IMPACT OF NUTRITIONAL PRACTICES ON MILK LOSS AND WASTAGE IN DAIRY FARMING: A CASE STUDY OF BUNGOMA COUNTY, KENYA

SUSAN NYAGICHUHI NJUGUNA

A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Master of Science Degree in Animal Nutrition of Egerton University

EGERTON UNIVERSITY

NOVEMBER, 2025

DECLARATION AND RECOMMENDATION

Declaration

This is to declare that the work contained herein is my original work and that it has not been submitted to Egerton University or any other institution of higher learning for examination.

Signature: Date: 11th November 2025

Susan Nyagichuhi Njuguna

KM113/04122/22

Recommendation

This thesis has been submitted with our approval as University Supervisors.

Signature: Date: 12th November 2025

Prof. James O. Ondiek, PhD

Department of Animal Science

Egerton University

Signature: Date: 12th November 2025

Dr Fred Kemboi, PhD

Department of Animal Science

Egerton University

Signature: Date:13th November 2025

Dr. Joseph O. Anyango, PhD

Department of Dairy, Food Science and Technology

Egerton University

COPYRIGHT

DEDICATION

Dear family, your never-ending support, patience and encouragement have meant so much on this journey. My strength and balance throughout, your love, inspiration and belief in me have been. With heartfelt gratitude, I dedicate this work to you.

ACKNOWLEDGEMENT

I sincerely thank Food Waste Reduction and Food Quality Living LAB (FORQLAB) via Center of Excellence for Livestock Innovation and Business (CoELIB) at Egerton University for funding this project and the willingness to cooperate and participate of the eager dairy farmers in Bungoma County. I would like to extend my gratitude to my supervisors, Prof. James Ondiek, Dr. Fred Kemboi and Dr. Joseph Anyango for their kindness and guidance.

ABSTRACT

In Bungoma County in Western Kenya, dairy farming is an important economic activity in Bungoma County in Western Kenya. However, optimising dietary strategies to improve milk output and minimize losses continue to pose significant challenges. Still, the optimization of nutritional strategies for enhanced milk production and reduction of milk losses and wastage is a problem. Therefore, this study aimed to assess the effects of different nutritional practices by dairy cattle farmers on milk loss and wastage in Kitinda and Kaptama milk collection centres, Bungoma County, Kenya. The first objective involved proximate and *in-vitro* degradability analysis of feed. The second objective determined the milk quality parameters and safety. The third objective involved the assessment of the general dairy performance attitudes, the dairy cattle feeding practices, losses, and wastages. The gas production method was used to determine the *in-vitro* organic matter digestibility. Raw milk butterfat, protein, and density were measured by Gerber, Kjeldahl, and lactometer methods respectively. Aflatoxin levels in feed and milk were assessed. For the third objective, 200 farmers from Kitinda and Kaptama were sampled. The most common feeds in the areas were, crop residues and roughages. Data collected was subjected to the analysis of variance in a completely randomized design using the General linear model procedure of Statistical Analysis System version 9.4, Pearson correlation as well as excel. Super Napier (*Pennisetum purpureum* × *P. glaucum*) had the highest crude protein content of 149.3 g/kg dry matter (DM), and neutral detergent fibre content at 733.3 g/kg DM, and maize silage had the lowest crude protein at 56.1 g/kg DM. Sugarcane tops had the lowest crude protein content at 27 g/kg DM. At 24 h and 48 h fermentation, the rate of gas production was highest in fodder crops and trees, particularly lucerne, at 12.7%, and 10% compared to *calliandra* sesbania and *leuceana* while crop residues such as sugarcane tops had the lowest at 1.60 %. Aflatoxin assessments showed that 30.77% of samples from Kitinda MCC and 23.53% from Kaptama MCC exceeded the recommended aflatoxin threshold of 50 µg/kg. About 77.5% of farmer's experience significant losses primarily due to feed-related factors (44%) and health issues (19.5%). Most farmers (90.5%) acknowledge a direct link between feeding practices and milk yield. This study concludes that fodder trees and legumes have superior nutritional profiles compared to crop residues, which are of low quality. High aflatoxin levels and poor feeding practices are key factors reducing milk production in Bungoma County.

Table of Contents

DECLARATION AND RECOMMENDATION ..... **i**

COPYRIGHT ..... **ii**

DEDICATION ..... **iii**

ACKNOWLEDGEMENTS ..... **iv**

ABSTRACT ..... **v**

LIST OF TABLES ..... **x**

LIST OF FIGURES ..... **xi**

LIST OF ABBREVIATIONS AND ACRONYMS ..... **xii**

CHAPTER ONE **1**

INTRODUCTION **1**

1.1 Background information 1

1.2 Statement of the problem 3

1.3 Objectives 4

1.3.1 General Objective 4

1.4 Hypotheses 4

1.5 Research Question 4

1.6 Justification 4

CHAPTER TWO 6

LITERATURE REVIEW 6

2.1 An overview of dairy farming in Kenya 6

2.2 Production systems of Kenya's dairy industry 7

2.3 Kenya's dairy nutritional regime – fodder involvement 8

2.4 The aspect of feeds and feeding versus dairy performance 8

2.5 How feeds and feeding affects milk yield 10

2.6 Impact of feeds and feeding on milk butterfat 11

CHAPTER THREE 13

EVALUATION OF NUTRITIONAL COMPOSITION AND *IN VITRO* DIGESTIBILITY OF DAIRY CATTLE FEED RESOURCES IN BUNGOMA COUNTY, KENYA 13

Abstract 13

3.0 Introduction 13
3.1 Materials and methods 14
3.1.1 Feed sample preparation 14
3.1.2 Chemical analysis 14
3.1.3 Rumen fluid sampling and *in-vitro* digestibility 15
3.1.4 Statistical analysis 15
3.2 Results and Discussion 16
3.3 *In-vitro* gas production 18
3.3.1 Fodder trees and legumes 18
3.2.2 Crop residues 21
3.3.3 Roughages 23
3.3.4 Concentrates and total mixed ration 26
3.4 Conclusion 29
3.5 Recommendation 29
CHAPTER FOUR 30
EFFECT OF FEEDING PRACTICES ON QUALITY AND AFLATOXIN LEVELS OF MILK IN BUNGOMA COUNTY, KENYA 30
Abstract 30
4.0 Introduction 30
4.1 Materials and methods 32
4.1.1 Study rea 32
4.1.2 Sample collection 32
4.1.3 Determination of butterfat in raw milk 33
4.1.4 Determination of crude protein content in raw milk 33
4.1.5 Determination of density of the raw milk 33
4.2 Determination of M1 aflatoxins in raw cow milk 34
4.2.1 Sample preparation 34
4.2.2 ELISA procedure 34
4.3 Determination of total aflatoxins in feed 35
4.3.1 Sample Preparation 35
4.3.2 Assay Procedure 35

4.4 Statistical analysis 36
4.5 Results 36
4.5.1 Milk quality parameters 36
4.6 Discussion 38
4.6.1 Milk quality 38
4.6.2 Aflatoxins in feed and milk 39
4.6.3 Correlation analysis of aflatoxins in feeds and milk 41
4.7 Conclusion 42
CHAPTER FIVE 43
EVALUATION OF DAIRY CATTLE FEEDING PRACTICES, LOSSES, AND WASTAGE AND THEIR IMPACT ON MILK YIELD IN KAPTAMA AND KITINDA MILK COLLECTION CENTRES 43
Abstract 43
5.1 Introduction 43
5.2 Methodology 44
5.2.1 Study area 44
5.2.2 Research design 45
5.2.3 Sampling and sample size 45
5.2.5 Data collection instruments 46
5.2.6 Pilot testing 46
5.2.7 Data collection 46
5.2.8 Data analysis 46
5.2.9 Ethical considerations 47
5.3 Results and discussions 47
5.3.1 Demographics 47
5.3.2 The dairy cattle feeding practices, losses, wastages, and their effect on milk yield 51
5.3.3 The general dairy performance and attitudes of dairy farmers 54
5.4 Conclusions 55
CHAPTER SIX 56
6.0 GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS 56
6.1 General discussion 56

6.2 Conclusions 58
6.3 Areas of further research 59
APPENDICES 70
Appendix A: NACOSTI permit 70
Appendix B: Publication 71
Appendix C: Ethical clearance 72
Appendix D: Questionnaire 74

List of Tables

Table 3. 1. Chemical composition for roughages in $g/Kg^{-1}DM$ 16
Table 3. 2. Chemical analysis for crop residues in $g/Kg^{-1}DM$ 17
Table 3 3: Chemical composition of fodder trees, legumes, concentrates, and total mixed rations (g/KgDM) 18
Table 3 4: In-vitro gas production (ml/200 mg DM), OMD ME SCFAs at 24 and 48hrs and fermentation characteristics of legumes and fodder trees 20
Table 3. 5. In-vitro gas production (ml/200 mg DM), OMD ME SCFAs at 24 h and 48 h and fermentation characteristics of crop residues 22
Table 3.6: In-vitro gas production (ml/200mg DM), OMD ME SCFAs at 24 and 48hrs and fermentation characteristics of roughages for different farmers 25
Table 3.7: In-vitro gas production (ml/200mg DM), OMD ME SCFAs at 24 and 48hrs and fermentation characteristics of concentrates and TMR from different farmers 28

Table 4 1: Milk quality and safety parameters analysis from 12 farmers in Kitinda MCC……………… 37
Table 4 2: Milk quality and safety parameters analysis from 13 farmers in Kaptama MCC……………. 38
Table 4 3: Pearson correlation for total aflatoxins in feed and milk……………………………………... 42
Table 5 1: Gender Distribution of the Participants 48

Table 5 2: Age and Lactating animals per household……………………………………………………….. 50

List of Figures

Figure 1: Gas production trends for legumes and fodder trees 21

Figure 2. Patterns of *in vitro* cumulative gas production of crop residues 23

Figure 3. Gas production trends from different roughages farmers 26

Figure 4: Gas production trends for concentrates and others from different farmers 29

Figure 5: Map of Bungoma County showing the study site. Source: Kenya Institute of Surveying and Mapping (KISM). (2024) 32

LIST OF ABBREVIATIONS AND ACRONYMS

CP	Crude Protein
DM	Dry Matter
DMI	Dry Matter Intake
GDP	Gross Domestic Product
FAO	Food and Agriculture Organization of the United Nations
MCCs	Milk Collection Centres
FGD	Focus Group Discussion
LWT	Live Weight
ME	Metabolizable Energy
NDF	Neutral Detergent Fibre
NFFs	Non-forage Fibre Sources
SCFA	Short Chain Fatty Acids
SPEs	Service Provider Enterprises
TMR	Total Mixed Ration
VFAs	Volatile Fatty Acids

CHAPTER ONE

INTRODUCTION

1.1 Background information

In Kenya, dairy farming is the most common economic activity in the entire agricultural sector, accounting for 4% of the country's gross domestic product (GDP) (Wamuyu, 2020). Dairy farming is considered prosperous in the high-altitude zone. As asserted by Wambugu *et al*. (2011), dairy production systems can be either semi-intensive or intensive, depending on the size of the dairy cattle population and management levels. Kashongwe *et al*. (2017) found that only 5 kg dry matter (DM) is available on-farm for an individual cow per day, an amount of feed that cannot support even a cow producing 10 litres of milk in a day. The study exposes the vulnerability of dairy farming in the regions of Kenya; dairy farming is challenged with adverse feed scarcity, which is worse during dry seasons. Furthermore, as noted by these authors, dairy farming in Kenya is constrained by a lack of capacity to enhance the nutritional value of readily available diets. According to Kashongwe *et al*. (2017), a dairy feed characterized by a crude protein of less than 8%, organic matter digestibility of less than 55%, low levels of soluble sugars, minerals, and vitamins deficiency, especially phosphorous and calcium, and also low levels of metabolizable energy (between 5 and 8 MJ/kg DM), lowers the production capacity of the animal through the limitation of the dry matter intake.

Farmers in Kenya rely heavily on traditional modes of feeding that comprise open grazing. The cost of feeding is the main factor driving many farmers towards traditional feeding systems, which are less expensive. According to FAO (2014), the cost of feed in the dairy industry is more than half (50% - 60%) of the entire dairy production cost. While the production cost in this sector is relatively high, dairy performance is still low. Every dairy farmer's ambition is to realize enhanced dairy productivity; however, the poor quality and low levels of cattle feed resources are the main limitations facing dairy productivity. Losses are high when poor-quality feeds are supplied to the dairy cows because of the resultant poor-quality milk, which is rejected in the markets (Ragkos *et al*., 2015). Also, since low production is a loss, low levels of nutrients in diets result in dairy cows failing to produce the anticipated levels of milk. Focusing on enhancing the efficiency of the conversion of feed to milk is crucial as it positively impacts dairy productivity. At the global stage, food loss or waste is a widespread issue posing a significant challenge to food security, nutrition, safety, economy, and environmental sustainability. While many individuals sleep hungry globally, it is estimated that a third of all food produced, which amounts to 1.3 billion tonnes, gets lost or wasted (FAO, 2014). Food losses or wastages related to milk account for about 21%, with annual post-harvest losses ranging from 10% to 23% (FAO, 2011; Gustafsson *et al*., 2013). Additionally, 3.5% of milk loss is a result of uncollected milk that is contributed to by factors such as production losses and animal diseases (FAO, 2014). In the situation of illness, an animal lacks the necessary capacity to produce milk as required due to poor health and feeding habits, which directly reduces the quality and quantity of milk produced. Conversely, the production losses may refer to instances where feeding strategies applied in the feed farms are poor and cannot support appropriate milk production. In regard to this state of affairs, a need to reduce food losses and wastage along the entire food value chain has been launched to ensure an enhanced food security guarantee.

The Kenyan dairy industry relies on the growth of domestic milk production (5.3% a year, on average), processing capacity (7% a year, on average), annual per capita milk consumption (5.8% a year, on average; currently 110 litres), and export potential (Rademaker, 2016). Concerning the tremendous increase in population, together with rising milk markets in the urban areas, Blackmore *et al*. (2020) indicate that both the demand and the annual consumption of milk – come 2030 – are anticipated to rise, with milk consumption expected to hit a high of 230 litres per person.

Dairy farming is an economic pillar in the Republic of Kenya, both for the government and the people (Rademaker, 2016). Nonetheless, the dairy sector (Munyori, 2019) faces a post-harvest loss despite its huge contribution to the national economy and households' income. The term post-harvest loss refers to loss at farm level after milking as well as through the market chain up to consumption. According to Wamuyu (2020), loss and waste can occur through feed, spillage, and/or spoilage which is because of limited market opportunities. Kenya is losing about 95 million litres of milk annually, according to FAO (2014). This is resulting in a loss of about US$ 22.4 million (about KES 2.24 billion) annually, with the greatest impact felt at farm level.

The dairy cattle value chain in Bungoma County is one of the most vibrant. From census data, the County population involved in the production of dairy cattle is between 41 to 60 per cent. 32,344 households own a total of 62,009 exotic dairy cattle, while 113,733 households own 279,428 indigenous cows (KNBS, 2019). The total value is KES 6.7 billion. Bungoma County contains two milk collection centres (MCCs) at Kaptama and Kitinda which collect milk from farmers and sell it to Brookside, New Kenya Co-operative Creameries (New KCC), hospitals, schools, hotels and the local community. However, Kitinda milk sheds were found to suffer the most losses at the cooperative with total losses of KES 11.5 million/year. According to Kemboi (2022), the Kaptama MCC incurred an annual loss of KES 4.7 million. Management practices for feeding on the farm level they could mainly affect on the milk losses and wastage through improper feeding programmes. (Kemboi, 2022) So, dairy cows need proper nutrition to ensure that they perform to their genetic potential, therefore measuring the effects of nutrition on dairy performance is very important.

More knowledge is needed on the importance of different nutritional practices on milk yield. The current study focuses on addressing the previous research gap and insufficient information concerning the impact of different nutritional practices on dairy performance, milk loss, and wastage. The study is significant as it successfully captures evidence based on the research objectives. The findings will used to advise farmers and other stakeholders on the best nutritional strategies to fully optimize their dairy productivity while minimizing farm losses and wastage.

1.2 Statement of the problem

Low milk production, milk losses, and wastage are the constraints faced by most farmers in Kenya, particularly western Kenya. In an ideal situation, a dairy cow should be fed with a balanced diet that includes good-quality fodder, minerals, and water. By doing so, losses and wastages are significantly reduced. Farmers supplying the Kaptama and Kitinda MCCs in Bungoma County are faced with immense milk loss and wastage annually. This is contributed by the inappropriate nutritional practices comprising low-quality feeds supplied to dairy cows and poor feeding practices. Nonetheless, a few studies have focused on the contribution of feeding practices to milk losses and wastage and their impact on milk quality in western Kenya, particularly Kitinda and Kaptama MCCs. Therefore, this study investigated the link between feeding practices on the quality and safety of milk from these MCCs in Bungoma County, as a way of mitigating losses and wastage.

1.3 Objectives

1.3.1 General objective

To contribute to improved, food safety, livelihoods and poverty reduction through assessment of the impact of different nutritional practices of dairy farmers and the effects on milk loss and wastage in Bungoma County, Kenya.

1.3.2 Specific objectives

i. To determine the nutritional value and safety of the main dairy cattle feed resources used by farmers in the Kaptama and Kitinda milk collection centres (MCCs) in Bungoma County, Kenya.

ii. To determine the milk quality parameters and safety in Kaptama and Kitinda MCCs in Bungoma County, Kenya.

iii. To assess the general dairy performance, attitudes, the dairy cattle feeding practices, losses, and wastages in Kaptama and Kitinda MCCs Bungoma County, Kenya.

1.4 Hypotheses

i. There is no significant difference in the nutritional value and safety of the main dairy cattle feed resources used by farmers in the Kaptama and Kitinda milk collection centers (MCCs) (MCCs) in Bungoma County, Kenya.

ii. There is no significant difference in the milk quality parameters and safety in the Kaptama and Kitinda MCCs in Bungoma County, Kenya.

1.5 Research question

iii. What are the dairy general dairy performance attitudes, cattle feeding practices, losses, and wastages in Kaptama and Kitinda MCCs in Bungoma County, Kenya?

1.6 Justification

In the dairy industry, improving dairy cow productivity—which has a direct impact on milk yield and quality—requires proper nutrition. Poor handling, storage, and shipping methods are frequently the cause of milk losses, but dietary habits also play a big role. In Bungoma County, dairy farming practices need to align with the County Integrated Development Plan (CIDP) in order to realize maximum milk production for economic development and food security. Dairy farming can be used as a strategic economic activity to increase household income, generate employment and lessen poverty as per the CIDP. By reviewing and improving nutritional practices, local farmers can improve productivity and support Bungoma's development objectives. As per the Kenya Vision 2030, which sees agriculture as an important economic sector to enhance sustainability and economic growth in Kenya, Dairy farming is a major economic sector. The government's objective of food security and improvement in the lives of dairy farmers can be achieved through appropriate nutritional practices. It can also help in diminishing the wastage of milk and increasing production efficiency. In Kenya, this is part of a drive towards achievability. Enhancing the feed and nutrient quality of dairy farms improves the nutritional and financial availability of dairy farmers. The dairy production has SDGs link for the UN-level SDGs and targets. Dairy farming can improve the 2nd (zero hunger) and 8th (decent work and economic growth) SDG targets. The dairy sector can help to global programmes for food security, prosperity and sustainable farming by assisting in the efficient production of milk and reducing waste. The study shows approaches can be used by farmers, government and organisations that will make nutrition-related practices more sustainable and productive locally, nationally and globally.

CHAPTER TWO

LITERATURE REVIEW

2.1 An overview of dairy farming in Kenya

The dairy sector in Kenya plays a critical role in the economy of the country. The sector contributes about 4% of the GDP of the state. According to the report by the Ministry of Agriculture, Livestock and Fisheries (MoALF, 2010), the industry has indeed experienced a steady expansion that is characterized by a rise in milk production at a rate of 5.3% per annum, processing capacity rate growing by 7% and milk consumption rising by 5.8% per annum. The industry also has great potential for exports; a growth of 10% per annum is projected. This continuous growth demonstrates the industry's vigor and pertinence to state and household budgets.

In the past, dairy farmers in Kenya practiced subsistence farming. This means farmers kept a small number of indigenous dairy cow to meet personal needs. Surplus milk was sold off, not exceeding 10 litres per day. However, as Leenstra (2014) notes, commercialization has clearly taken front stage. Many farmers today are switching to large-scale dairy farming with an eye toward the industry's commercial promise. This change in farming methods is indicated by major expenditures in modern dairy breeds, better barns, and sophisticated feed management methods. Optimizing profitability by better procedures and higher milk output is a shared objective of small- and large-scale farmers (Ettema, 2015).

These developments nonetheless still exist difficulties. Many farmers find it difficult to buy required farm supplies since they have limited access to capital. Moreover, limited acreage and poor availability of high-quality nutritional feed for dairy cattle still major obstacles to increase output (FAO, 2014). Many times, dairy businesses are backed by other income-generating activities to assist households maintain and grow their dairy operations, therefore mitigating some limitations.

Better resourced medium- and large-scale farmers typically make significant investments in mechanized systems and sophisticated infrastructure. These farmers can embrace high-efficiency agricultural techniques since they frequently own big areas of land and have more financial means. On the other hand, the bulk of small-scale farmers battle with problems including inadequate resources and limited mechanization that affect their output. Even medium-scale farmers, however, struggle with dairy company management, which can lower profitability even with their higher investments (Ettema, 2015).

Kenyan dairy industry is changing generally in a good direction. As farmers are using effective farm practices, herd quality is improving and milk output is increasing. Along with this comeback, milk prices are rising, farmer education is improving, and industry commercial acumen is under more emphasis. Kenya's dairy farming's ongoing change demonstrates its potential to become pillar of agricultural and economic growth in the nation.

2.2 Production systems of Kenya's dairy industry

Parts of the Rift Valley and the former Central Province highlands, among other areas marked by heavy rainfall and mild temperatures, dairy production in Kenya thrives. Over 73% of the agricultural population in these areas practices mixed crop-dairy farming (Majiwa et al., 2022). Even on one acre of land, these farms often incorporate dairy animals, which are rather prevalent. Emphasizing its economic relevance, the sector generates over 5.2 billion kg of milk yearly from total dairy cattle count of almost 6.1 million (Majiwa et al., 2022). Depending on variables including land size, resource availability, and management techniques, the nation's dairy production systems are often classified as either intensive or semi-intensive systems. Usually on little land areas where cattle are mostly stall-fed, intensive techniques are used. Farmers from these systems primarily rely on large quantities of fodder like silage and hay, which can be supplemented with concentrates. Semi-intensive systems combine some grazing and stall-feeding. Medium and large scale farmers often use pasture-based production systems because they have access to larger land areas and can invest in more feed and infrastructure (FAO, 2014).

Most of Kenya's dairy producers, who are small-scale farmers, have a hard time adopting intensive methods. Land deemed appropriate for commercial purpose still cannot freely be sold like in the past. Programs such as the Kenya Market-led Dairy Program (KMDP) have intervened to eliminate these barriers by introducing inventive concepts such enhanced fodder farming, silage-making technologies, and better land-use methods (Rademaker et al., 2015). These initiatives aim to ensure the economic viability of smallholders as they transition to more efficient systems. As farmers embrace more efficient methods, the dairy output systems in Kenya are changing gradually. The growing acceptance of different practices such as animal nutrition, silage storage, and effective land use has helped in better production of milk and in more resistance to problems like climate change. The dairy farming could significantly benefit the rural livelihood and agricultural development in Kenya (Majiwa et al., 2022).

2.3 Kenya's dairy nutritional regime – fodder involvement

Many efforts by the Kenya Market-led Dairy Program (KMDP) have enhanced the quality and quantity of fodder on dairy farms across the country. For their cattle, dairy producers mostly feed stored corn, hay, sorghum fodder, and Napier grass. As Ettema (2015) emphasizes, good management and mechanization of fodder production can greatly maximize feed availability and quality, therefore immediately enhancing milk yields.

For many farmers, access to good feed is still difficult, though. Consistent feed production is hampered by problems like limited acreage, competition for fodder crops, and inadequate understanding of automation and seed preservation (Rademaker et al., 2015). Particularly small-scale farmers find these difficulties that affect the general effectiveness of their activities. Understanding the importance of quality feed, KMDP has helped farmers by introducing better fodder seed varieties, encouraging automation, and providing training on strategies of fodder preservation. Workshops on preparing and saving maize silage, computing and compounding rations, and knowledge of dry matter (DM) feed intake needs comprise KMDP's activities. The program has also focused on commercial possibilities, including marketing preserved waste, which has helped farmers to vary their income streams. These treatments have helped to guarantee constant milk output all year long, improve herd health, and help to lower seasonal feed shortages.

2.4 The aspect of feeds and feeding versus dairy performance

Sakwa (2020) report no positive effect on milk yield when the crude protein concentration in a dairy cow's diet is more than 160 g/kg. Feeding a dairy cow with too much protein is expensive. Also, high-protein diets limit the efficiency at which the animal uses nitrogen. Corea *et al*. (2017) confirm that the excretion of nitrogen in dairy cow's manure, as opposed to in milk, is two to four times more, indicating an increase in environmental nitrogen pollution. The protein content in an animal diet dictates milk nitrogen efficiency, urinary excretion of nitrogen, and sound emission of ammonia (Powell *et al*., 2011). As such, reducing dietary protein – to 155 g/kg from 170 g/kg – has no negative impact on milk but minimizes nitrogen emission. Various research studies – including Cantalapiedra-Hijar *et al*. (2014) have ascertained that the lower the concentration of dietary protein, the higher the protein efficiency. Further, the lower the crude protein in the dairy diet, the lower the urinary and milk nitrogen emissions (Spek *et al*., 2013). Regarding the above establishment, it can be deduced that limiting protein concentration in the animals' diet – keeping the quality of roughage at a good state – enhances the efficiency of nitrogen conversion from feed to milk. The grass diets, as opposed to their legume counterparts, have higher concentrations of neutral detergent fiber (NDF) when dairy farm diets are prepared to have comparable forage dry matter (DM) amounts. The amount of dry matter in lactating dairy animals is negatively affected when concentrations of NDF in the diets are increased. An average supplementation of forages with concentrates is necessary without considering the animals' milk production potential or lactation status (Cantalapiedra-Hijar *et al*. 2014).

Table 2.1 presents the dietary requirements of dairy cattle having dissimilar Body live weight (LWT) and milk yield. The table provides a guideline for establishing optimum dietary strategies for dairy animals for maximum performance. Sakwa *et al*. (2020) clearly states that the nutritional components in the feed rations affect the milk production capacity of a dairy cow.

***Table 2 1*: Nutritional requirements of dairy cows**

Live weight (kg)	Milk yield (kg)	Dry matter intake (kg)	Metabolizable energy (MJ)	Crude protein (g)	Calcium (g)	Phosphorous (g)
350	5	10	72	806	27	27
	10	11	97	1093	42	36
	15	13	123	1393	57	45
400	5	11	78	874	28	29
	10	12	103	1161	44	39
	15	14	129	1448	58	48
450	5	11	84	946	31	32
	10	13	110	1234	45	41
	15	15	135	1521	60	50
	20	17	161	1826	75	59
500	10	14	113	1275	46	43
	15	16	138	1560	59	51
	20	18	162	1823	74	59
550	10	15	121	1359	48	46
	15	17	145	1635	61	53

	20	19	168	1892	75	62
	25	21	194	2179	90	71
600	10	16	129	1431	50	49
	15	18	152	1710	63	55
	20	20	174	1984	77	65
	25	22	201	2262	91	75
	30	23	227	2545	106	85

Source: Sakwa *et al.* (2020)

Based on Goopy and Gakige (2016), whose findings is in agreement with the findings of Lukuyu *et al*. (2011), a feed containing 75%, 24%, and 1% of energy, protein minerals sources, respectively, is the optimal dairy cows' nutritional regime. Milk production, as well as general body maintenance, is enabled by energy availability. Protein, on the other hand, is responsible for breaking down roughage into disposable nutrients. Apelo *et al*. (2014) confirm that higher starch concentrations in dairy cows' diets are associated with synthesizing milk protein.

2.5 Effects of feeds and feeding on milk yield

Forage's nutritional composition in the ration and its physical characteristics influence how a dairy cow utilizes its diet. Compared to legumes, grasses have higher total neutral detergent fiber (NDF) and the concentration of digestible NDF; their digestion is, therefore, slower but longer, impacting the yield of dairy milk (O'Callaghan, 2016). Concerning this establishment, Steinshamn (2010) noted that dry matter intake and milk yield amongst dairy cows fed on grass is lower than cows fed on legumes; this finding is further supported by the articulation by Wambugu *et al*. (2011).

The higher the pasture content in the animal's feed, the higher the protein content in the milk. The increase in protein content in cow's milk can be explained by the energy modification that results from the increase in propionic acid. The production performance of a feed is determined by the cows' feed intake and feed digestibility. Generally, the feed's digestibility, which significantly impacts intake, determines its nutritional value (O'Callaghan, 2016). Consequently, Getachew *et al*. (2004) note that intake and digestibility are the productive performance of the feed that comprises milk synthesis. The poor quality or unreliable supply of quality feeds for dairy cattle suggests poor dairy performance. Osuga *et al*. (2008) mention that poor-quality feeds are not in a position to maintain a dairy cow to a standard and optimum productive capacity; this means poor-quality diets or unreliable diets cannot support the productive potential of the dairy animal appropriately and as anticipated.

Service provider enterprises (SPEs) aid dairy farmers in making and farming silages. Apart from harvesting, chopping, compacting, and tubing, SPEs provide the necessary ensiling materials. As Kilelu *et al*. (2018) affirmed, most farmers in 2016 – especially in Kenya's Eastern and Central regions - used SPEs to make dairy farm silages. According to Kilelu *et al*. (2018), in 2016, among the silages made by SPEs, maize silage topped the list, with more than 9 thousand tons made. It is a fact to state that scarcity and poor-quality diets are significant challenges curtailing the prosperity of dairy productivity. Considering this perspective, enhancing feed-to-milk conversion efficiency is a solution to the dairy industry's productivity.

2.6 Impact of feeds and feeding on milk butterfat

The nutritional strategies applied in the dairy farm may impact the quality of milk the animal produces. As articulated in the Shingfield *et al*. (2013) study – whose findings similarly relate well with those of Khiaosa-ard *et al*. (2010) – the proportions of forage-concentrate and roughages' origin impact the conjugated linoleic acids and n-3 fatty acids (FA) in milk fat. To enhance the energy density of the ration by providing milk production's glucose precursors and substrates for microbial protein production, corn grain is substituted for the forage in the diets of dairy cattle. To minimize the dependence on ingredients high in starch, such as corn, the identification of alternative feedstuffs that provide energy and maintain desired components in the milk is a solution. Boerman *et al*. (2015) established non-forage fibre sources (NFFS) as the best starch alternative feedstuffs for dairy cows.

Similar to the above studies is Couvreur *et al*. (2006) articulation; it is established that the incorporation of total mixed rations (TMR) as a feeding strategy contributes to the production of milk rich in fat contents. Boerman *et al*. (2015) were keen to explain how providing an animal with a TMR diet with high levels of unsaturated fatty acids (UFA) reduces fat content in milk; rumen bacteria find UFA toxic. Hence, the activity of acetyl CoA carboxylase enzyme and de novo synthesis is significantly reduced.

2.7 Research gap

While great progress has been made in understanding the impact of feeds and feeding techniques on milk production in Kenya, there are still many key gaps. Mostly, current research concentrate on how feed quality and nutritional balance affect milk yield and nitrogen efficiency

(Sakwa, 2020; Powell et al., 2011). However, there is limited information on how regional differences in feed supply and farmer capacity affect the adoption of better feeding techniques. In regions with fluctuating climatic conditions, for example, the maintenance of consistent feed quality and availability may present unique challenges that have not been sufficiently investigated. More information is needed on the impact of various nutritional practices on milk production. As a result, this study had three goals: first, to assess the nutritional value of feed supplies for dairy cattle; second, to assess feeding practices and their impact on milk production; and third, to assess milk quality indicators at Kaptama and Kitinda Milk Collection Centres in Bungoma County, Kenya. The study results provided guidance for dairy value chain stakeholders on raising productivity and reducing food loss and waste.

CHAPTER THREE

EVALUATION OF NUTRITIONAL COMPOSITION AND *IN VITRO* DIGESTIBILITY OF DAIRY CATTLE FEED RESOURCES IN BUNGOMA COUNTY, KENYA

Abstract

Dairy cattle productivity depends on feed quality. Dairy farmers in Kenya feed their fodder crops, silage, legumes and agricultural waste. The nutrient content, digestibility and suitability of different feeds are quite different for optimum milk production. Examining these feeds' nutritional values and digestibility improves feeding practices, milk yield and profitability of the dairy farm. Proximate composition and in vitro digestibility of the main dairy cattle feed resources in Bungoma County was done as part of this study. Two milk collection centers provided the feeds that were grouped into 25 diets. A nutrient composition chemical analysis of the sample with results. The gas production method was used to assess the in vitro organic matter digestibility of all 25 experimental diets. The data obtained from proximate analysis was subjected to analysis of variance in a completely randomized design using General linear Model procedure of Statistical Analysis System version 9.4. Based on the findings, it can be noted that there was a wide range of dry matter of the roughages from 904.1 g/kg DM to 936.1 g/kg DM. Super Napier possessed the highest crude protein content (149.3 g/kg DM) and neutral detergent fibre content (733.3 g/kg DM), while maize silage had the lowest crude protein content (56.1 g/kg DM). Groundnut residue recorded the highest crude protein content of 114.6 g/kg DM while sugarcane tops contained the least crude protein content of 27 g/kg DM among the crop residues. The highest gas production rate at 24 and 48 hours of fermentation was recorded from fodder crops and trees, with lucerne at 12.7 % and other species at 10 % while crop residues, sugarcane tops at 1.60 %. According to this research, legumes and fodder trees offer better protein, energy, and digestibility. On the other hand, crop residues comprise a low-quality fodder with lower protein, energy and digestibility.

3.0 Introduction

About 10,000 farmers in Bungoma County, Kenya derive their livelihood from the dairy business, and the sector contributes considerably to the county economy (Were, 2017). Farmers of the region maintain cattle and increase the milk production of dairy cattle farming on the following feeds as part of their crucial agricultural activities. The health, milk production, and profitability of the farm are all affected by the nutritional worth and quality of these feed resources. To create balanced diets that satisfy the nutritional needs of dairy cattle, it is important to know the nutrient composition and digestibility of feed resources (Tona, 2018). The use of local feed resources will guarantee continuous dairy production in Bungoma County (Tona, 2018). For optimizing the feeding and improving the performance of the animals, it is essential to scientifically analyze the feeding resources, though in general selection of a feed and the management techniques is governed by the traditional knowledge and empirical observations. Through proximate analysis and in vitro digestibility experiments, the nutrient composition, digestibility and energy content of several feedstuffs is determined.

Proximate analysis can quantify the protein, fibre, fat and ash contents of feeds which are among the more basic nutrients (Mertens & Grant, 2020). One way to assess feed digestibility and expect nutrient availability is via in vitro digestibility trial which mimics the digestive processes taking place in the rumen of cattle. Although implementing these analytical methods is very important, more research needs to be done into the feed resources of dairy cows in Bungoma County, Kenya. More general agricultural and socio-economic issues have overshadowed a little investigation on the significance of feed quality in boosting the well-being and production of dairy animals. The main aim of the study was to ascertain the nutritional values of the major dairy cattle feed resources in Bungoma County of Kenya through in-vitro digestibility and proximate analysis.

3.1 Materials and methods

3.1.1 Feed sample preparation

A total of 500g each of feed samples including roughages, concentrates, crop residues, total mixed rations, fodder trees and legumes were collected from different farmers in Kaptama and Kitinda milk collection centres (MCCs) packed in khaki bags and transported to Egerton University's Animal Science Laboratory for nutrient analysis. The feed samples were first dried in a draft oven at 105°C. Subsequently, the samples were shredded using a shredder so that they could pass through a 1 mm screen. This was utilized for in vitro digestibility. Additionally, it was also utilized for chemical analysis (AOAC, 2012).

3.1.2 Chemical analysis

The proximate analysis was carried out as specified by AOAC (2012). Organic matter (OM), dry matter (DM) and crude protein (CP) value of the cichlids analysed using standard procedure. The methodologies devised by Van Soest et al. (1991) were utilized for the determination of NDF, ADL, and ADF.

3.1.3 Rumen fluid sampling and *in-vitro* digestibility

The *in vitro* gas production of all dietary treatments was determined strictly according to the guidelines of Getachew et al. (2004). Before morning feeding, rumen liquor was collected from randomly selected cows at the farm level with the help of a stomach tube connected to a suction pump. The liquor was filtered through a two layered cheesecloth and the fluid was placed in a thermos flask where it was continuously flushed with carbon dioxide (CO_2) to remove impurities. Three samples of 200 mg of milled sample were filled in 100 ml glass syringes. About 50 g of rumen fluid was mixed with 180 ml of buffer (35g of Dipotassium Hydrogen Phosphate and 4g of Magnesium Sulphate) in a 1:2 ratio. Thereafter, 30 ml of the above mixture was added to each syringe. The blank syringes contained just 30 ml of fluid and buffer, but no feed sample. All the syringes were incubated at the same time in a water bath at 39°C. Gas production was recorded at the 0, 3, 6, 9, 12, 18, 36, 48, 72, and 96 hour intervals by reading the calibration on the piston. The volume of gas produced from the blanks was subtracted from the volume of gas produced from the diet-based sample. The figures regarding net gas volumes were subsequently applied to the Ørskov and McDonald (1979) model. *In-vitro* organic matter digestibility (OMD) was then determined from the model below: - The exponential equation was -

$Y= a+b\ (1-e^{-ct})$,

Where,

Y - gas produced at the time t, a+b - potential gas produced (ml), c is the gas production rate constant, and t is the incubation time.

3.1.4 Statistical analysis

Data collected for proximate analysis were analyzed using analysis of variance (ANOVA) in CRD using the General linear model procedure of statistical analysis system (SAS, 2002) version 9.4. Means were separated using LSD at (p<0.05). The model was as follows:

$Y_{ij} = \mu + T_i + \varepsilon_{ij}$

where:

Y_{ij} = dependent variable

μ = overall mean

T_i = effect of the treatment

ε_{ij} = random error term

3.2 Results and Discussion

The proximate composition results of sampled feed roughages are shown in Table 3.1. All the roughages varied greatly in dry matter (DM) content, ranging from 904.1 g/kg DM to 936.1 g/kg DM. Significant difference was observed in the ash content of different roughages ($p<0.05$). Panicum (*Panicum miliaceum*) had the highest value of 130.8 g/kg DM. On the other hand, oats had the least amount of 27.0 g/kg DM. Super Napier has a higher crudeprotein cp content than that of Dombar et al. (2022), which is 84.4 g/kg dm with measured value of cp for Super Napier 149.3 g/kg dm.

Table 3 1: Chemical composition for roughages in g/Kg^{-1}DM

	Parameters							
Sample	**DM**	**Ash**	**EE**	**CF**	**CP**	**NDF**	**ADF**	**ADL**
Kikuyu grass	932.8^{bcd}	97.8^{gh}	15.0^{jkl}	307.9^{f}	146.4^{e}	693.2^{c}	424.7^{de}	75.5^{ed}
Bracharia	936.1^{abc}	85.4^{ij}	39.7^{de}	340.5^{de}	107.1^{fgh}	617.4^{ef}	277.3^{i}	48.7^{i}
Boma Rhodes	910.2^{jk}	88.4^{i}	16.2^{ijk}	362.0^{bc}	89.7^{ij}	526.3^{h}	390.6^{f}	20.8^{k}
Panicum	936.0^{abc}	130.8^{d}	16.5^{ijk}	357.2^{cd}	101.3^{hij}	598.5^{f}	506.4^{b}	70.6^{ef}
Super Napier	920.8^{fghi}	115.2^{f}	42.0^{de}	379.8^{b}	149.3^{e}	733.3^{ab}	432.0^{d}	63.7^{fg}
Elephant Grass	925.1^{defg}	101.3^{g}	34.2^{ef}	333.5^{e}	86.8^{j}	710.2^{bc}	390.4^{f}	66.7^{fg}
Oat grass	904.1^{k}	27.0^{o}	60.9^{c}	349.9^{cde}	107.6^{fg}	626.5^{ef}	492.1^{bc}	72.3^{def}
Maize Silage	935.9^{abc}	69.7^{k}	19.7^{hij}	341.0^{de}	56.1^{k}	474.7^{ij}	361.7^{g}	64.7^{fg}
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	0.16	0.07	0.16	0.35	0.21	0.56	0.52	0.16

a, b, c, d, e, f, g, i, j, k, l means in the same column with different superscripts are significantly different at $p<0.05$). DM=Dry matter, CP=Crude protein, EE=Ether extracts, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin, CF=Crude Fiber

The CP content of maize silage was 56.1 g/kg DM which could be due to the change in maize quality and harvesting stages as reported by Mandić et al. (2018). The fiber contents of various roughages were different. The highest NDF (Neutral Detergent Fiber) content was found in Super Napier (733.3 g/kg DM) while the lowest was found in maize silage (474.7g/kg DM).

The ADF content of brachiaria (*Brachiaria brizantha*) and oats ranged from 277.3 g/kg DM to 492.1 g/kg DM. The chemical composition of the crop residues varied, with dry matter (DM) ranging from potato peels (888.3 g/kg DM) to banana leaves (942.6 g/kg DM), as shown in Table 3.2. The highest ash content 161.9 g/kg DM was found in groundnut residues while the lowest was in sugarcane tops (62.9 g/kg DM). Similarly, CP content of the groundnut residue at 114.6 g/kg DM was lower 181.0 g/kg DM Koura et al. (2016). Sugarcane tops had the lowest CP content of 27 g/kg DM which was lower than that reported by Wangila (2021). The fiber composition of crop residue varied greatly where bean residue was reported with the highest NDF of 732.1 g/kg DM. The NDF level in potato peels was 92.2 g/kg DM. Similar patterns were observed in the ADF and ADL components.

Table 3 2: Chemical analysis for crop residues in g/Kg^{-1}DM

	Parameter							
Sample	DM	Ash	EE	CF	CP	NDF	ADF	ADL
Bean Residue	938.9^{ab}	124.2^{e}	23.7^{ghi}	490.1^{a}	60.8^{k}	717.2^{abc}	615.1^{a}	105.1^{c}
Millet Residue	915.1^{hij}	116.1^{f}	6.5^{l}	361.0^{bc}	55.6^{k}	658.7^{d}	399.2^{ef}	58.8^{gh}
Groundnut residue	921.1^{fgh}	161.9^{b}	11.0^{kl}	203.4^{i}	114.6^{f}	474.7^{ij}	390.1^{fg}	67.8^{ef}
Potato Peels	912.1^{ijk}	64.9^{l}	11.0^{kl}	115.8^{l}	95.5^{hij}	92.2^{n}	70.5^{n}	11.9^{l}
Maize Stover	930.8^{bcde}	34.0^{m}	8.7^{kl}	336.4^{e}	59.0^{k}	451.7^{jk}	238.1^{j}	35.6^{j}
Sugarcane Tops	935.1^{abc}	62.9^{l}	46.2^{d}	362.5^{bc}	27.8^{l}	645.9^{de}	427.9^{d}	71.6^{ef}
Banana Leaves	942.6^{a}	122.2^{e}	39.2^{de}	139.8^{k}	110.0^{fg}	732.1^{ab}	586.7^{a}	135.2^{b}
Banana stems	928.3^{l}	152.3^{c}	30.5^{fg}	278.4^{a}	5.73^{k}	566.9^{g}	415.8^{def}	80.4^{d}
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	0.16	0.07	0.16	0.35	0.21	0.56	0.52	0.16

$^{a, b,c,d,e,f,g,h,j,\ k,l,m,n,o,p}$ means in the same column with different superscripts are significantly different at p<0.05). DM=Dry matter, CP=Crude protein, EE=Ether extracts, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin, CF=Crude Fiber

As shown on Table 3.3, the nutritional characteristics of the fodder trees and legumes were consistent with earlier studies (Castro-Montoya & Dickhoefer, 2020). The CP content ranged from 240.7 g/kg DM to 183.4 g/kg DM. Understanding the nutritional value of available feed resources is important according to these results. In addition, they highlight the planting species, harvesting phases, and planting systems that affect these compounds. This information is crucial for optimizing livestock feeds and ensuring the health and efficiency of animals.

Table 3 3: *Chemical composition of fodder trees, legumes, concentrates, and total mixed rations (g/KgDM)*

	Parameter							
Sample	**DM**	**Ash**	**EE**	**CF**	**CP**	**NDF**	**ADF**	**ADL**
Sesbania sesban	925.6^{def}	61.6^{l}	25.2^{gh}	273.0^{h}	240.7^{a}	742.0^{a}	605.1^{a}	185.7^{m}
Leucaena leucocephala	933.4^{bcd}	50.2^{m}	60.5^{c}	170.1^{j}	201.4^{c}	308.2^{m}	110.1^{m}	20.9^{k}
Calliandra calothyrsus	894.8^{l}	121.7^{e}	14.7^{jkl}	201.6^{i}	228.0^{b}	620.3^{ef}	469.6^{c}	53.7^{ih}
Medicago sativa	928.6^{cdef}	95.4^{h}	21.2^{hij}	196.1^{i}	195.0^{c}	397.9^{l}	319.4^{h}	67.5^{efg}
Desmodium uncinatum	904.2^{k}	170.2^{a}	78.3^{b}	293.2^{fg}	197.3^{c}	517.0^{h}	248.5^{j}	66.5^{fg}
Ipomoea batatas	916.9^{ghij}	70.4^{k}	41.9^{de}	188.9^{ij}	183.4^{d}	443.4^{k}	209.5^{k}	34.9^{j}
Maize Bran	932.6^{bcd}	14.7^{p}	90.4^{a}	87.1^{m}	89.1^{j}	483.0^{i}	225.4^{jk}	18.9^{kl}
Dairy Meal	923.6^{efgh}	83.8^{j}	63.1^{c}	172.2^{j}	116.3^{f}	280.3^{m}	152.1^{l}	16.9^{kl}
Total mixed ration	928.7^{cdef}	26.9^{o}	42.2^{de}	116.8^{l}	102.4^{gh}	373.4^{l}	177.1^{l}	20.9^{k}
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	0.16	0.07	0.16	0.35	0.21	0.56	0.52	0.16

$^{a, b,c,d,e,f,g,h, I,j,k,m,n,o,p}$ means in the same column with different superscripts are significantly different at $p<0.05$) DM=Dry matter, CP=Crude protein, EE=Ether extracts, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin, CF=Crude Fiber

3.3 *In-vitro* gas production

3.3.1 Fodder trees and legumes

This study found significant differences in gas production among feed resources from different farmers. The data on in-vitro gas production and gas production trends for legumes and fodder trees has been presented in Table 3.4 and Figure1. The first gas production (A) and the rate of gas production (C) were different ($p<0.05$) in all feed resources. The gas production *in vitro* was measured from 0 to 96 hours which was done for all the fodder legumes and trees leuceana, lucerne, sweet potato vines, calliandra, Sesbania, desmodium. At 24 hours of fermentation, lucerne recorded the highest rate of gas production at 12.70 while leuceana had the lowest at 5.88%. On the other hand, lucerne recorded the highest OMD. The Mean OMD values of desmodium, calliandra and sweet potato vines were statistically similar ($p > 0.05$). In the current study, the variations in the species concerned can be attributed to the accumulation of fibre, which is in turn, influenced by stage of maturity. Along with this gas production (C) and initial gas production (A) of the tree resources and feed legumes collected from different farm areas differed significantly.

Earlier research indicates that due to higher protein and carbohydrate levels in legumes than in tree fodders, legumes can produce more gas (Abraham et al., 2023). This research confirms the findings of Tunkala et al. (2023), who established that the chemical composition of materials has an important effect on the fermentation parameters and protein percentage values of legumes. Previous studies show that Lucerne is a better feed for ruminant animals (Wangila, 2021). Similarly, the findings of this study with results in higher organic matter digestibility (OMD) as compared to other fodder resources confirm the same. Ngunjiri (2020), stated that there was no significant variation of OMD among desmodium, calliandra and sweet potato vines, but other factors like maturity at harvesting and processing methods can affect the digestibility of these feed resources.

Table 3 4: *In-vitro* gas production (ml/200 mg DM), OMD ME SCFAs at 24 and 48hrs and fermentation characteristics of legumes and fodder trees

Sample	**24**	**48**	**A**	**B**	**C**	**A+B**	**RSD**	**OMD**	**ME**	**SCFAs**
Calliandra	8.92^{bcd}	1.67^{c}	0.47^{a}	2.80^{b}	0.17^{a}	3.27^{b}	3.35bc	21.31^{c}	7.76^{c}	0.19bcd
Desmodium	10.38^{ab}	1.64^{c}	1.74^{a}	2.49^{b}	0.04^{b}	4.23^{ab}	3.87^{ab}	21.11^{c}	9.09^{a}	0.23^{ab}
Leuceana	5.88^{d}	6.95^{b}	0.21^{a}	4.50^{a}	0.06^{ab}	4.71ab	2.19^{c}	26.04^{b}	7.83^{bc}	0.13^{d}
Lucerne	12.70^{a}	10.06^{a}	0.46^{a}	5.45^{a}	0.10^{ab}	5.91^{a}	4.57^{ab}	28.88^{a}	7.71^{c}	0.28^{a}
Sweet Potato Vines	7.03^{cd}	2.17^{c}	2.81^{a}	2.95^{b}	0.11^{ab}	5.75^{a}	4.91^{a}	21.52^{c}	7.12^{d}	0.15^{cd}
Sesbania	9.56^{abc}	9.02^{a}	0.66^{a}	4.56^{a}	0.09^{ab}	5.21^{a}	3.54^{abc}	28.17^{a}	8.21^{b}	0.21^{abc}
SEM	0.65	0.27	0.61	0.29	0.02	0.39	0.30	0.24	0.08	0.01
p-value	0.0006	<.0001	0.0810	0.0003	0.0440	0.0067	0.0025	<.0001	<.0001	0.0006

A, B, C are constants in the equation (Ørskov & McDonld, 1979); *a, b, c,d* Means with the same letter superscript in a column are not significantly different ($p<0.05$). OMD: Organic Matter Digestibility; RSD: Residual Standard Deviation; SCFA: Short Chain Fatty Acids; A is the initial gas produced; B is the actual gas produced during DM degradation; A+B is the total gas produced during fermentation

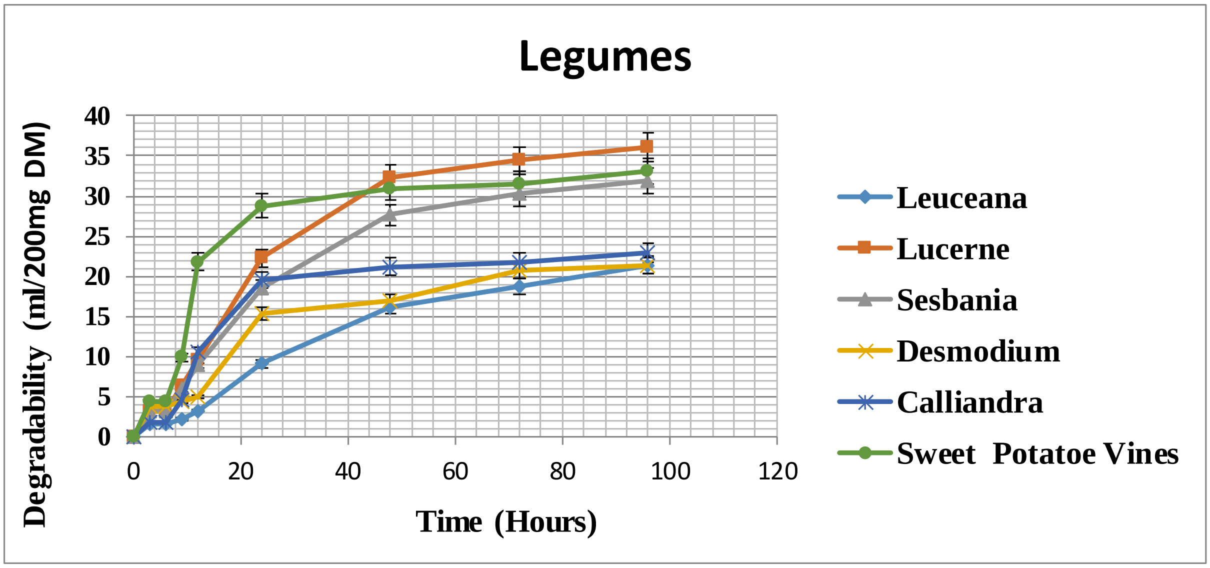

Figure 1: Gas production trends for legumes and fodder trees

3.2.2 Crop residues

At 24 and 48 hours of fermentation of the crop residues, the rate of gas production was highest in maize stover (12.27%). This was followed by the banana stem (10.59%). The lowest values were recorded for the sugarcane tops and millet residue (1.60% and 0.54%, respectively, as shown in Table 3.5 and Figure 2. As the sugarcane tops and millet residue are rich in structural carbohydrates such as cellulose and lignin, they are less prone to bacterial degradation than the non-structural carbohydrates present in other feed components. Microbial breakdown of structural components in the rumen is complicated and results in lesser gas production. The findings matched the findings of Zhao et al. (2020) that sugarcane has a high cellulose and lignin level that makes them hard for microbes to consume. The present study observed that ME, OMD and SCFA value (32.10 MJ/kg DM, 32.15 and 0.27 µmol) of maize stover was higher ($P<0.05$). The researchers reported these measured values. The values of these measures were greater than 7.25-10.10; less than 51.87-80.19 and less than 0.74-1.22. These were observed for several forages. According to Yusuf et al. (2013), the gas produced from the maize stover was slightly lower than the previously mentioned 16.00 – 22.67 ml/200 mg DM (Tona et al., 2018). The results showed that the nutritional value of maize stover was better than the bean residue and banana residues when fed to ruminants. However, sugarcane tops had the lowest nutritional value due to lower fibre content. Thus, these diets have a big impact on the quality, quantity and welfare of ruminant milk production and, thus, should not be the only feed rations of dairy animals.

Table 3 5: *In-vitro* gas production (ml/200 mg DM), OMD ME SCFAs at 24 h and 48 h and fermentation characteristics of crop residues

Sample	24	48	A	B	C	A+B	RSD	OMD	ME	SCFAs
Banana leaves	6.56[d]	3.81[cd]	0.42[ab]	2.41[cd]	0.12[bc]	2.84[cd]	2.30[ef]	22.65[cd]	22.65[a]	0.14[a]
Banana stem	10.59[b]	2.23[de]	0.23[b]	3.48[bc]	0.15[ab]	3.71[bc]	3.79[c]	20.90[de]	20.90[b]	0.23[b]
Bean hualms	6.30[d]	7.87[b]	0.25[b]	4.23[b]	0.06[cd]	4.48[b]	2.79[de]	26.13[b]	26.13[c]	0.14[c]
Groundnut hualms	9.11[c]	5.90[bc]	0.25[b]	4.40[b]	0.11[bc]	4.65[b]	2.97[d]	24.60[bc]	24.60[a]	0.20[a]
Maize stover	12.27[a]	14.40[a]	0.41[ab]	7.62[a]	0.07[cd]	8.03[a]	5.46[a]	32.15[a]	32.15[b]	0.27[b]
Millet straw	0.54[e]	3.26[d]	0.68[ab]	1.17[d]	0.11[bc]	1.85[d]	1.53[g]	21.84[d]	21.84[e]	0.01[e]
Potato peels	12.00[a]	0.88[e]	1.24[a]	2.68[c]	0.19[a]	3.92[bc]	4.79[b]	19.55[e]	19.55[a]	0.26[a]
Sugarcane tops	1.60[e]	6.39[b]	0.92[ab]	2.91[c]	0.04[d]	3.84[bc]	2.14[f]	24.58bc	24.58[d]	0.03[d]
SEM	0.29	0.48	0.19	0.24	0.01	0.23	0.11	0.44	0.04	0.01
p-value	<.0001	<.0001	0.0201	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

A, B, C are constants in the equation (Ørskov & McDonld, 1979); a, b, c,d Means with the same letter superscript in a column are not significantly different ($p<0.05$). OMD: Organic Matter Digestibility; RSD: Residual Standard Deviation; SCFA: Short Chain Fatty Acids; A is the initial gas produced; B is the actual gas produced during DM degradation; A+B is the total gas produced during fermentation.

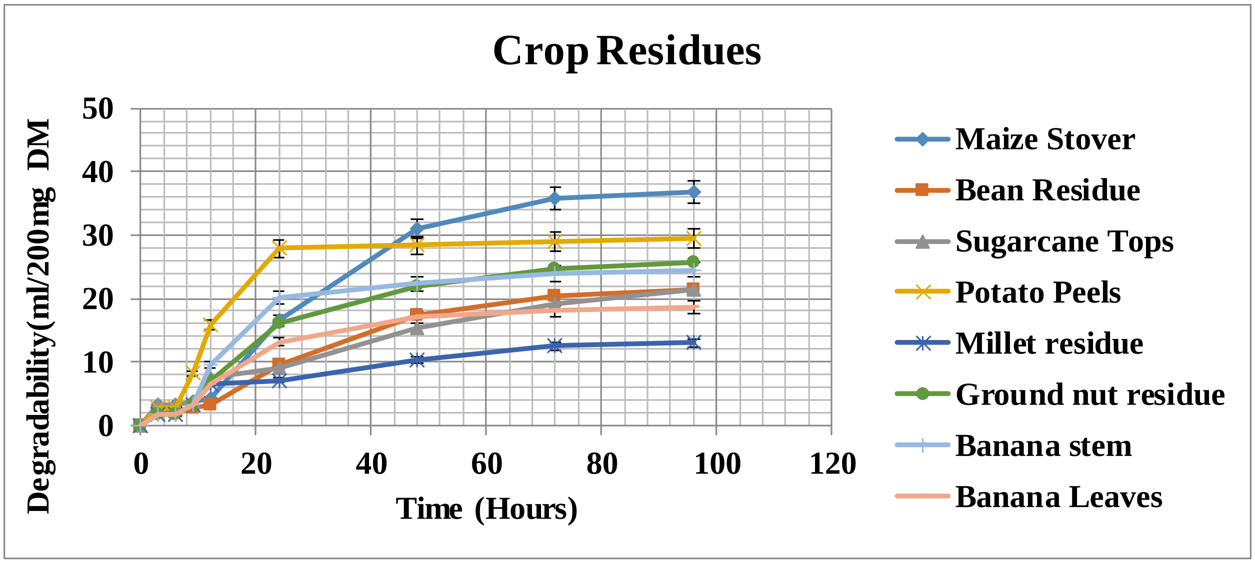

Figure 2. Patterns of in vitro cumulative gas production of crop residues

3.3.3 Roughages

Kikuyu grass produced the highest gas at 24 hr and 48 hr (11.20 ml/200mg DM, 11.20 ml/200mg DM)), it was followed by elephant grass (10.19ml/200mg DM), oats (10.98ml/200mg DM), maize silage (5.86 ml/200mg DM, 8.53ml/200mg DM), which can be seen in **Table 3.6** and **Figure 3**. Different roughages have different fermentability properties like OMD ME SCFAs, etc. Overall, Kikuyu grass had OMD, ME and SCFAs values of 7.70%, 29.67% and 6.53%, respectively, which were higher than those of other forages studied.

The differences in gas production values originating from the different roughages studied in this work could be the result of differences in chemical composition characterisation such as a high starch and CP but low NDF. The findings present study confirms those of Spanghero et al. (2017), who found that the effect on the subsequent substrate fermentation, at least on early colonization of the feed materials by the microbes. Kikuyu grass features good fermentation characteristics in ruminants due to its good growth and high productivity, according to reports. This is because it is able to digest fibre relatively well and this is also the reason for the high organic matter digestibility (OMD) observed in the present experiment. Moreover, the elevated values of ME and SCFA were also in agreement (Abu et al., 2022) which showed Kikuyu grass performs better in fermentation than most roughages.

The maize silage produced low gas due to the varying silage quality. The fermentation pattern and fermentation of DM are likely affected, due to differences in the type of substrate available for fermentation, etc.; in particular, the greater cell wall content plus decreasing contents of water-soluble carbohydrates and crude protein (CP) in poorly made maize silage. The studies endorsed by Khan et al. (2015) stressed on the importance of silage making from maize at the correct stage with the right DM content. Earlier research has shown that fermentation properties were found to vary in elephant grass, oats and maize silage (Yuan et al., 2013). During the study, it was found that the maize silage has low gas production and due to this especially low OMD, ME and SCFA was observed during the analysis of the study. Tauqir et al. (2008) noted that the materials used to make the silage and the stage of harvesting can cause differences in silage quality.

Table 3 6: *In-vitro* gas production (ml/200mg DM), OMD ME SCFAs at 24 and 48hrs and fermentation characteristics of roughages for different farmers

Sample	24	48	A	B	C	A+B	RSD	OMD	ME	SCFAs
Brachiaria	8.97^{ab}	9.50^{bc}	5.39^{ab}	5.39^{bcd}	0.07^{cd}	5.42^{bc}	3.49^{ab}	27.88^{bc}	5.87^{b}	0.19^{ab}
Elephant grass	10.19^{ab}	2.68^{d}	4.18^{ab}	4.18^{de}	0.14^{a}	4.15^{cd}	3.22^{bc}	21.48^{d}	5.55^{bc}	0.22^{ab}
Kikuyu grass	11.20^{a}	11.20^{a}	7.13^{a}	7.13^{a}	0.08^{c}	7.70^{a}	4.17^{a}	29.67^{a}	6.53^{a}	0.24^{a}
Maize silage	5.86^{c}	8.53^{c}	4.86^{ab}	4.86^{bcd}	0.06^{d}	5.23^{bcd}	2.53^{c}	26.71^{c}	4.15^{d}	0.13^{c}
Oat grass	10.98^{a}	3.30^{d}	3.64^{ab}	3.64^{e}	0.14^{a}	3.80^{d}	3.84^{ab}	22.16^{d}	6.78^{a}	0.24^{a}
Panicum	8.48^{b}	9.54^{bc}	5.97^{ab}	5.97^{abc}	0.07^{cd}	6.26^{ab}	3.17^{bc}	27.89^{bc}	5.34^{c}	0.18^{c}
Boma Rhodes	10.23^{ab}	10.23^{ab}	6.59^{a}	6.59^{ab}	0.07^{cd}	7.09^{a}	3.85^{ab}	28.47^{ab}	5.35^{c}	0.22^{ab}
Super Napier	9.17^{ab}	2.70^{d}	4.68^{b}	4.68^{cde}	0.12^{b}	4.49^{cd}	2.70^{c}	21.83^{d}	6.77^{a}	0.20^{ab}
SEM	0.49	0.29	0.12	0.31	0.00	0.31	0.15	0.26	0.08	0.01
p-value	<.0001	<.0001	0.0038	<.0001	<.0001	<.0001	<.0001	<.0001	<.001	0.0001

A, B, C are constants in the equation (Ørskov & McDonld, 1979); $^{a, b, c,d}$ *Means with the same letter superscript in a column are not significantly different (p<0.05)*. OMD: Organic Matter Digestibility; RSD: Residual Standard Deviation; SCFA: Short Chain Fatty Acids; A is the initial gas produced; B is the actual gas produced during DM degradation; A+B is the total gas produced during fermentation

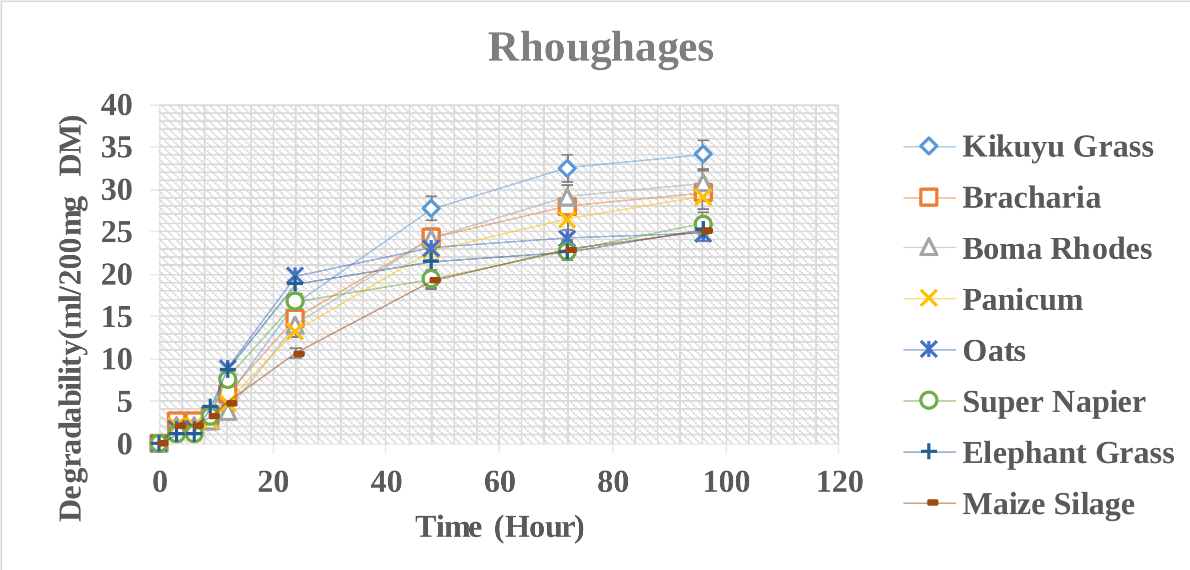

Figure 3: Gas production trends for from different roughages farmers

3.3.4 Concentrates and total mixed ration

After 24 and 48 hours, maize bran gas production was greater compared to TMR which was 12.57 ml/200 mg DM and 18.89 ml/200 mg DM for maize bran and 7.89 ml/200 mg DM and 3.68 ml/200 mg DM for TMR as shown in Table 3.7 and Figure 4. Gas production was lowest for dairy meal which was 7.50 ml/200 mg DM and 0.54 ml/200 mg DM. Based on to the results, OMD (9.45%) ME (6.18%) and SCFAs (36.46%) were highest when maize bran was included. The elevated gas production was likely due to fermentable carbohydrates and soluble fiber in maize bran.

This study found differences in fermentation characteristics between maize bran, dairy meal, and TMR (maize silage/maize bran) that can be at least partly attributed to differences in the highly fermentable dietary fibres and their fermentation processes (Muqier et al, 2023). The fermentation patterns and product levels in TMR were similar to maize silage. Similar results were reported by Kidane et al. (2020), who argued that the lack of any interaction effects between concentrate feed type and maize silage quality in the diets here could be an artefact of a batch culture system, or result from the inability of the concentrate feeds to change the maize silages differentially at the forage-to-concentrate mixing ratio that was utilized in this study. The findings on concentrates particularly with reference to the dairy meal used in the study is very relevant. It highlights the importance of obtaining a good quality dairy meal for the dairy cows. Furthermore, maize silages and their mixtures with concentrate feeds reinforce the importance of maize silage quality as modified due to cutting age.

Table 3 7: *In-vitro* gas production (ml/200mg DM), OMD ME SCFAs at 24 and 48hrs and fermentation characteristics of concentrates and TMR from different farmers

Sample	24	48	A	B	C	A+B	RSD	OMD	ME	SCFAs
Dairy Meal	7.50[b]	0.54[c]	0.74[a]	1.84[c]	0.20[a]	2.58[c]	3.00[c]	19.65[c]	6.58[b]	0.16[a]
Maize Bran	12.57[a]	18.89[a]	-0.27[b]	9.72[a]	0.08[a]	9.45[a]	6.18[a]	36.46[a]	7.93[b]	0.27ac
TMR	7.89[b]	3.68[b]	-0.04[b]	3.89[b]	3.26[a]	3.85[b]	3.96[b]	22.48[b]	5.70[a]	0.17[a]
SEM	0.43	0.52	0.12	0.08	1.02	0.15	0.07	0.49	0.11	0.01
p-value	0.0057	<.0001	0.0151	<.0001	0.2513	<.0001	<.0001	0.0001	0.0010	0.0057

A, B, C are constants in the equation (Ørskov & McDonld, 1979); *a, b, c,d* Means with the same letter superscript in a column are not significantly different ($p<0.05$). OMD: Organic Matter Digestibility; RSD: Residual Standard Deviation; SCFA: Short Chain Fatty Acids; A is the initial gas produced; B is the actual gas produced during DM degradation; A+B is the total gas produced during fermentation.

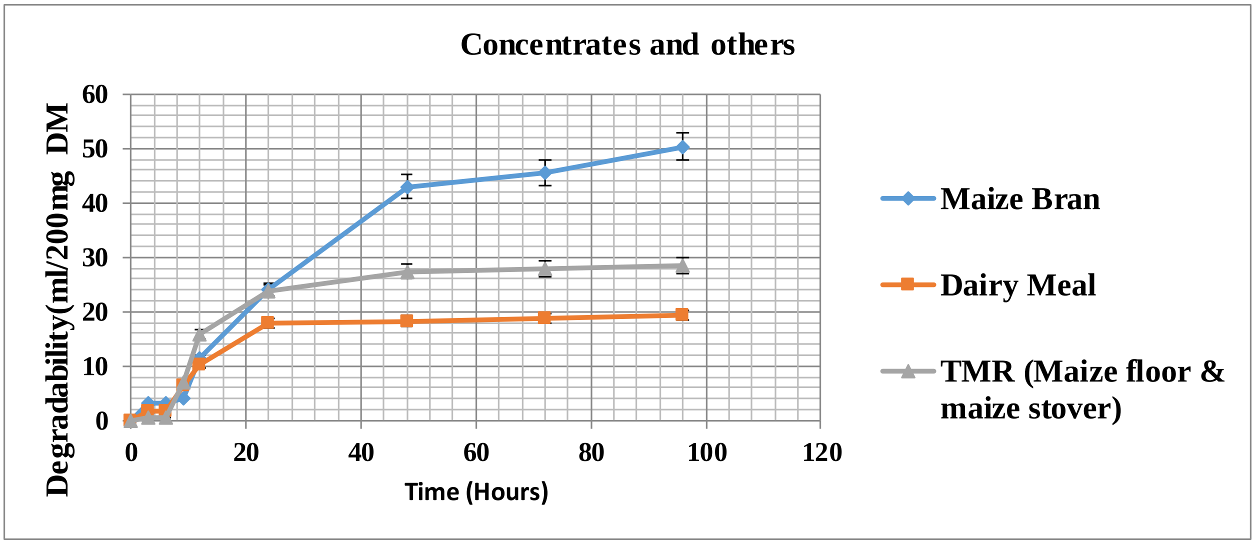

Figure 4: Gas production trends for concentrates and others from different farmers

3.4 Conclusion

The conclusions drawn from the research show that fodder trees and legumes are superior to crop residues in nutritional value, being higher in protein and digestibility which is essential to maximize dairy cow production. Crop residues are acknowledged to be less nutritious but the roughage has a fairly balanced value meaning that it can offer alternative feeding though not as effective as supplementary feeding.

3.5 Recommendation

The study suggests inclusion of quality fodder trees and legumes in dairy cattle ration's formulations. Fodder species like lucerne, Sesbania and calliandra contain better nutritional quality and a high crude protein content which could improve the diet and increase quality milk production. Additionally, strategically supplementing concentrate feeds or other protein-rich ingredients can facilitate the utilization of crop residues. Maize stover has better nutritional value than most other residues feeding it alone may however fail to meet the nutritional requirement of dairy cattle. Their total feeding value can be improved by combining with supplements. In addition, it is advisable to evaluate the composition of feed resources and their digestibility frequently since they may affect due to maturity stage, harvesting time and processing.

CHAPTER FOUR

EFFECT OF FEEDING PRACTICES ON QUALITY AND AFLATOXIN LEVELS OF MILK IN BUNGOMA COUNTY, KENYA

Abstract

Milk is an important food element with great nutritional value. However, it is also a potential health hazard when contaminated. Due to aflatoxin contamination, Bungoma County's milk products have persistently surpassed the safety limits set by WHO. To safeguard public health and maintain the economic sustainability of the dairy sector, this problem needs to be tackled. To protect people, more evidence proving that the quality of animal feed affects the quality and safety of milk in handling outlets must be obtained. Accordingly, the study sought to assess the impact of feeding practices on the nutritional quality and aflatoxin levels of milk from Kitinda and Kaptama milk collection centres in Bungoma County, Kenya. Researchers analyzed the milk of 25 dairy farmers from Kaptama and Kitinda dairy cooperatives. The Gerber, Kjeldahl and Lactometer methods were used to evaluate milk quality parameters like butterfat, protein content and density of raw milk, respectively. Research teams measured aflatoxin levels with a special assay. The results showed that these parameters differed significantly, whereby crude protein content was between 2.257% to 4.572% and butterfat was between 2.450% to 3.550%, indicating some dietary effects. The Kitinda samples showed that 30.77% of it exceeded the recommended aflatoxin threshold (20 µg/kg), while 23.53% of Kaptama's samples did which indicates serious public health risk. A statistical analysis was done on the aflatoxin levels in feed and milk using Pearson correlation with results of $r=0.749$; $p<0.01$ indicating a strong positive correlation. The different qualities of milk show that feed could have an impact. The collected samples show aflatoxin levels beyond permissible limits suggesting that the feed material and their storage needs to improve. The correlation analysis showed a strong relationship between aflatoxin in feed and aflatoxin in milk – so if your feed is contaminated, your milk will be too. The report calls for long-term engagement for safety and quality assurance of milk and milk products.

4.0 Introduction

The production of milk fat and protein is influenced by rumen fermentation with an important role for butyrate and other volatile fatty acids. According to Garamu, 2019, Milk fat content is significantly contributed by acetate and β-hydroxy butyrate. Rumen microbes transform dietary protein into microbial protein, which provides amino acids for milk protein. Nonetheless, energy and protein levels should be balanced, since high-energy diets can reduce milk fat (Pereira, 2014). Furthermore, the composition alters the density of milk, which is determined by the cow's diet affecting the milk quality (Garamu, 2019).

Despite milk being an essential food in the diet, the presence of harmful chemicals or unsafe practices while handling milk can be dangerous (Pereira, 2014). Among these hazards, aflatoxins pose a very high risk. Toxins are created in nature by the Aspergillus genus of fungi including *Aspergillus flavus* and *Aspergillus parasiticus* (Navale et al. 2021). Dairy cattle can eat contaminated feed. The development of liver cancer, immunological diseases, and developmental problems in children can occur due to this (Gima et al., 2014). It is difficult to ensure the safety of milk due to the thermoresistance of toxins.

Aflatoxins in milk have been recognized as a serious global problem (Jallow et al., 2021). Kenya's dairy business is a significant subsector in the agricultural economy. According to MoALF (2019), it supports the livelihood of millions of people and offers nutritional value to the highly populated regions. The purity of this important food has been compromised more than once due to aflatoxin contamination. A study done in Kenya found that several dairy products exceeded the aflatoxin limits (50 µg/kg) which were recommended by the World Health Organization (Hell et al., 2010).

In Kenya's Bungoma County, specifically in Kaptama and Kitinda, the situation is very severe (Kemboi, 2022). The studies conducted by Sirma (2020) argues that poor agricultural practices and low-quality feed aggravate aflatoxins in the area. These regions milk collecting centres will provide the vital function of first screening the milk for aflatoxin contamination. These centres are responsible for strict testing and ensuring compliance with local and international safety standards. To ensure aflatoxin management in Kaptama and Kitinda MCCs, it is necessary to test frequently, comply with the limit, and ensure the farmers are educated widely on the appropriate feed storage and handling to prevent fungal contamination (Sirma, 2020). Improvement of these practices for the enhancement of the safety and quality of milk will ensure public health safety and augment the expansion and profitability of the local dairy business. Accordingly, this study ascertained the milk quality parameters and the safety of milk in Kitinda and Kaptama milk collection centres.

4.1 Materials and methods

4.1.1 Study rea

The study was carried out in Kenya Bungoma County which is the main focus of the study that covers dairy farmers who are members of Kaptama and Kitinda cooperative societies. The County has geographical coordinates of 340º 20' to 350º 15' east and from 0º 28 ' to 10º 30' north. The total area of the County is 3032.4 km^2. Bungoma County is bordered by Uganda to the northwest, on the northeast Trans-Nzoia County; to the west and southwest is Busia County while on the east and southeast is Kakamega County. The County's lowest and highest monthly rainfall measures are assigned 400 and 1800 mm respectively, while its lowest and highest annual temperature readings are allocated 0º and 32º (Bungoma CIDP, 2018-2022).

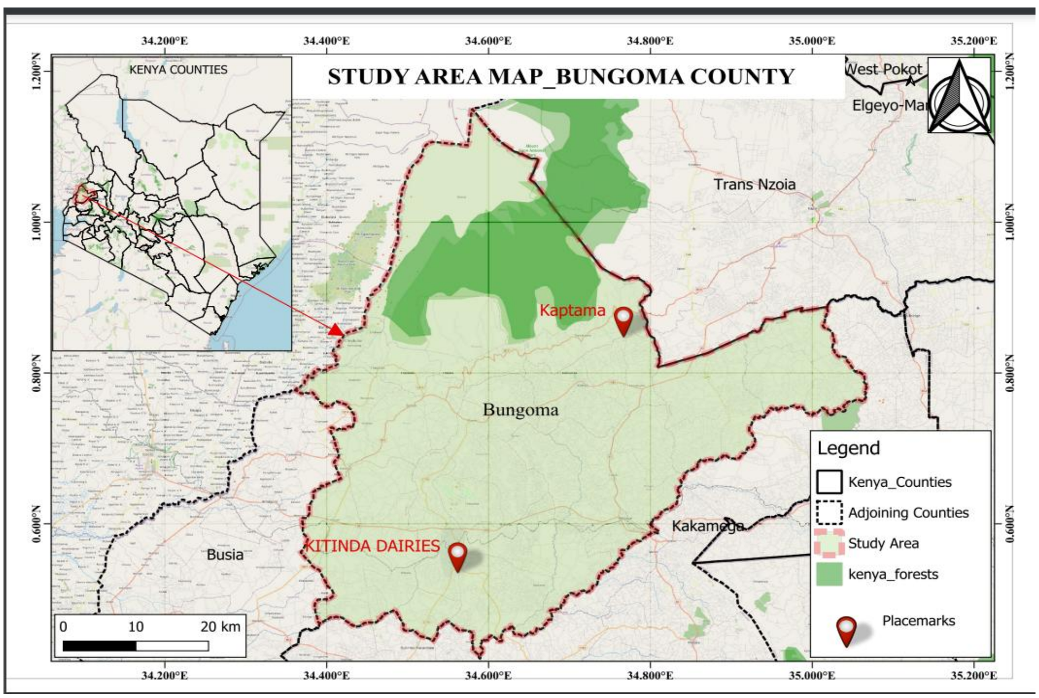

Figure 5: Map of Bungoma County showing the study site.

Source: KISM, (2024)

4.1.2 Sample collection

A total of 25 milk samples (10 mL each) were taken from 12 farmers in Kitinda (KTD 1–KTD 12) and 13 farmers in Kaptama (KTM 1–KTM 13) milk collection centres. The samples were placed in a plastic sampling bottle and transported in cooler boxes at 4°C. Furthermore, 25 feed samples of 1 kg each were collected from the same farmers nominated for milk samples, packed in khaki bags and delivered to Egerton University Animal Science Laboratory for analysis of butterfat, density, protein, and aflatoxins using specific reference methods.

4.1.3 Determination of butterfat in raw milk

The Centrifugal Separation of Fat Volumetric Gerber Method (Richardson, 1985) (Helica Bosystems,Santa Ana, CA, USA) was employed for rapid determination of fat in milk. Gerber acid, which is a sulphuric acid with a specific gravity 1.84 and 96% (w/W) at 20oC, was measured in the butyrometer. Moreover, 10.75 mL of milk was added to it. Amylalcohol (1 mL) was added to break the emulsion. The sulphuric acid broke the fat globule membrane through its coagulating effect on proteins and dissolved the milk fat in it. The fat dissolved in the acid separated by the centrifugal force of 219.1×g, the reading was taken in the stem of butyrometer.

4.1.4 Determination of crude protein content in raw milk

The Kjeldahl technique was used to investigate raw milk protein. Samples of milk were weighed (0.2 g) and placed into kjeldahl digest tubes. In each test tube, a selenium tablet was taken, and concentrated sulphuric acid (10 mL) was then added into the test tube. The samples were digested in a digester at 445°C for 3 h. After digestion, the samples were allowed to cool to the temperature of 25oC and distilled with the help of a Kjeldahl distillation unit (Helica Bosystems, Santa Ana, CA, USA). A mixed indicator of methyl red and methylene blue was added to the distillate collected in 15 mL solution of 0.1 M HCl. The collected HCl was titrated against 0.1 N NaOH. The crude protein content was calculated as follows:

% Crude protein= $(V_2 - V_1) \times M \times 14 \times 6.25 / W$

Where V_2 is the volume of HCl used for the test portion

V_1 is the volume of HCl used for the blank test

M is the molarity of acid

W is the weight of the test portion

4.1.5 Determination of density of the raw milk

The lactometer method by Richardson (1985) was used to determine the density of raw milk. A glass jar was taken and was cleaned and dried. Then about 2/3 of the volume of the jar was filled with milk. The milk was poured down the jar's sides to avoid injecting air into the milk. The lactometer (Helica Bosystems, Santa Ana, CA, USA) was lowered gently in the milk so that it floated freely, not touching the jar sides. Milk was added to the brim of the jar. The reading of the lactoscope was observed at the top of the meniscus within a minute only. The temperature of the milk was recorded.

4.2 Determination of M1 aflatoxins in raw cow milk

4.2.1 Sample preparation

The raw cow milk was placed in a refrigerated temperature (4°C) overnight for the fat globules to rise at the top during a natural creaming effect. The surgeon aspirated out the thick upper layer of fat and transferred it into the clean mid-plasma for the assay in a microtube.

4.2.2 ELISA procedure

Before the beginning of the analysis, the reagents were brought to room temperature (25°C) using the cool box, and content of the PBS-Tween packet (Helica Bosystems and Santa Ana, CA, USA) was reconstituted with distilled water into a 1 litre container. For each standard and sample which had to be tested, one mixing well was placed in a microwell holder. Two times the amount of Antibody Coated Microtiter Wells (Helica Bosystems and Santa Ana, CA, USA) was put in 1 other microwell holder. Microtubes (1000 mL) were taken and transferred 1.2 mL from each standard and sample. With the 8-multichannel pipettor, 200 µL aliquots of the standards and samples were transferred with duplicates from the microtubes into the Antibody Coated Wells (Helica Bosystems and Santa Ana, CA, USA), and the first incubation was conducted in the incubator for 20 min. The microwells were emptied into a discard basin after use. The reconstituted PBS-Tween wash buffer was used to fill the wells, then decant off the buffer back into the discard basin. This was repeated for a total of three washings. The wells were then tapped face down onto a layer of absorbent paper Richardson (1985).

After transferring the standards and samples in a second aliquot of 200 µL, a second 20-minute incubation followed. At the same time, 150 µL was added into each mixing well of standards or samples and conjugate was added into this well, 150 µL. The mixture was mixed by repeating the priming of the pipette 3 times. Volumes were adjusted when running singlets. Throughout the test, we documented the locations of all Standards and Samples. The plate was washed as in previous washing steps the second incubation was done. Subsequently, the conjugate mixture from 100 µL of each mixing well is transferred to the corresponding antibody-coated well. It is also incubated for a further 20 min, covered to avoid direct light. The content of the microwells was emptied into a discard basin again. To wash the wells, the wells were filled with reconstituted PBS-Tween wash buffer. The wash buffer was decanted into the discard basin. This was repeated for a total of five washings. The bottles were inverted onto a layer of blotting paper. 100 µL of enzyme-substrate (TMB) was added to each well, and the wells were incubated for 10 minutes, covering them to avoid direct light due to the TMB substrate's light-sensitivity. A yellow colour appeared after adding 100 µL of stop solution following incubation. Finally, the optical density (OD) of every microwell was read using a microplate reader at 450 nm on an air blank or differential filter of 630 nm.

4.3 Determination of total aflatoxins in feed

4.3.1 Sample Preparation

A bottle filled with deionized or distilled water was placed in a water bath of about 40 °C, according to the manufacturer's instructions. The bottle was let pre-warm for 1 h for the uniform temperature before using it. A sample weighing 5 grams was placed in an extraction cup. A precise scale was used to maintain accuracy. We added two capsules of Hydro extraction buffer (Catalogue #928XB001) (Helica Bosystems and Santa Ana, CA, USA) to the extraction cup containing the powder. Deionized or distilled water which was pre-warmed was added to the cup so as to cover the capsules and this was 25mL in amount. After allowing the capsules to soften for 5 min, the buffer was able to get mixed with the sample. The sample in the cup was hand-shaken for 2–3 minutes to ensure that it mixes well with the extraction buffer. It was essential to extract the desired materials from the target. The sample measuring 1 ml taken from the extraction cup was placed into a microcentrifuge tube as reported by Richardson (1985).

The tube undergoes centrifugation at 219.1 ×g for 1 minute to separate the supernatant from particles. Using a freshly opened pipette tip, 700 µL of clean deionized or distilled water was transferred into a clean microcentrifuge tube. The water-filled tube was also loaded with 100 mL of supernatant from the previous step. The solution was vortexed for a while to ensure everything was mixed. The last step diluted the sample to a 1:40 ratio, suitable for the ELISA method.

4.3.2 Assay procedure

Prior to the use of ELISA reagents and samples in accordance with manufacturer's instructions, all samples and reagents were acclimatized to 25°C and sample preparation was conducted at this temperature of 25°C. The PBS-Tween packet was gently washed with distilled water to make up in 1-litre container. For every sample, one green-marked mixing well was removed, and for six standards, an additional six green-marked mixing wells were removed. Remove double the number of antibody-coated wells required. Return unused wells to the foil pack along with desiccant. Before using each reagent bottle, its contents were mixed through swirling. The green-capped bottle dispensed conjugate, adding 200 µL to each mixing well with green markings. A fresh pipette tip was used for each addition with a 100 µL pipette to add 100 µL of standards and samples to the mixing wells, which were green marked. An 8-channel pipette was used to pipette up and down the liquid three (3 times), and around 100 µL were pipetted from the 2 wells into the antibody-coated wells to mix it. Each standard or sample could be run in duplicate since there was enough volume in the mixing wells.

The preparations were incubated at room temperature for 15 minutes. After incubation, the wells were discarded into the discard basin. To ensure thorough washing, the wells were filled/emptied and washed five times with PBS-Tween wash buffer. When the washing was done, the wells were tapped down on towels to remove any leftover buffer left in the wells. A 100 µL substrate reagent from the blue-capped bottle was added to each well with the 8-channel pipettor. The wells were then placed in darkness at room temperature for 5 minutes. Adding 100 µL of the stop solution from the red-capped bottle was done in the same order and same way as the addition of the substrate to stop the reaction. In the end, the optical density (OD) of every microwell was measured with a microplate reader equipped (Helica Bosystems and Santa Ana, CA, USA) with a 450 nm filter within 10 min of addition of stop solution to ensure accurate readings. This procedure ensured that the experimental conditions were controlled and consistent for optimal results.

4.4 Statistical analysis

Data obtained were analyzed using Excel and various graphs were generated to elaborate the findings. Pearson correlation analysis was used to elaborate on the correlation between aflatoxin in feeds and milk at ($p<0.05$) significance level.

4.5 Results

4.5.1 Milk quality parameters

The samples from 12 different farmers in Kitinda milk collection centres showed significant differences ($p<0.05$) in crude protein, butterfat, and density as shown in Table 4.1. The crude protein content ranged from 2.257% Kitinda 2(KTD2) to 4.225% Kitinda 5(KTD5). Butterfat content varied significantly ($p<0.05$) with 2.5% Kitinda 12 (KTD12) as the lowest while Kitinda 1(KTD1) was the highest with 3.4%. There was no significant difference ($p>0.05$) in density.

Table 4 1: Milk quality and safety parameters analysis from 12 farmers in Kitinda MCC

Sample	Crude Protein (%)	Butterfat (%)	Density(g/cm^3)	AFM1(µg/kg)	Total AF(µg/kg)
KTD1	3.356^{ab}	3.400^{a}	1.027^{bc}	510.7024	72.43339
KTD2	2.257^{c}	2.550^{fg}	1.026^{bc}	706.4979	2.48013
KTD3	3.500^{ab}	2.900^{cde}	1.027^{bc}	27.59411	3.431099
KTD4	3.067^{bc}	2.650^{fg}	1.025^{e}	3.245964	2.160466
KTD5	4.225^{a}	2.650^{fg}	1.027^{bc}	8.946678	2.547904
KTD6	2.951^{bc}	2.950^{bcd}	1.028^{a}	560.9281	54.94629
KTD7	4.109^{a}	2.750^{def}	1.027^{c}	583.2436	5.349014
KTD8	2.720^{bc}	2.550^{fg}	1.024^{e}	17.60196	32.17325
KTD9	3.647^{ab}	2.700^{efg}	1.029^{e}	2.064722	2.871726
KTD10	3.414^{ab}	3.100^{bc}	1.028^{a}	4.1926	1.324459
KTD11	3.125^{bc}	3.150^{b}	1.028^{a}	10.1935	2.412922
KTD12	3.125^{bc}	2.500^{g}	1.025^{e}	0.000	0.000
Ave	3.291	2.821	1.027	202.934	15.178
SD	0.528	0.270	0.001	277.170	23.470
SEM	0.181	0.040	0.000	0.000	0.000
p-value	<.0001	<.0001	<.0001	<.0001	<.0001

$^{a, b, c, d, e, f, g}$ means in the same column with different superscripts are significantly different at p<0.05) KTD= Kitinda and 1,2,3….12= 12 different sampled farmers, Ave= average, SD= standard deviation

The analysis of quality indicators (crude protein, butterfat, and density) from samples collected from 13 farmers in Kaptama reveals statistically significant variations ($p<0.05$) among the samples as shown in Table 4.2. The crude protein content exhibited significant variations ($p<0.05$), ranging from a low value of 2.430% in sample KTM10 to a high value of 4.572% in sample KTM3. The butterfat concentration exhibited significant variance ($p<0.05$), ranging from 2.450% in samples KTM6 and KTM10 to 3.550% in sample KTM5. The sample KTM4, KTM7, and KTM10 have the density values of 1.025 and the sample KTM5 and KTM11 has the density value of 1.030.

Table 4 2: Milk quality and safety parameters analysis from 13 farmers in Kaptama MCC

Sample	Crude Protein (%)	Butterfat (%)	Density (g/cm$^{3)}$	AFM1(µg/kg)	Total (µg/kg)
KTM1	4.167^{a}	3.350^{d}	1.0287^{c}	560.9281	87.1428
KTM2	2.604^{bc}	2.900^{g}	1.0267^{d}	832.4809	3.29422
KTM3	4.572^{a}	3.050^{f}	1.029^{ab}	13.73016	4.443101
KTM4	3.704^{ab}	2.700^{h}	1.025^{e}	20.9206	3.269543
KTM5	3.588^{abc}	3.550^{a}	1.030^{ab}	11.27983	53.16964
KTM6	2.546^{bc}	2.450^{i}	1.028^{cd}	49.79994	65.12169
KTM7	3.414^{abc}	2.700^{h}	1.025^{e}	48.066	29.77031
KTM8	3.762^{ab}	3.150^{e}	1.027^{d}	2.819976	3.608137
KTM9	4.514^{a}	3.450^{bc}	1.029^{ab}	44.48113	2.731415
KTM10	2.430^{c}	2.450^{i}	1.025^{e}	848.6603	4.511939
KTM11	4.167^{a}	3.500^{ab}	1.030^{a}	20.51247	3.749449
KTM12	3.646^{abc}	3.050^{f}	1.027^{cd}	88.48283	3.331356
KTM13	3.704^{ab}	3.400^{cd}	1.028^{bc}	66.6546	4.360973
Ave	3.601	3.054	1.028	200.678	20.654
SD	0.678	0.374	0.002	306.200	27.910
SEM	0.236	0.019	0.000	0.000	0.000
p-value	<.0001	<.0001	<.0001	<.0001	<.0001

$^{a, b, c, d, e, f, g,h,i}$ means in the same column with different superscripts are significantly different at p<0.05) KTM= Kaptama and 1,2,3….12= 12 different sampled farmers, Ave= average, SD= standard deviation

4.6 Discussions

4.6.1 Milk quality

The comparison of milk quality from Kitinda and Kaptama farmers' samples of raw milk shows a abundance of useful data for examining crude protein, butterfat and density variations. The results show that these parameters vary significantly as per the statistics which are crucial when assessing their nutritional value and processing.

In Kitinda, crude protein content varied from 2.257% to 4.225%, both KTD5 and KTD7 had the highest values. Different cattle diets or genetics affecting protein synthesis could explain this variability. The protein of Kaptama showed a similar trend with a value between 2.430% and 4.572%. The highest protein was found in KTM3. According to past works, milk protein levels are affected by several factors, including breed, feed quality, and feeding regimen (Larsen et al., 2010; Leiber et al., 2015; Alothman et al., 2019). The data from both regions indicate that some farmers have better feeding management and cattle breeds that are genetically more endowed to produce more protein.Within each of the two regions, differences in butterfat content were also noticeable. The butterfat levels in Kitinda ranged between 2.5% and 3.4%.

In Kaptama, these levels were a bit wider, ranging from 2.450% (KTM6, KTM10) to 3.550% (KTM5). According to O'Callaghan (2018), the composition of milk can also be influenced by the stage of lactation and the dietary fat level. Such differences matter a lot for the dairy industry because they alter product processing and marketability. Milk density indicates total solids in the milk, which did not vary in Kitinda but did in Kaptama. Water addition to milk is a common practice and affects the solids (fat and protein) content, and other chemical factors, of milk. These factors affect the density of milk. Seasonal variations can also change the density of milk due to changes in the water content in the fodder and hence, in the milk (Parmar et al., 2020).

The data from this study followed the trend across the world where milk composition of either peoples in a region provides quality and quantity is affected by environmental condition, breed of cattle and farming practice (Tyasi et al., 2015). The results have serious ramifications for dairy farming and product development in the region. This suggests that improving milk quality will require specific actions which could include educating farmers about their best options, improving cattle genetics and possibly forming co-operative groups to standardise milk quality. The nutritional quality of the milk could be improved with the same and also its economic viability.

4.6.2 Aflatoxins in feed and milk

The suggested quantity of total aflatoxins in feeds is generally 20 μg/kg (Thakur, et al.2022). Based on to the study, most samples had the required levels (69.23 and 76.47) in Kitinda and Kaptama, respectively as illustrated in figure 4.1. Kitinda had the highest levels of aflatoxins (30.77%) above recommended levels. Conversely, Kaptama accounted for 23.53%. The high percentage of animal feed samples contaminated with total aflatoxin above the international limit for human consumption means that animals and humans were likely exposed to aflatoxins through food over a long time (Kamala et al., 2018; Kotinagu et al., 2015). The study indicates that high percentages (30.77%, 23.53%) at Kitinda and Kaptama respectively corroborate with Makori et al. (2019) findings that postharvest handling methods of animal feeds by suppliers and consumers being inadequate could have resulted in higher levels of aflatoxin contamination. Inefficient processing practices, like failing to adequately dry raw animal feed materials or failing to properly distinguish between infected and non-infected raw animal feed materials have also been noted to play a role in aflatoxin contamination throughout the chain (Shabani et al., 2020).

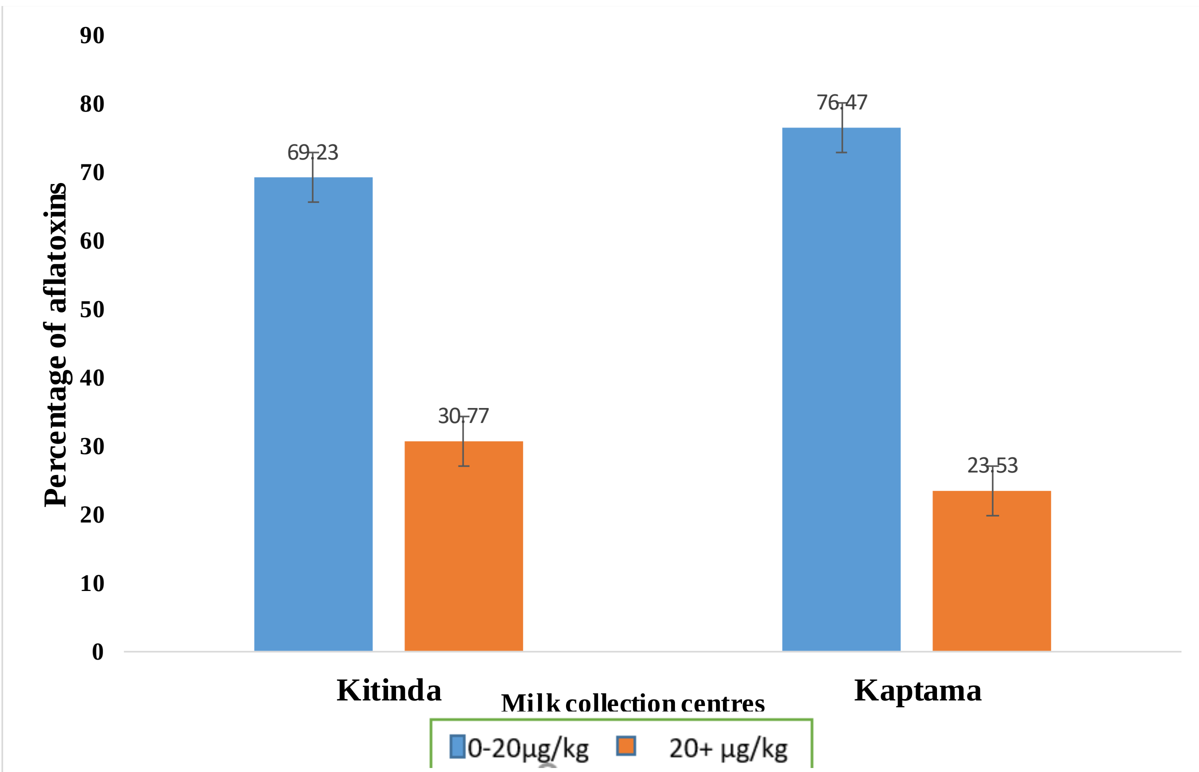

Figure 4.1: A graph showing the total aflatoxins in feeds in Kaptama and Kitinda

The specified level of aflatoxins M 1 in raw milk is usually 50 µg/kg (Zebib et al., 2022). The results showed that most of the samples were found to be within the limits (61.54% and 70.59%) in Kitinda and Kaptama respectively (Figure 4.2). Conversely, Kitinda had an aflatoxin amount of 38.46%, which is significantly higher than the permissible levels. Kaptama, on the other hand, had a percentage of 29.41% of the M1 aflatoxins as a result of variation in diets.

The results of this study is above the previous findings by Mutiga et al. (2015) who found that raw milk from western Kenya had 15% aflatoxins above the recommended levels. Moreover, the disparity in contamination levels between the two locations may potentially indicate distinct local differences in the storage and handling methods of animal feed. This argument corroborates the report by Gizachew et al., (2016), who discovered that poor storage results in the occurrence of aflatoxins in feeds and milk.

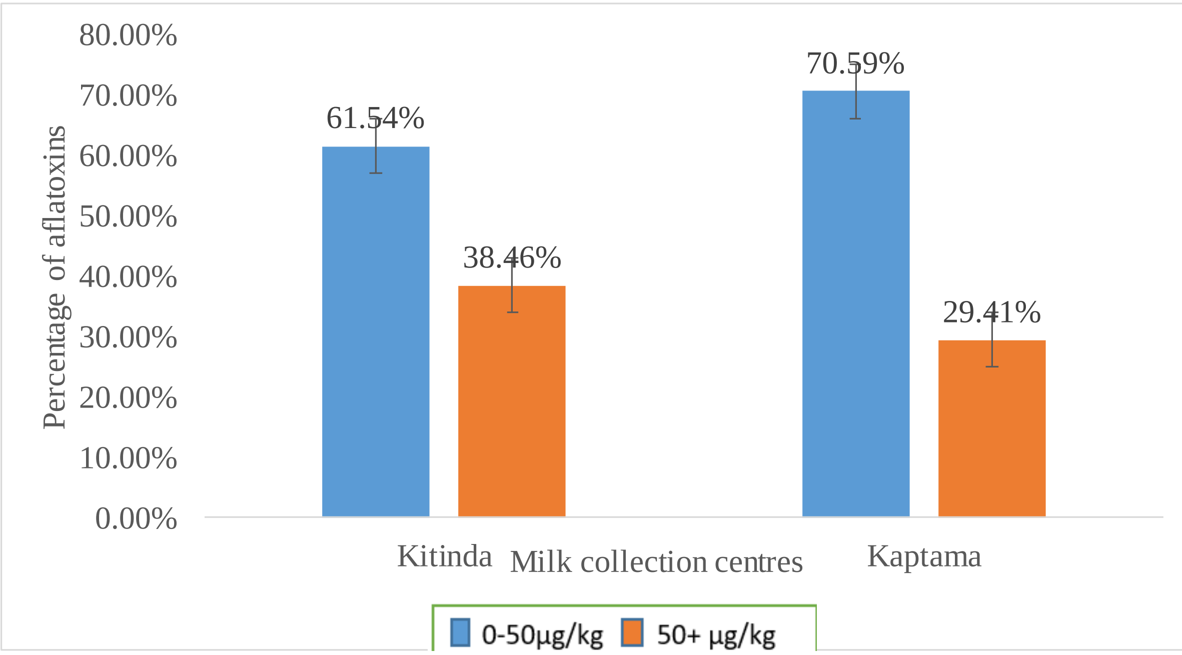

Figure 2.2: Aflatoxins (M1) in raw milk from Kitinda and Kaptama MCCs

4.6.3 Correlation analysis of aflatoxins in feeds and milk

Aflatoxin levels in feed and milk were all investigated for associations using Pearson correlation analysis. There was a significant difference between feed and milk ($p > 0.01$), indicating a strong association between the two (Table 4.3).

Table 4 3: Pearson correlation for total aflatoxins in feed and milk

	Feed	Milk
Feed	1	.749**
Milk	.749**	1

**Correlation is significant at the 0.01 level (2-tailed correlation).

The aflatoxin levels present in feed and milk have a strong relationship as proven by the Pearson coefficient. In agreement with the findings of Admasu et al., (2021), these results indicate a strong correction between aflatoxins in feed and AFM1 in raw milk. Further, Bahrami et al. (2016) emphasized that the safety of milk was reliant on feed quality. This correlation demonstrates how aflatoxins produced by Aspergillus fungi contaminate the dairy supply chain, which are strong carcinogens and can cause harmful health effects.

The quality and safety of dairy products are largely influenced by feed, according to Akbar et al. (2020). The investigation of aflatoxin contamination on several farms showed a positive correlation between aflatoxin levels in feed and that in milk. Thus, this enhances the argument strength. The similarity here suggests a consistency in farms situated in different areas and using different farming practices, which ultimately brings out a universal aspect in respect of aflatoxin contamination in milk production.

4.7 Conclusion

Conclusively, findings showed that the milk quality parameters like crude protein, butterfat, and density varied significantly due to the factors in diet. The most important finding is a clear exceedance of recommended limits of aflatoxin contamination in feed and milk. This poses potential health risks to consumers. Ensuring safe and good quality milk requires a long-term approach. We need to teach farmers proper feed storage to reduce aflatoxin growth, enforce stricter milk safety standards, and explore ways to improve milk quality by feeding better.

CHAPTER FIVE

EVALUATION OF DAIRY CATTLE FEEDING PRACTICES, LOSSES, AND WASTAGE AND THEIR IMPACT ON MILK YIELD IN KAPTAMA AND KITINDA MILK COLLECTION CENTRES

Abstract

Kenya's agricultural sector relies heavily on the dairy sector which plays a key role in the national economy through income generation as well as supplying essential nutrients. At the farm level, feeding management practices could contribute to milk losses and wastage. We need more information and research regarding the effect of various feeding strategies on milk. Thus, the aim of this study was to assess dairy cattle feeding practices, losses and wastages, general dairy performances as well as attitudes of dairy farmers in Kaptama and Kitinda MCCs. Two hundred farmers were sampled with a stratified sampling technique, and structured questionnaires were used. A study found that 77.5 percent of farmers suffered considerable losses, mostly from issues loke feed (44 percent) and health (19.5 percent). The majority of farmers (90.5%) assert that the feeding practice is directly related to the milk yield. More than two third (84.5%) of the farmers had observed a difference in the milk yield due to the difference in the feeding practices. The survey further indicates that 51% of farmers largely depend on crop residues for feed, as 71% are feeding their cattle twice daily. More than half (58%) of the farmers acknowledged that their milk production performance was poor. The current dairy farming practices make many farmers very dissatisfied – 34 per cent and 40.5 per cent are dissatisfied. Dairy farmers in the area lose milk production significantly due to ineffective feeding methods, the study reveals.

5.1 Introduction

The Kenyan agricultural sector relies on the dairy sector for sustainability efforts. It provides enormous income to boost the economy. In addition to that, it also supplies essential nutrients to the nation. In Kenya, smallholder farmers contribute 80% of the milk supply, thereby making them key players in the milk industry (KDB, 2019). Yet, it must be noted that this farmers' group plays a great role in raising production in agriculture, but they have to face a number of problems that restrict the production ability. Foremost among them are inefficient feeding routines, large milk losses, and high rates of wastage. A study by Mahanta *et al* (2020) provided insights into feed systems and how various systems contribute greatly to milk production. However, the direct relationships among these parameters, milk loss, and waste, and how they contribute to production performance have not been studied extensively, which is an unconsidered aspect (Kemboi, 2022).

Bungoma County's dairy cattle value chain is one of the most vibrant sectors. Between 41-60% of the County population is involved in dairy cattle production, with 32,344 households owning a total of 62,009 exotic dairy cattle, 113,733 households owning 279,428 indigenous cows (KNBS, 2019), with a total value of KES 6.7 billion. In Bungoma County, the Kaptama and Kitinda milk collection center (MCCs) collects milk from farmers and sells it to Brookside, new Kenya Creameries Corporation (KCC), hospitals, schools, hotels, and the local community. However, it was found that the Kitinda MCC suffered the most losses at the cooperative, with a total loss of KES11.5 million/year (Kemboi, 2022). The Kaptama MCC had a total loss of KES 4.7 million/year (Kemboi, 2022). Feeding management practices at the farm level could majorly impact milk losses and wastage. Therefore, proper nutritional strategies play a vital role in allowing dairy cows to produce to their genetic potential, thus the need to assess the effects of nutritional practices and the impact on dairy performance. More knowledge is needed on the importance of different nutritional practices on milk yield. Therefore, this study's objective was to determine the dairy cattle feeding practices, losses and wastages, general dairy performances as well as attitudes of dairy farmers in Kaptama and Kitinda MCCs. The results from the study aimed to provide background information to advise stakeholders in the dairy value chain on the best approaches to optimize productivity and lessen food losses and waste.

5.2 Methodology

5.2.1 Study area

This study was carried out in Bungoma County – a central point of attention of the FORQLAB project research – covering dairy farmers who are members of Kaptama and Kitinda cooperative societies. The County's location is 340º 20' and 350º 15' East and 0º 28' and 10º 30' North. The County's area estimate is 3032.4 square kilometers. Bungoma borders Uganda to the northwest, while to the northeast border is Trans-Nzoia County; Busia County is located to the west and southwest, while Kakamega County lies to the east and southeast. The County records 400 and 1800 millimeters as its lowest and highest monthly rainfall, while 0º and 32º are its lowest and highest annual temperature readings (2018-2012 CIDP).

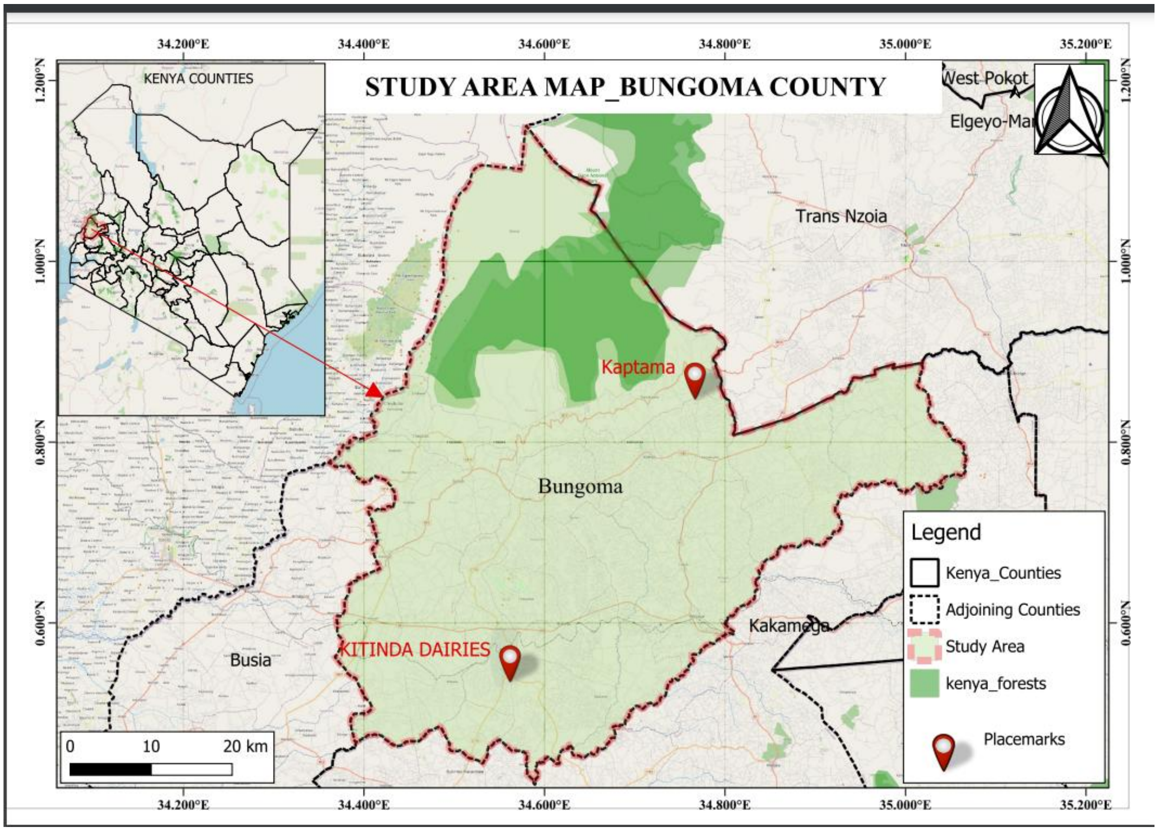

Figure 3.1: Map of Bungoma County showing the study site.
Source: KISM, (2024)

5.2.2 Research design

This study utilized a cross-sectional research design to collect data from dairy farmers in the Kitinda and Kaptama regions. This design enabled the researcher to assess nutritional practices and general performance at a given moment in time and their impacts on milk loss and waste, all at one point in time.

5.2.3 Sampling and sample size

Participants were selected using technique of stratified random sampling. The samples were grouped by their location where Kitinda & Kaptama MCCs are located and their routes of milk collection. Random sampling was then done from each stratum targeting a representative sample of the population. This sampling helped get the views of respondents in both the areas, thus enhancing the generalisability of the study findings.

200 was the sample size obtained from both MCCs with active farmers having about 670 in Kitinda and 430 in Kaptama using Yamane's (1967) formula which is;

$n = \frac{N}{1+N(e^{2})}$ where;

n- sample size

N- the size of the population

e- precision error

n= $670/1+670(0.09)^2$=104 (Kitinda)

n= $430/1+430(0.09)^2$=96 (Kaptama)

Therefore, 200 were randomly sampled

5.2.5 Data collection instruments

A structured questionnaire was created to collect data from participants. The survey comprised of demographic information, such as age, gender and educational qualification, and feeding practices, milk production, attitude towards dairy farming and more. To achieve accuracy and relevance, the questionnaire was designed that way so that the participants could understand it quite easily.

5.2.6 Pilot testing

Before the collection of major data, we pilot tested the questionnaire on some students to represent the farmers. The pilot test assisted in removing the any tricky errors in a questionnaire or any clause found confusing. In light of the pilot test's feedback, the questionnaire was revised to ensure clearer answers were obtained and the necessary data was collected.

5.2.7 Data collection

The selected participants were interviewed face-to-face using the questionnaire. Trained interviewers conducted the interview and data collected is accurate and full like in a sample survey. The interviewers valued the participants' time and space, so they only imposed on them as much as was required from their end.

5.2.8 Data analysis

Statistics description were used for data analysis. Frequencies and percentages were computed for the categorical variables (sex and education), while means and standard deviation were collected for the continuous variables (milk production, feeding practices as well as performance attitudes). The analyzed data was represented in graphs, bars, pie charts, and tables. The results of this analysis helped in summarizing the main findings of the study and detecting any trends in it.

5.2.9 Ethical considerations

The ethical virtues of the research were adhered strictly in conducting this research study. After data collection, the collected data was securely stored for further analysis. Before collecting or recording any data, informed consent was first established. The study ensured that all participants received adequate support, fair treatment and legal protection in terms of data and publication.

5.3 Results and discussions

5.3.1 Demographics

The study's participant demographic distribution shows that there is a varied representation of gender in the Kaptama and Kitinda dairy farming communities as shown in **Table 5.1**. The gender distribution of the 200 participants is shown by the tabulated data, which shows that 73 of them were men, made up 36.5% of the sample, while 127 of them were women, and made up 63.5%. The diversity in gender mix of the people selected for the study indicates that the dairy farming industry captures the views and experiences from both sex groups. It is imperative to acknowledge the significance of gender relations in agriculture as they can influence many aspects of farm management; decision-making patterns and the adoption of new practices.

Table 5 1: Gender Distribution of the Participants

Gender	**Frequency**	**Percent (%)**
Male	73	36.5
Female	127	63.5
N	200	100
	Location Distribution of the Participants	
Kaptama	108	54.0
Kitinda	92	46.0
N	200	100
	Level of Education Distribution of the Participants	
Primary	89	44.5
Secondary	90	45.0
Tertiary	21	10.5

N= 200

Table 5.1 shows the distribution of participants as per their location (Kaptama and Kitinda). Out of 200 respondents, 108 (54.0%) from Kaptama and 92 (46.0%) from Kitinda. This division plays an important role in contextualizing these findings, as geographic regions can affect the availability of resources, adoption of farming methods or practices, and climate. Understanding the participant distribution at these locations will help evaluate how the geographical variation affects the dietary practices, milk quality and performance of the dairy products. The later sections of the study have location-specific results which explains how the differences between Kitinda and Kaptama might have led to different results in the context of dairy farming. Considering a regional perspective can improve the interpretation of the study. This can also help in forming recommendations that can be easily adopted by the local farmers.

As demonstrated in Table 5.1, the educational backgrounds of the study respondents showed a wide academic achievement in Kaptama and Kitinda dairy farming communities. A large part of the sample, 44.5%, is an illiterate which indicates that a large number of people working at the dairy farm are illiterate. This means that a considerable number of participants have acquired the essential reading and mathematics skills. Another significant participant group (45.0%) of the sample has completed secondary schooling. People who studied beyond the primary level seem to be fairly evenly distributed, as per this distribution. Students graduating out of secondary school may enhance their farming methods via the addition of new skills and knowledge, which may affect their decisions and adoption of new agricultural practices.

Moreover, a smaller yet notable share of participants—10.5%—have gone on to further their studies beyond high school. This subset of people includes individuals with greater education meaning a proportion of those take part in the experiment might have greater skillsets and possibly more knowledge about agricultural practices. Those with tertiary education may have specialized knowledge that could apply to enhancing farm management practices and perhaps even developing new approaches to the dairy industry.

It is important to understand the educational background of the subjects for the interpretation of results in nutritional practices, milk quality and performance of dairy products (Sharma, 2016). A person's ability to comprehend and use recommendations, communicate with agricultural extension services, and adopt sustainable farming methods can all be influenced by his education.

Table 5.1 indicates that the age of the respondents ranges from 21 years to 87 years, with the mean age being 49.62 years. The variability of the participants' ages was moderate, as seen by the 13.745-degree standard deviation. The age group of the sample may influence the attitude and farming methods as highlighted in the demographic information. The age distribution of participating farmers shows the generation dynamics of the community of dairy farmers. We can further our understanding by looking at experience in the dairy farming and assessing whether there are identifiable patterns in practices and attitudes based on how long people have been in dairy activities.

Table 5 2: Age and Lactating animals per household

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Age of the Respondent (Years)	200	21	87	49.62	13.745
Size of the family	200	2	13	5.74	2.386
Number of lactating animals	200	1	4	2.26	1.025
Valid N (listwise)	200				

The family size is one of many demographic factors which influence dairy farming in many ways. The family size determines resource allocation, decision-making, and overall farm management. In a larger family, the labour force may be larger and involved in a wider variety of farming activities. However, small families may face a different set of challenges in dealing with the range of responsibilities concerning dairy farming. When assessing the socio-economic setup of families that farm for dairy, it is essential to know the type of family. The household resource allocation, the division of work, and the well-being of its members are significantly influenced by the family size. Larger families may require more resources and face challenges to fulfill everyone's needs including their human and animal family members. This study shows that there is an average family size of 5.74 members, with family sizes ranging from a minimum of 2 members to a maximum of 13 members. The standard deviation of 2.386 reveals that family sizes seem to vary to a considerable extent. In dairy farming, an understanding of family structure is utilised to assess resource use, decision-making and the general well-being of the household.

It is interesting to note that, on average, the study cohort owned 2.26 lactating animals per household from the total of 2.09 cows and 0.17 buffaloes. By law, only a maximum of four lactating animals are allowed to be owned. Animals that lactate have a standard deviation equal to 1.025 which signifies a certain amount of variation. This particular variable impacts various sectors within the dairy industry significantly. An important determinant of the total output of dairy products in the house holds is the number of lactating animals as it has a direct bearing on milk production. The number of lactating animals also differed which shows the size of the dairy operation of the respondents. Similarly, this also shows how they maintain and care for their animals. To determine the extent of dairy activities, the distribution and range of lactating animals must be understood. Household dairy farming helps in production and economic benefit. It is a good way of helping ourselves and our nation. Furthermore, this variable is essential to the development of successful feed management plans. Because there is a direct correlation between the nutritional requirements and the production capacity of lactating animals, feeding practices must be customized to meet the unique needs of these animals.

5.3.2 The dairy cattle feeding practices, losses, wastages, and their effect on milk yield

This section provides an in-depth understanding of feeding patterns, problems faced, and farmers' perceptions of dairy farming and milk quality in Kaptama and Kitinda. In the study, 200 farmers were surveyed. Diverse feed resources used in this region were identified whereby the majority of the farmers (51%) feed crop residue as the main feed, followed by fodder trees and legumes (21.5%), roughages (14%), and obtain concentrate and total mixed ration (TMR) (13.5%) as shown in Figure 1. The feeding frequency was recorded twice daily (71%). This clearly shows a bit of organized feeding time, with the majority of farmers giving cows feed in the morning and afternoon (38.2%) or morning and evening (34.2%).

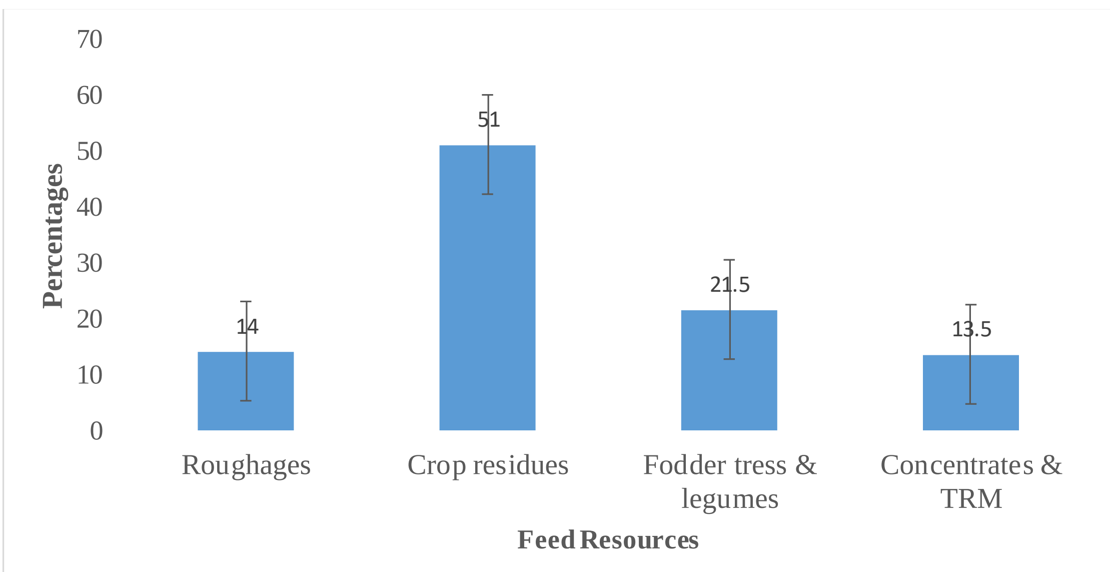

Figure 1. Main feed resources in Kaptama and Kitinda

The majority of farmers (77.5%) experienced losses or wastages in their practices, most commonly due to feed-related factors (44%) and health matters (19.5%) as shown in Figure 2 below. Results suggest a high level of acceptance among farmers (90.5%) that feeding practices are directly linked with milk yield, with 84.5% of farmers witnessing sometimes effects in milk yield through different feeding practices.

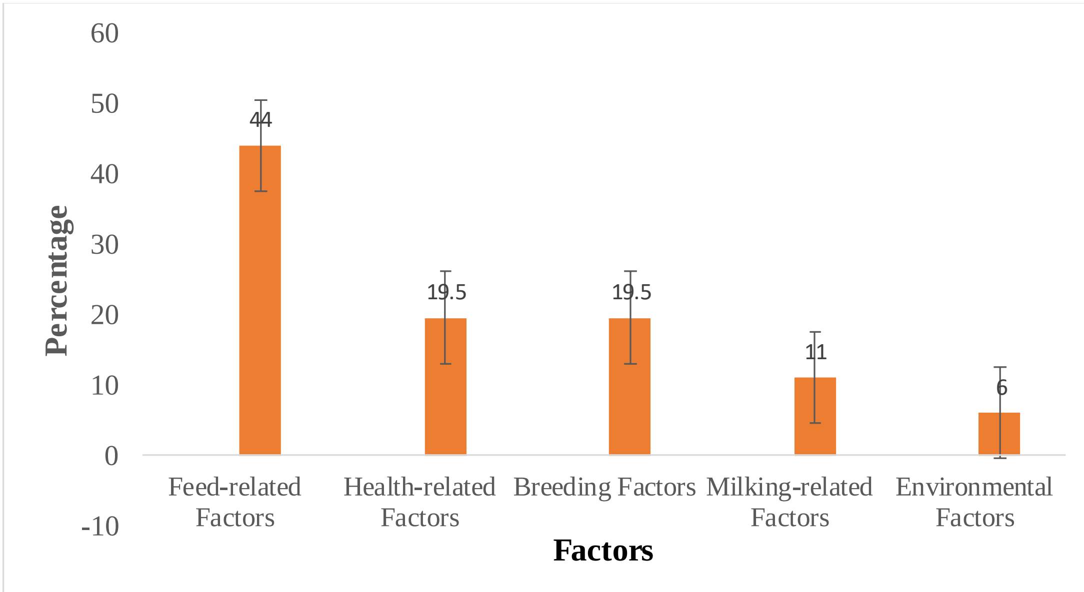

Figure 2. Causes of losses and wastages in milk in Kaptama and Kitinda MCCs

However, feeding resources are efficiently considered a difficult task, as evident from the issues regarding the quality of feed and its nutrient contents (52%), balanced ratios (13.5%), and feed losses (13%). The majority perceived the overall performance in milk production negatively; very poor (34.5%) and poor (23.5%) ranked highest. Most of the respondents mentioned the milk quality in the area to be very poor (49.5%), while a response of poor (23.5%) was a close second. Most responders reported being very unsatisfied (34%) with their current dairy farming practices, followed by unsatisfied (40.5%). The opportunity that exists in the dairy farming practices of the region.

Many dairy farms depend on feed supply – that is to say, crop residues, which are the feed resource (Maleko et al., 2020; Mahanta et al., 2020). The studies showed that the use of such resources was key to the development of dairy farming in low-resource settings. This is relevant to us as we deal with agricultural residues. Low-nutritional diets such as crop residues can lead to milk production inefficiencies (Hills et al. 2015). Most of the farmers in the study fed their cattle two times a day, which is a normal feeding practice. This is consistent with Kumar and Singh's (2020) findings which state that through timely structured feeding, milk yield can be optimized, and the importance of enhancing their diet by adding more nutritious feeds to make this happen.

A majority (77.5%) of the the respondents expressed concern over losses and wastages in dairy operations (particularly those caused by feed). Such difficulties were also highlighted in Ojango et al. (2017), who note that feed quality and management are key drivers of dairy productivity. This further strengthens the view of research that suggests better feed management tactics can help reduce the losses. According to Ongadi et al. (2020), farmers strongly believe that the feeding practices have a significant impact on milk yield. Most farmers notice changes in yield due to feeding practices. The quality of the feed supplied and the feeding regimes greatly impact the milk production. This indicates a possible area of intervention, as feeds of better quality and improved feeding practices could significantly increase the milk yield of dairies.

Efficiency issues in feed resource management comprising feed quality, nutrient composition and feed wastage reflect a more general problem of the dairy sector particularly in scarce resources (Van der Poel, 2020). To overcome these challenges, feed resource management can be made more sustainable and the use of improved feeding methods can be considered. Meena et al. (2023) research found similar issues occurring in developing countries it is severe concern where the perception of milk production performance and milk quality is not optimum in a region. This demand on dairy animals can be managed better through health and welfare of dairy cattle, milking and handling, and breeding, which will help in increasing the quality and quantity of milk production. Farmers are unhappy with their lot in the dairy industry shows that there is much unease throughout and there needs to be a shift in policies and practices to help farmers cope with all the ills that they encounter.

In summary, findings add important new insights to the current literature on dairy farming within developing contexts in Kaptama and Kitinda more particularly. They stress the urgent need for action to enhance milk output and quality in the region through better management of feed resources, nutrition of animals and general dairy farm practices.

5.3.3 The general dairy performance and attitudes of dairy farmers

As per survey, 9.5% respondents rated the performance of their dairy cattle as ‘Very Poor’. This is a very important fact because this means a certain section of farmers must be grappling with huge problems affecting their yield. Research done by Sorge et al., (2013), showed that poor feeding methods could lead to reduced productivity of dairy cattle. When farmers fail to use current dairy farming methods or do not have the better feeding regimes, these problems often get worse. As the rating increases, 19.0% of the farm owners rated the performance of their cattle “Poor.” It can be expected that these groups will face challenges that severely limit the production of their operation. According to Quddus (2012), better feeding techniques and other types of technology significantly increase milk yield and grow household income with dairy growth.

The majority of respondents (54.5%) rated their cattle’s productivity as “Neutral”, meaning they only just meet basic expectations. The adequacy but not the excellence of genetic potential, feed quality, and management activities could be responsible for such a feeling. The findings of the present study aligns with those of Hemsworth and Coleman (2010) who suggested that average performance is usually the product of resource allocation and management techniques which do not fully realize their output potential.

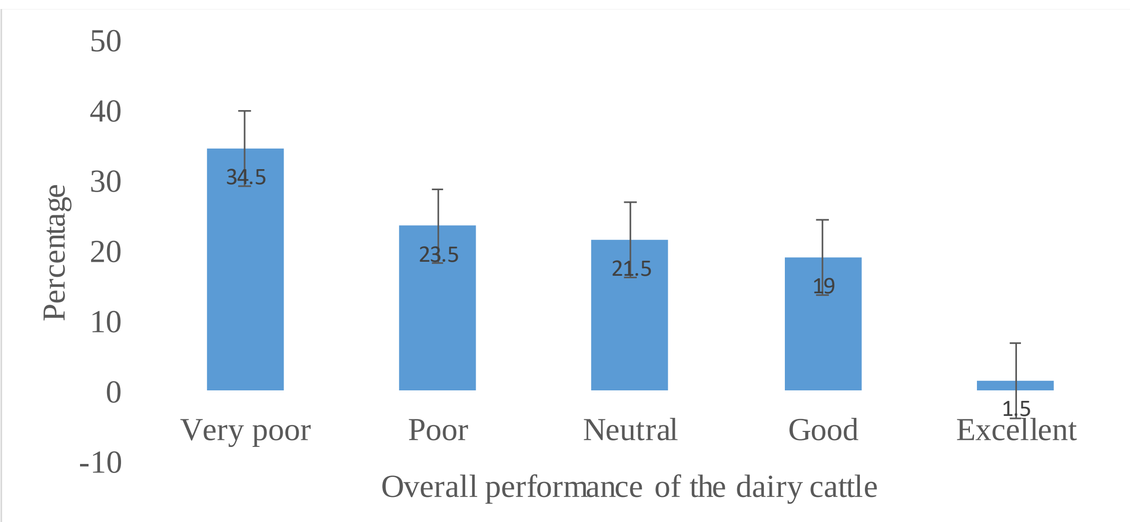

Figure 3. Description of the overall performance of dairy cattle in terms of milk production

The large majority of respondents (88%), as depicted in **Figure 6**, felt that the nutritional value of feed has an impact on milk quality. This shared belief among the respondents shows an understanding that the nutritional quality of their feed impacts the milk that their dairy cows produce (Garamu, 2019).

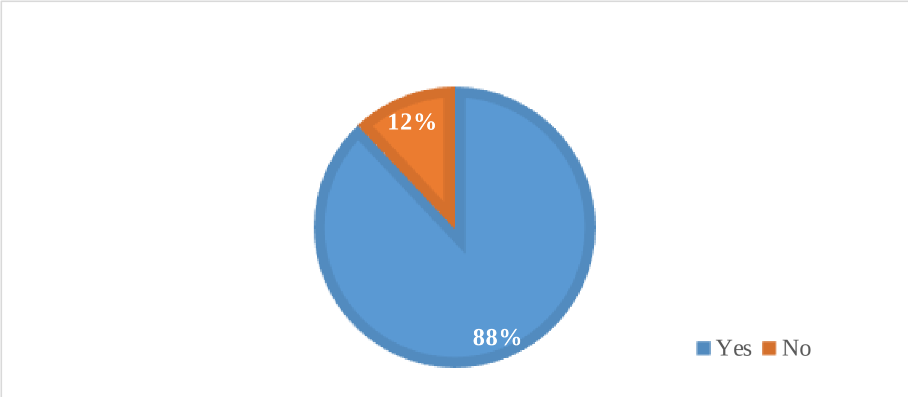

Figure 4: Perception of the nutritional value of feed on milk quality

Meanwhile, a smaller percent of 12% say that they do not think the nutritional value of feeds impacts on milk quality. Even though this percentage may seem low, it is a considerable percentage of participants who may either hold contrary opinions or may not believe that feed nutrition and milk quality are related to their dairy farming.

5.4 Conclusions

The study found that poor feeding practices and over-reliance on nutrient-rich forages with plant residues negatively affect milk yield at Kaptama and Kitinda collection centers. As a result of these nutritional deficiencies, the yield is lower and the quality of milk is poor, which spoils the dairy farming potential in the region.

CHAPTER SIX

6.0 GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

6.1 General discussion

The aim of the study was to evaluate the chemical composition and in vitro gas production of feed roughages, crop residues, fodder trees and legumes. There were differences in dry matter (DM), crude protein (CP), and fiber contents of the feed samples. Super Napier was found to have the highest content of CP (149.3 g/kg DM) while maize silage had the lowest level which was 56.1 g/kg DM. Furthermore, other studies showed that the harvesting stage and maize quality influenced CP content (Mandić et al, 2018). The NDF content of various fodders was significantly different. The Super Napier had the maximum value of 733.3 g/kg DM while similarly maize silage had the least value of 474.7 g/kg DM. These findings are consistent with those of Adnew et al., (2019) and underline the necessity of studying the dietary chemical profiles of various feed resources.

Analysis of gas production in vitro revealed differences in fermentation characteristics of feed resources. The legumes and fodder tree with the highest gas production and organic matter digestibility (OMD) was lucerne. This confirms the nutritional superiority of lucerne (Wangila, 2021). Gas production from maize stover was most suitable for other crops as it produced a relatively higher volume of gas amongst the various residues. Roughages like Kikuyu grass have high OMD, ME, and SCFAs, affirming its good fermentation characteristics according to previous studies (Abu et al., 2022). As the chemical make-up of feed materials influences the fermentation process in ruminants, appropriate feed resources must be selected to enhance ruminant nutrition and productivity.

The demographics of the respondents during the study show that gender representation is varied in Kaptama and Kitinda Dairy Farming Community. Table data of the 200 subjects portrayed the gender distribution. As shown, 73 of them were men, making up 36.5% of the sample. Meanwhile, 127 of them were women, and made up 63.5%. The gender distribution in this study demonstrates its inclusivity as it captures the views and experiences of both males and females in dairy farming. Gender issues must be recognised in the agricultural context since they can impact many processes from farm management to decision-making and adoption of innovations.

The survey results indicate that 9.5% of respondents rated their dairy cattle performance as ‘Very Poor’. This is an eye-opener because it implies that a small percentage of farmers are having serious issues that are affecting their performance. Sorge et al. (2013) found that poor feeding practices can greatly reduce the productivity of dairy cattle. Farmers tend to worsen these problems when they are not applying current dairy farming techniques or do not have access to better feeding regimens. As the rating increases, 19.0 % of farmers feel that the performance of their livestock is "Poor." This part of the group is not likely to face difficulties that will obstruct the production of their enterprise severely. According to Quddus (2012), the enhancement of feeding methods and the use of other kinds of technologies increase milk quantity, households' income and the dairy growth.

The study found that ineffective methods of feeding greatly reduce the amount of milk produced by the farmers in the area. The efficiency of the dairy animals is highly affected with their dependence on low-nutrient feeds like crop residues coupled with inadequate feeding practices. The quality of feed and feeding routines can help effectively address the inefficiencies. As a result, milk production can increase significantly and the smallholder farmer livelihoods can improve and ultimately the economy of the region. A large percentage of dairy farmers are unhappy with the present-day farming methods because of low milk production and poor milk quality caused by feeding strategies. There is an urgent need for targeted educational interventions and policies that promote better nutrition and efficient feed management. It is possible to improve dairy farm production and increase ambient satisfaction by matching feeding methods with the specific nutritional requirements of dairy cattle.

The milk from Kitinda and Kapstama showed strong variations in the value of crude protein, butterfat and density. These are some essential factors in any milk which determine the goodness of milk. The highest crude protein content of 4.225% was obtained from KTD7 while the lowest 2.257% was from KTD5. Sample KTM3 from Kaptama showed the highest protein level of 4.572% which ranged from 2.430% to 4.572% in Kaptama. The breed of cattle, the quality of feed, and the feeding schedule are some factors that affect the levels of proteins in milk (Larsen et al., 2010; Leiber et al., 2015; Alothman et al., 2019). Certain farmers may have better feeding strategies or cattle varieties with enhanced genetic traits to produce greater amounts of proteins, the data suggest.

There were also notable butterfat differences in both areas. The butterfat levels were 2.5% (KTD12) to 3.4% (KTD1) in Kitinda and 2.450% (KTM6, KTM10) to 3.550% (KTM5) in Kaptama. The butterfat content differs depending on lactation stage where the diet particularly fat in the diet affects butterfat (O'Callaghan, 2018). These variations are critical for the dairy sector as they affect product processing and marketability. The milk density results for Kitinda was consistent while Kaptama reported a variability due to the solids content. There is also a possibility of water addition and other adulteration practices. The weather can change the density of milk by changing the water content of fodder and with it the milk (Parmar et al., 2020). A regional variation in the composition of milk is not a strange phenomenon and has been recorded in other parts of the world.

The study also looked at aflatoxins in feed and milk. It is usually allowed 20 ppb aflatoxin in feeds. Most samples from Kitinda (69.23%) and Kaptama (76.47%) conformed to the standards. Kaptama had 23.53% of samples exceeding the recommended range; however Kitinda had a higher percentage at 30.77%. Those individuals might be at risk of long-term aflatoxin exposure via their respective diets (Kamala et al., 2018; Kotinagu et al., 2015). Poor methods of postharvest handling of animal feeds might have contributed to high aflatoxin levels (Makori et al., 2019; Shabani et al., 2015). The level of aflatoxins M1 in raw milk not more than 50 ppb. A majority of the samples from Kitinda (61.54%) and Kaptama (70.59%) complied with limits. Kaptama recorded 80% of milk samples within permissible limits while Kitinda didn't record the samples mentioned above. The difference in contamination levels could be as a result of the local storage and handling of the animal feed (Gizachew et al., 2016). The numerical value of 0.749 of Pearson correlation coefficient of aflatoxin level in feed and aflatoxin level in milk shows a strong positive correlation of the two. Thus, this result confirms the finding of Admasu et al. (2021) and Bahrami et al. (2016). The interaction illustrates the importance of feed quality to milk safety and the health concerns that arise due to aflatoxin contamination in the dairy food chain.

6.2 Conclusions

i. Fodder trees and fodder legumes have good nutritional value, whereas crop residues are low in quality.
ii. Milk quality parameters like crude protein, butterfat, and density differed significantly, indicating the influence of factors in diet. Nonetheless, the most alarming finding is the aflatoxin contamination of the feed and the milk exceeding recommended safety limits.
iii. Ineffective feeding practices have contributed significantly to a reduction in milk production as observed in the dairy farmers of the area. A majority of farmers agree there

is a link between feeding and their milk production. Consequently, they are unhappy with the present feeding practices.

6.2 Recommendations

i. Inclusion of quality fodder trees and legumes in dairy cattle diet formulations. Fodder species (lucerne, sesbania, calliandra) with a better nutritional profile and more crude protein will improve the quality of the diet and milk production. Improve the efficiency and usage of crop residues through strategic supplementation with concentrate feeds or other protein meals.

ii. Dairy cattle should not be solely fed maize stover to meet their nutritional needs; rather, maize stover should be supplemented with protein and energy. Research likely should concentrate on optimising blends and low-cost supplements.

iii. Educational programs and policy intervention to promote better nutrition and effective feed management practices. Dairy farmers in the region can achieve high levels of satisfaction and enhance the effectiveness of dairy farming by implementing matching types of feeding techniques within the required diets of dairy cattle.

6.3 Areas of further research

i. Research on fodder trees and legumes in different agro ecological zones and how they affect milk quality and quantity should be carried out.

ii. Future research should focus on enhancing the nutritional profile of crop residues through treatments such as ensiling, ammonia treatment, or supplementation with protein-rich ingredients.

iii. Studies should assess the economic feasibility and practicality of these feeding practices for farmers.

iv. Research on the cost-benefit analysis of improved nutritional practices on milk loss and waste in Dairy farming.

REFERENCES

Abraham, G., Kechero, Y., & Andualem, D. (2023). Potential of indigenous legume fodder tree and shrubs to animal feed and mitigation of methane emission in the semi-humid condition of southern Ethiopia. *Legume Science*, *5*(4), e200. https://doi.org/10.1002/leg3.200

Abu Hafsa, S. H., Hassan, A. A., Elghandour, M. M., Barbabosa-Pliego, A., Mellado, M., & Salem, A. Z. (2022). Dietary anti-nutritional factors and their roles in livestock nutrition. In *Sustainable agriculture reviews 57: Animal biotechnology for livestock production 2* 131–174. Springer International Publishing. https://doi.org/10.1007/978-3-030-86001-6_5

Admasu, F. T., Melak, A., Demissie, B., Yenew, C., Habtie, M. L., Bekele, T. T., ... & Dejenie, T. A. (2021). Occurrence and associated factors of aflatoxin M1 in raw cow milk in South Gondar Zone, North West Ethiopia, 2020. *Food Science & Nutrition*, *9*(11), 6286-6293. https://doi.org/10.1002/fsn3.2316

Adnew, W., Tsegay, B. A., Tassew, A., & Asmare, B. (2019). Effect of Harvesting stage and Altitude on Agronomic and Qualities of six Brachiaria grass in Northwestern Ethiopia. *AgroLife Scientific Journal*, *8*(1), 9–20. https://www.agrolifejournal.usamv.ro/index.php/agrolife/article/view/411?utm_source=chatgpt.com

Akbar, N., Nasir, M., Naeem, N., Ahmad, M. U. D., Saeed, F., Anjum, F. M., ... & Atif, M. (2020). Assessment of aflatoxin in milk and feed samples and impact of seasonal variations in the Punjab, Pakistan. *Food Science & Nutrition*, *8*(6), 2699-2709. https://doi.org/10.1002/fsn3.1413

Alothman, M., Hogan, S. A., Hennessy, D., Dillon, P., Kilcawley, K. N., O'Donovan, M., ... & O'Callaghan, T. F. (2019). The "grass-fed" milk story: Understanding the impact of pasture feeding on the composition and quality of bovine milk. *Foods*, *8*(8), 350. https://doi.org/10.3390/foods8080350

AOAC. (2012). *Official Methods of Analysis of the Official Analytical Chemists*, 19th Edition, AOAC, Washington, DC, USA.

Apelo, S.A., Bell, A.L., Estes, K., Ropelewski, J., de Veth, M.J. and Hanigan, M.D. (2014). Effects of reduced dietary protein supplemental rumen-protected essential amino acids on the nitrogen efficiency of dairy cows. *Journal of Dairy Science*. *97*(9), 5688-5699. https://doi.org/10.3168/jds.2013-7833

Bahrami, R., Shahbazi, Y., & Nikousefat, Z. (2016). Occurrence and seasonal variation of aflatoxin in dairy cow feed with estimation of aflatoxin M 1 in milk from Iran. *Food and Agricultural Immunology*, *27*(3), 388-400. https://doi.org/10.1080/09540105.2015.1109613.

Blackmore, E., Guarín, A., Alonso, S., Grace, D., & Vorley, B. (2020). *Informal milk markets in Kenya, Tanzania and Assam (India): An overview of their status, policy context, and opportunities for policy innovation to improve health and safety* (ILRI Research Report 62). Nairobi, Kenya: International Livestock Research Institute. https://hdl.handle.net/10568/109797

Boerman, J.P., Potts, S.B., VandeHaar, M.J., Allen, M.S. and Lock, A.L. (2015). Milk production responses to a change in dietary starch concentration vary by production level in dairy cattle. *Journal of Dairy Science*, 98(7), 4698-4706. https://doi.org/10.3168/jds.2014-8999.

Cantalapiedra-Hijar, G., Peyraud, J.L., Lemosquet, S., Molina-Alcaide, E., Boudra, H., Noziere, P. and Ortigues-Marty, I. (2014). Dietary carbohydrate composition modifies the milk N efficiency in late lactation cows fed low crude protein diets. *Animal*, *8*(2), 275-285. https://doi.org/10.1017/S1751731113002012.

Castro-Montoya, J. M., & Dickhoefer, U. (2020). The nutritional value of tropical legume forages fed to ruminants as affected by their growth habit and fed form: A systematic review. *Animal Feed Science and Technology*, *269*, 114641. https://doi.org/10.1016/j.anifeedsci.2020.114641.

Corea, E.E., Aguilar, J.M., Alas, N.P., Alas, E.A., Flores, J.M. and Broderick, G.A. (2017). Effects of dietary cowpea (*Vigna sinensis*) hay and protein level on milk yield, milk composition, N efficiency and profitability of dairy cows. *Animal Feed Science and Technology*, *226*, 48-55. https://doi.org/10.1016/j.anifeedsci.2017.02.002.

Couvreur, S., Hurtaud, C., Lopez, C., Delaby, L. and Peyraud, J.L. (2006). The linear relationship between the proportion of fresh grass in the cow diet, milk fatty acid composition, and butter properties. *Journal of Dairy Science*, *89*(6), 1956-1969. https://doi.org/10.3168/jds.S0022-0302(06)72263-9.

Davide, C. L. (1973). *Laboratory guide in dairy chemistry practicals*. Dairy Training and Research Institute, University of the Philpppines.

Dombar, R., Ramachandra, B., Thirumalesh, T., Kulkarni, S., Suranagi, M. D., Patil, V., & Jaishankar, N. (2022). Dry matter intake, nutritive value and digestibility of Super Napier fed to adult Kenguri sheep. *Cellulose, 32*, 8-67.

Emukule, J. I. (2019). *Determinants of Milk Market Participation and Viability of Community Milk Cooling Plants in Bungoma and Kakamega Counties, Kenya* (Doctoral dissertation, Maseno University).

Ettema, F. (2015). Status report medium-scale farmers (MSFs) and commercial fodder producers (CFPs) agenda. *Leeuwarden: Landfort Adviesbureau/PUM Netherlands Senior Experts Program*.

FAO. (2011). Global food losses and waste: magnitude, causes, and prevention Rome, Italy: FAO.

FAO. (2014). Food and agriculture organisation of the United Nations Rome, Dairy development in Kenya.

Garamu, K. (2019). Significance of feed supplementation on milk yield and milk composition of dairy cow. *Dairy and Veterinary Science Journal*, *13*(2), 555860. https://doi.org/10.19080/JDVS.2019.13.555860.

Getachew, G., Robinson, P.H., DePeters, E. J, & Taylor, S.J. (2004). Relationships between chemical composition, dry matter degradation, and *in vitro* gas production of several ruminant feeds. *Animal Feed Science and Technology*, *111*(1-4), 57–71. https://doi.org/10.1016/S0377-8401(03)00217-7.

Girma, K., Tilahun, Z., & Haimanot, D. (2014). *Review on milk safety with emphasis on its public health*. 166-183.

Gizachew, D., Szonyi, B., Tegegne, A., Hanson, J., & Grace, D. (2016). Aflatoxin contamination of milk and dairy feeds in the Greater Addis Ababa milk shed, Ethiopia. *Food control*, *59*, 773-779. https://doi.org/10.1016/j.foodcont.2015.06.060.

Goopy, J. P., & Gakige, J. K. (2016, September). *Improving productivity in Kenyan smallholder dairy systems through selective, intensive education and supported adoption*. International Livestock Research Institute. https://hdl.handle.net/10568/77015

Gustafsson, J., Cederberg, C., Sonesson, U., & Emanuelsson, A. (2013). *The methodology of the FAO study: "Global food losses and food waste – extent, causes and prevention"* (Report). SIK – The Swedish Institute for Food and Biotechnology.

Hell, K., Mutegi, C., & Fandohan, P. (2010). Aflatoxin control and prevention strategies in maize for Sub-Saharan Africa. *Julius-Kühn-Archives,* (425), 534.

http://www.wageningenur.nl/cdi.

Jallow, A., Xie, H., Tang, X., Qi, Z., & Li, P. (2021). Worldwide aflatoxin contamination of agricultural products and foods: From occurrence to control. *Comprehensive Reviews in Food Science and Food Safety, 20*(3), 2332–2381. https://doi.org/10.1111/1541-4337.12734.

Kamala, A., Shirima, C., Jani, B., Bakari, M., Sillo, H., Rusibamayila, N., … Simba, A. (2018). Outbreak of an acute aflatoxicosis in Tanzania during 2016. *World Mycotoxin Journal, 11*(3), 311–320. https://doi.org/10.3920/WMJ2018.2344.

Kashongwe, B. O., Bebe, B. O., Ooro, P. A., Migwi, P. K., & Onyango, T. A. (2017). Integrating characterisation of smallholders' feeding practices with on-farm feeding trials to improve utilisation of crop residues on smallholder farms. *Advances in Agriculture, 2017*, Article ID 6952407. https://doi.org/10.1155/2017/6952407

KDB (Kenya Dairy Board). (2019). Kenya Dairy Board website. https://www.kdb.go.ke.

Kemboi, M. J. (2022). *Assessment of food loss along the dairy value chain* (Doctoral dissertation, Van Hall Larenstein).

Kenya Dairy Board (KDB). (2015). Activities within the Kenyan Dairy Industry and List of processors. *Nairobi: Government of Kenya*.

Kenya Institute of Surveying and Mapping (KISM). (2024). *Cartography department*. Kenya Institute of Surveying and Mapping. https://kism.ac.ke/cartography-department/.

Khan, N. A., Yu, P., Ali, M., Cone, J. W., & Hendriks, W. H. (2015). Nutritive value of maize silage in relation to dairy cow performance and milk quality. *Journal of the Science of Food and Agriculture*, *95*(2), 238-252. https://doi.org/10.1002/jsfa.6703.

Khiaosa-ard, R., Klevenhusen, F., Soliva, C.R., Kreuzer, M. and Leiber, F. (2010). Transfer of linoleic and linolenic acid from feed to milk in cows fed iso-energetic diets differing in proportion and origin of concentrates and roughages. *Journal of Dairy Research*, *77*(3), 331-336. https://doi.org/10.1017/S0022029910000257.

Kidane, A., Hoøen, A. J. H., Prestløkken, E., Vhile, S. G., Jensen, R. B., & Mydland, L. T. (2020). Interactive effects of three different compound feeds and two contrasting grass silages mixed at different proportions on in vitro gas production and fermentation kinetics. In *Meeting the future demands for grassland production* (p. 291).

Kilelu, C. W., Koge, J., Kabuga, C., & van der Lee, J. (2018). *Performance of emerging dairy services agri-enterprises: A case study of youth-led service provider enterprises (SPE)* (Wageningen Livestock Research Report No. 1094 / 3R Research Report No. 001). Wageningen Livestock Research. https://doi.org/10.18174/446466.

Kim, H., Sefcik, J. S., & Bradway, C. (2017). Characteristics of qualitative descriptive studies: A systematic review. *Research in nursing & health*, *40*(1), 23–42. https://doi.org/10.1002/nur.21768.

KNBS. (2019). Kenya Population and Housing Census Volume IV: Distribution of the population by socio-economic characteristics. https://www.knbs.or.ke/download/2019-kenya-population-and-housing-census-volume-iv-distribution-of-population-by-socio-economic-characteristics/

Kotinagu, K., Mohanamba, T., & Kumari, L. R. (2015). Assessment of aflatoxin B1 in livestock feed and feed ingredients by high-performance thin layer chromatography. *Veterinary World*, *8*(12), 1396. https://doi.org/10.14202/vetworld.2015.1396-1399.

Koura, I. B., Calabrò, S., Dossa, L. H., Musco, N., Cutrignelli, M. I., & Houinato, M. R. B. (2016). Nutritional Value of Cereal and Legume Crop Residues Fed to Ruminant in Republic of Benin. *Journal of Nutritional Ecology and Food Research*, *3*(2), 151-160. https://doi.org/10.1166/jnef.2016.1123.

Larsen, M. K., Nielsen, J. H., Butler, G., Leifert, C., Slots, T., Kristiansen, G. H., & Gustafsson, A. H. (2010). Milk quality as affected by feeding regimens in a country with climatic variation. *Journal of Dairy Science*, *93*(7), 2863-2873. https://doi.org/10.3168/jds.2009-2953.

Leenstra, M. (2014). From suitcase farmers to telephone farmers: Agriculture and diversified livelihoods among urban professionals. In A. Akinyoade, W. Wijnand Klaver, S. Soeters, & D. Foeken (Eds.), *Digging deeper: Inside Africa's agricultural, food, and nutrition dynamics* (pp. 217–231). Brill. https://doi.org/10.1163/9789004282698_011.

Leiber, F., Dorn, K., Probst, J. K., Isensee, A., Ackermann, N., Kuhn, A., & Neff, A. S. (2015). Concentrate reduction and sequential roughage offer to dairy cows: effects on milk protein yield, protein efficiency and milk quality. *Journal of Dairy Research*, *82*(3), 272-278. https://doi.org/10.1017/S0022029915000205.

Lukuyu, B., Franzel, S., Ongadi, P.M. and Duncan, A.J. (2011). Livestock feed resources: Current production and management practices in central and northern rift valley provinces of Kenya. *Livestock Research for Rural Development*, 23(5), 112. https://www.lrrd.org/lrrd23/5/luku23112.htm.

Mahanta, S. K., Garcia, S. C., & Islam, M. R. (2020). Forage based feeding systems of dairy animals: issues, limitations and strategies. *Range Management and Agroforestry*, *41*(2), 188-199. https://doi.org/10.31782/rma.41.2.2020.18-199.

Majiwa, E., Otieno, G., & Ngugi, C. (2022). Marketing of dairy goat products in Kenya: A survey of the dairy products in selected supermarkets in Nyeri, Meru and Kiambu counties. *Journal of Agricultural Extension and Rural Development*, *14*(2), 73-78. https://doi.org/10.5897/JAERD2022.1311.

Makori, N., Matemu, A., Kimanya, M., & Kassim, N. (2019). Inadequate management of complementary foods contributes to the risk of aflatoxin exposure and low nutrition status among children. *World Mycotoxin Journal*, *12*(1), 67-76. https://doi.org/10.3920/WMJ2018.2344.

Mandić, V., Bijelić, Z., Krnjaja, V., Simić, A., Petričević, M., Mićić, N., & Caro-Petrović, V. (2018). Effect of harvesting time on forage yield and quality of maize. *Biotechnology in Animal Husbandry*, *34*(3), 345-353. https://doi.org/10.2298/BAH1803345M.

Menke, K.H. and Steingass, H. (1988). Estimation of the Energetic Feed Value obtained from chemical analysis and *in-vitro* gas production using rumen fluid. *Animal Resource Development*.28:7-55.

Mertens, D. R., & Grant, R. J. (2020). Digestibility and intake. In K. J. Moore, M. Collins, C. J. Nelson, & D. D. Redfearn (Eds.), *Forages: The science of grassland agriculture* (7th ed., Vol. II, pp. 609–631). Wiley-Blackwell. https://doi.org/10.1002/9781119436669.ch34

MoALF. (2010). Kenya National Dairy Master Plan.A situational analysis of the dairy sub-sector. Volume I. Nairobi: Ministry of Agriculture, Livestock and Fisheries (MoALF), Republic of Kenya.

Muchuma, K. F., Obando, J., & Kweyu, R. (2021). Land use/land cover change detection using geospatial techniques and field survey on Chetambe Hills in Bungoma County, Kenya. *Middle East Journal of Applied Science & Technology*, *4*(1), 80-93.

Munyori, M. N. (2019). *Determinants of post-harvest milk losses among milk producers and transporters in the dairy value chain in Nyandarua North Sub-County, Kenya* (Doctoral dissertation, Egerton University).

Muqier, X., Eknæs, M., Prestløkken, E., Jensen, R. B., Eikanger, K. S., Karlengen, I. J., & Kidane, A. (2023). *In Vitro* Rumen Fermentation Characteristics, Estimated Utilizable Crude Protein and Metabolizable Energy Values of Grass Silages, Concentrate Feeds and Their Mixtures. *Animals*, 13(17), 2695. https://doi.org/10.3390/ani13172695.

Mutiga, S. K., Hoffmann, V., Harvey, J. W., Milgroom, M. G., & Nelson, R. J. (2015). Assessment of aflatoxin and fumonisin contamination of maize in western Kenya. *Phytopathology*, *105*(9), 1250-1261.

Navale, V., Vamkudoth, K. R., Ajmera, S., & Dhuri, V. (2021). Aspergillus derived mycotoxins in food and the environment: Prevalence, detection, and toxicity. *Toxicology Reports, 8*, 1008-1030. https://doi.org/10.1016/j.toxrep.2021.04.013.

Ngunjiri, V. W. (2020). *Evaluation of Performance of Growing Dairy Goats Fed Rhodes Grass Hay, Supplemented with Dried Calliandra Leaves and Common Vetch Hay* (Doctoral dissertation, Egerton University).

O'Callaghan, T. F. (2018). Effect of cow feeding system on the quality and constituents of raw milk, dairy products and the rumen.

O'Callaghan, T., Hennessy, F., McAuliffe, D., Kilcawley, S., O'Donovan, K.N., Dillon, M. & Stanton, C. (2016). Effect of pasture versus indoor feeding systems on raw milk composition and quality over an entire lactation, *Journal of Dairy Science*, *99*(12), 9424–9440. https://doi.org/10.3168/jds.2016-10985.

Odero-Waitituh, J. A. (2017). Smallholder dairy production in Kenya; a review. *Livestock Research for Rural Development*, *29*(7), 139. https://www.lrrd.org/lrrd29/7/atiw29139.html.

Ørskov, E.R. and McDonald, I. (1979). The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *Journal of Agricultural Science, Cambridge* 92, 499–503.

Osuga, I.M., Wambui, C.C., Abdulrazak, S.A., Ichinohe, T. and Fujihara, T. (2008). Evaluation of nutritive value and palatability by goats and sheep of selected browse forages from the semi-arid area of Kenya. *Animal Science Journal* 79,582–589.

Parmar, P., Lopez-Villalobos, N., Tobin, J. T., Murphy, E., Buckley, F., McDonagh, A., ... & Shalloo, L. (2020). The effects of cow genetic group on the density of raw whole milk. *Irish Journal of Agricultural and Food Research*, *59*(1), 215-223. http://hdl.handle.net/11019/2591.

Pereira, P. C. (2014). Milk nutritional composition and its role in human health. *Nutrition*, *30*(6), 619-627. https://doi.org/10.1016/j.nut.2013.10.011.

Powell, J.M., Wattiaux, M.A. and Broderick, G.A. (2011). Evaluation of milk urea nitrogen as a management tool to reduce ammonia emissions from dairy farms. *Journal of Dairy Science*, *94*(9), 4690-4694. https://pubmed.ncbi.nlm.nih.gov/21854942/.

Quddus, M. A. (2012). Adoption of dairy farming technologies by small farm holders: practices and constraints. https://doi.org/10.3329/bjas.v41i2.14132.

Rademaker, I.F., Jansen, A., Koech, R.K, and van der Lee, J. (2016). Smallholder dairy value chain interventions: The Kenya Market-Led Dairy Program (KMDP) - Centre for Development Innovation. Status Report. Report CDI-16-018. https://edepot.wur.nl/395978.

Ragkos, A., Theodoridis, A., Fachouridis, A., & Batzios, C. (2015). Dairy farmers' strategies against the crisis and the economic performance of farms. *Procedia Economics and Finance*, *33*, 518-527. https://doi.org/10.1016/S2212-5671(15)01734-7.

Richardson, H.G. (1985). "Standard Methods for the Examination of Dairy Products. 6th edn", American Public Health Association, Washington DC.

Sakwa, B. N., Ondiek, J. O., King'ori, A. M., & Ndambi, O. A. (2020). Effects of fodder conservation and ration formulation interventions on dairy performance in Kenya. *International Journal of Agricultural Research, Innovation and Technology (IJARIT)*, *10*(2355-2021-439), 76-83. https://doi.org/10.3329/ijarit.v10i2.51580

SAS. (2002). Statistical Analysis System. *SAS Institute Inc.-Users Installation Guide*. Statistical Analysis Institute, Inc., Cary, NC. USA.

Shabani, I., Kimanya, M. E., Gichuhi, P. N., Bonsi, C., & Bovell-Benjamin, A. C. (2015). Maize storage and consumption practices of farmers in Handeni District, Tanzania: Corollaries for mycotoxin contamination. *Open journal of preventive medicine*, *5*(8), 330-339. https://doi.org/10.4236/ojpm.2015.58037

Sharma, M. (2016). Effect of age and educational level of dairy farmers on knowledge and adoption of dairy farming practices in Kapurthala district of Punjab. *International Journal of Farm Sciences*, *6*(4), 254-262.

Sirma, A. (2020). Assessment of risk to human health associated with aflatoxins in the Kenyan dairy value chain (Doctoral dissertation, University of Nairobi).

Sorge, U. S., Moon, R., Wolff, L. J., Michels, L., Schroth, S., Kelton, D. F., & Heins, B. (2016). Management practices on organic and conventional dairy herds in Minnesota. *Journal of dairy science*, *99*(4), 3183-3192. https://pubmed.ncbi.nlm.nih.gov/26830734/

Spanghero, M., Magni, G., Boselli, E., Piombino, M., Mason, F., & Cozzi, G. (2017). Prediction of metabolisable energy content of commercial total mixed rations (TMR) for lactating dairy cows based on gas production measured into two TMR fractions. *Animal Feed Science and Technology*, *226*, 65-70. https://doi.org/10.1016/j.anifeedsci.2017.01.010

Spek, J.W., Dijkstra, J., van Duinkerken, G., Hendriks, W.H. and Bannink, A. (2013). Prediction of urinary nitrogen and urinary urea nitrogen excretion by lactating dairy cattle in northwestern Europe and North America: A meta-analysis. *Journal of Dairy Science*, *96*(7), 4310-4322. https://pubmed.ncbi.nlm.nih.gov/23664347/

Steinshamn, H. (2010). Effect of forage legumes on feed intake, milk production, and milk quality– a review. *Animal Science Papers and Reports*, *28*(3), 195-206.

Tauqir, N., Nisa, M., Sarwar, M., & Bhatti, S. (2008). Impact of varying moisture levels, different additives, and fermentation periods on the nutritive value of leguminous and non-leguminous fodder silages in lactating nili-ravi buffaloes. *Pakistan Journal of Agricultural Sciences*, *45*(2).

Tona, G. O. (2018). Current and future improvements in livestock nutrition and feed resources. *Animal Husbandry and Nutrition*, pp. 147–169. https://doi.org/10.5772/intechopen.73088

Tunkala, B. Z., DiGiacomo, K., Hess, P. S. A., Gardiner, C. P., Suleria, H., Leury, B. J., & Dunshea, F. R. (2023). Evaluation of legumes for fermentability and protein fractions using *in vitro* rumen fermentation. *Animal Feed Science and Technology*, p. *305*, 115777. https://doi.org/10.1016/j.anifeedsci.2023.115777

Tyasi, T. L., Gxasheka, M., & Tlabela, C. P. (2015). Assessing the effect of nutrition on milk composition of dairy cows: A review. *International. Journal of Current. Science, 17*, 56-63.

Van Soest, P.V., Robertson, J.B. and Lewis, B.A. (1991). Methods for dietary fibre, neutral detergent fibre, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, *74*(10), 3583-3597.

Wambugu, S., Kirimi, L. and Opiyo, J. (2011). Productivity trends and performance of dairy farming in Kenya (No. 680-2016-46762). http://www.wageningenur.nl/cdi

Wamuyu, H. (2020). Economic development through the dairy sector: analysing the legal protection frameworks. *KAS African Law Study Library*, *7*(3), 463–472.

Wangila, A. J. (2021). *Biomass Yield and Quality of Fodder from Selected Varieties of Lablab in Nandi South Sub-county, Kenya* (Doctoral dissertation, University of Nairobi).

Were, M. A. (2017). *Influence of Dairy Farming Practices on Households Income in Kenya* (Doctoral dissertation, University of Nairobi).

Yuan, X., Yu, C., Li, Z., Shimojo, M., & Shao, T. (2013). Effect of inclusion of grasses and wet hulless-barley distillers' grains on the fermentation and nutritive quality of oat straw-and straw-grass silages in Tibet. *Animal Production Science*, *53*(5), 419-426. https://doi.org/10.1071/AN12345

Yusuf, K. O., Isah, O. A., Arigbede, O. M., Oni, A. O., & Onwuka, C. F. I. (2013). Chemical composition, secondary metabolites, *in vitro* gas production characteristics and acceptability study of some forage for ruminant feeding in South-Western Nigeria. *Nigerian Journal of Animal Production*, *40*(1), 179-190. https://doi.org/10.51791/njap.v40i1.693

Zhao, D., Momotaz, A., LaBorde, C., & Irey, M. (2020). Biomass yield and carbohydrate composition in sugarcane and energy cane grown on mineral soils. *Sugar Technology*, *22*(4), 630-640. https://doi.org/10.1007/s12355-020-00807-0

APPENDICES

Appendix A: NACOSTI permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 253225

Date of Issue: 06/May/2024

RESEARCH LICENSE

This is to Certify that Ms.. Susan Nyagichuhi Njuguna of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Bungoma on the topic: EFFECTS OF DIFFERENT NUTRITIONAL PRACTICES OF DAIRY CATTLE FARMERS AND THE IMPACT ON MILK LOSS AND WASTAGE IN BUNGOMA COUNTY, KENYA for the period ending : 06/May/2025.

License No: **NACOSTI/P/24/34932**

253225

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

Appendix B: Publication

Subscribe Print Journal

Recommend this journal TO YOUR LIBRARY

Journal's Code

ISSN Number: 2456-2912

ICV 2016: 60.37

Issue Bar

Past Issue

Coming Issue

Side Bar

Vol. 9, Issue 3, Part E (2024)

Evaluation of nutritional composition and in vitro digestibility of dairy cattle feed resources in Bungoma County, Kenya

Author(s): S Njuguna, JO Ondiek, F Kemboi and JO Anyango

Abstract: The aim of this study was to evaluate the nutritional value of the main dairy cattle feed resources through proximate and *in-vitro* digestibility analyses. The feeds were grouped into 25 diets using a completely randomized design. The chemical analysis was done to determine the nutrient composition. The *in-vitro* organic matter digestibility was determined using the gas production method for all experimental diets. Data collected on proximate analysis, was subjected to the analysis of variance in a completely randomized design using the General linear model procedure of Statistical Analysis System version 9.4. From the results, roughages displayed a diverse range of dry matter content, varying from 904.1 g/kg DM to 936.1 g/kg DM. Super Napier was highest in crude protein content at 149.3 g/kg DM, and neutral detergent fiber content at 733.3 g/kg DM, and maize silage had the lowest at 56.1 g/kg DM. The groundnut residue had the highest crude protein content at 114.6 g/kg DM among the crop residues, while sugarcane tops had the lowest crude protein content at 27 g/kg DM. At 24 and 48 hours of fermentation, the rate of gas production was highest in fodder crops and trees, particularly Lucerne, at 12.7%, and 10% while crop residues such as sugarcane tops had the lowest at 1.60%. This study concludes that fodder trees and legumes have better nutritional profiles, while crop residues are of low quality.

DOI: 10.22271/veterinary.2024.v9.i3e.1436

Appendix C: Ethical clearance

EGERTON UNIVERSITY

TEL: (051) 2217808 P. O. BOX 536 FAX: 051-2217942
EGERTON

EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

EU/RE/DIR/009

Approval No. EUISERC/APP/320/2024 9^{th} *April* 2024

Susan Nyagichuhi Njuguna,

P.O BOX 536-20115 Egerton, Njoro

Telephone: 0711320959 E-mail: suzanjuguna@gmail.com

Dear Susan,

RE: ETHICAL APPROVAL: EFFECTS OF DIFFERENT NUTRITIONAL PRACTICES OF DAIRY CATTLE FARMERS AND IMPACT ON MILK LOSS AND WASTAGE IN BUNGOMA COUNTY, KENYA

This is to inform you that the *Egerton University Institutional Scientific and Ethics Review Committee* has reviewed and approved your above research proposal. Your application approval number is *EUISERC/APP/320/2024.* The approval period is 9^{th} *April 2024 – 10*th *April, 2025*

This approval is subject to compliance with the following requirements;

Only approved documents including (informed consents, study instruments, MTA) will be used.

All changes including (amendments, deviations, and violations) are submitted for review and approval by *Egerton University Institutional Scientific and Ethics Review Committee*.

Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to *Egerton University*

Institutional Scientific and Ethics Review Committee within 72 hours of notification iv. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to *Egerton University Institutional Scientific and Ethics Review Committee* within 72 hours.

v. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.

"Transforming Lives through Quality Education"

vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal. vii. Submission of an executive summary report within 90 days upon completion of the study to *Egerton University Institutional Scientific and Ethics Review Committee*.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely.

Prof. Raphael M. Ngure

CHAIRMAN, EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW CTTEE

RMN/BK/

Appendix D: Questionnaire

My name is Susan N Njuguna. I appreciate your participation in this study, which aims to explore the effects of different nutritional practices among dairy farmers and their impact on milk loss and wastage in Bungoma County, Kenya. Your valuable insights will contribute to our understanding of the challenges faced by dairy farmers in the region and provide essential information for the development of strategies to improve dairy farming practices. Please be assured that all information provided will betreated with the utmost confidentiality. Your participation is voluntary, and you have the right to withdraw at any point during the survey. The data collected will beused for research purposes only and will bepresented in aggregate form to ensure anonymity.

Demographic and Agricultural Background Information

- Name of the respondent: ………………………………………….
- Contact information: ……………………………………….
- Age…………………………………….
- What is your gender?

  [ ] Male

  [ ] Female

- Location:

  [ ] Kaptama

  [ ] Kitinda

- What is your highest Education level?

  [ ] Primary

  [ ] Secondary

  [ ] Tertiary

- What is the size of your family? ………..
- Do you have credit access? Yes / No
- How do cooperatives support the famers?

  [ ]

[ ]

[ ]

[ ]

- What breed of dairy do you have?

  [ ]

  [ ]

  [ ]

  [ ]

- Do the farmers offer training by the extension offers, and how often?

[ ]

[ ]

[ ]

- What other business do you do apart from farming?

  [ ]

  [ ]

  [ ]

- Do you have containers to deliver milk? Yes/No
- Do you keep records? Yes/No
- Are you a member of the co-operative?

[ ] Yes

[ ] No

- What is the number of lactating animals you have?.........

Dairy Cattle Feeding Practices:

a. What are the main feed resources you use for your dairy cattle?

[ ] Concentrates

[ ] Pasture

[ ] Fodder crops

[ ] Crop residues

[ ] Other, specify……..

b. Could you specify the composition of the feed resources you provide?

[ ] Maize germ

[ ] Dairy meal

[ ] Bran

[ ] Napier grass

[ ] Lucerne

[ ] Calliandra

[ ] Desmodium

[ ] Sesbania

[ ] Kikuyu grass

[ ] Maize stovers

[ ] Sugar cane tops

[ ] Bean residues

c. How often do you feed your dairy cattle, and what is the feeding schedule?

[ ] once a day

[ ] twice a day

[ ] thrice a day

[ ] other (specify)…….

d. Are there any nutritional supplements or additives you use in the feed?

[ ] Dairy feeds

[ ] Salt

[ ] Molasses

[ ] Super Maxlin

[ ] Machick Super

1. **Losses and Wastages:**

a) Have you experienced any losses or wastages in your dairy farming practices? Yes/No

If yes, please describe.

[ ] Spillages

[ ] Inadequate storage facilities for storing feeds

[ ] Inadequate and poor feed quality

[ ] Inaccessibility of market

[ ] Diseases and pests

[ ] Dairy animals mortality

[ ] Quantity and quality of milk

[ ] Theft of dairy cattle

[ ] poor prices in the market

[ ] Debts owed by dairy farmers

b. What factors do you think contribute to milk losses or wastages on your farm?

[ ] poor quality

[ ] poor feed management

[ ] feeding practices

[ ] mastitis

[ ] poor milking practices

[ ] inadequate milking frequency

[ ] breeding

[ ] environment stress

[ ] nutrition and health of cows

[ ] milking parlor hygiene

[ ] handling and transportation

c. Are there any specific challenges you face in managing feed resources efficiently?

[ ] feed quality and nutritional content

[ ] forage management

[ ] balancing ratios

[ ] competition for feed resources

[ ] feed waste

[ ] storage and preservation of feed

[ ] environmental considerations

2. **Effect on Milk Yield:**

a. How do you think your feeding practices influence the milk yield of your dairy cattle?

[ ] Yes

[ ] No

b. Have you observed any changes in milk yield based on different feeding practices?

[ ] Yes

[ ] No

Section 2: General Dairy Performance and Farmer Opinions

1. **Dairy Performance:**

a. How would you describe the overall performance of your dairy cattle in terms of milk production?

[ ] very poor

[ ] poor

[ ] neutral

[ ] good

[ ] excellent

b. Are there any specific challenges you face in maintaining good dairy performance?

[ ] Yes

[ ] No

2. **Attitudes and Opinions:**

a. What is your perception of the milk quality in the Kaptama / Kitinda region?

[ ] very poor

[ ] poor

[ ] neutral

[ ] good

[ ] excellent

b. Do you believe that the nutritional value of feed affects milk quality?

[ ] Yes

[ ] No

c. How satisfied are you with the current dairy farming practices in your region?

[ ] very dissatisfied

[ ] dissatisfied

[ ] satisfied

[ ] very satisfied

3. **Suggestions and Improvements:**

a. Are there any changes or improvements you would like to see in the dairy farming practices in Kaptama / Kitinda?

[ ] Yes

[ ] No

If yes, please specify

[ ] Supply quality breeds i.e practicing AI

[ ] Offer sufficient and effective training to farmars

[ ] Better prices of milk

[ ] Sufficient supply of animal feeds

[ ] Offer financial support to farmers eg. Loans

[ ] Pay farmers on time.

b. Do you think there is a need for additional support or resources to enhance dairy farming in your region?

[ ] Yes

[ ] No

If yes, please describe…

[ ] Financial and material support

[ ] Training and capacity building

[ ] Provision of means of transport

[ ] Create good link between farmers and the market

[ ] Provision of quality or improved breeds

[ ] Better market with good prices

Conclusion

Thank you for taking the time to complete this survey. Your feedback is valuable and will contribute to the success of the dairy production in Kitinda and Kaptama. If you have any additional comments or suggestions, please feel free to share.