fumigation of milking containers
5. Lack of cool chains in production areas

## Camel Milk Marketing

All the camels’ keepers are mainly using camels for milk for their domestic use and marketing. Most respondent’s sale between 3-20 litres of milk on a daily basis. There are two Milk camel milk Factories one in Nanyuki (Vital Camel milk Private and Garrissa women group).

## Conclusion and Recommendations

This study examined camel milk health benefits, challenges and future prospects. Among indigenous camel keepers Somali, Gabbra, Rendille Sakuyes and Turkana. With modern livestock drugs, climate change, and demand for camel milk by huge urban population, Camel rearing for milk production is on the rise with new players like Borana, Samburu and Pokot communities joining the league. Camel milk health benefit is making many people to go for milk either to be cured with the supper food, Camel milk is the closest you can get to a human mother's milk, with 10 times more iron and three times more vitamin C than cow's milk (The results published in FAO are shown (below). The average amount of components of camel milk is protein 3.1%; fat 3.5%; lactose 4.4%; ash 0.79%, and total solids 11.9% (11–16). The most important factor in camel milk is water content. The total solid content is similar to that human milk (17).

Further research be carried out on integrated camel production systems, How to introduce clean milk hygiene, There is need to improve on value addition of camel milk and setting up cottages in peri urban areas to value add camel milk and also making of soaps and other beauty products from camel milk in Kenya.

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http://www.camelmilkassociation.org/index.php/camel-milk-did-you-know

Camel Milk: The Biggest Hump in the Milk Industry.

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