EVALUATION OF COMPOUNDED SUPPLEMENTARY CONCENTRATE ON MILK YIELD AND QUALITY AMONG HOLSTEIN FRIESIAN CATTLE

BY

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DECLARATION

Declaration by the candidate

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DEDICATION

First, I want to dedicate this work to God, who cared and gave me good health. I dedicate this thesis to my loving husband Dr. Wilson Kipkazi and my adorable children Angela Jelimo, Sheila Komen, Cathrine Jebiwott, Juliet Jemutai, Catra Katikit and Victor Kipkemei for their encouragement and moral support. To my siblings, Janet Jepchirchir, Melody Jepchumba, Diana Kechi and Peter Kiprop for their continuous motivation and support. Finally, to my parents Mr. Stanley Yator and Mrs. Lillian Yator, who are dedicated workers and for being uncompromising in principles that shaped my life.

ABSTRACT

The Dairy industry in Kenya contributes 26% of the National GDP. However, dairy farmers experience low milk production despite their investment on commercial concentrates. Seed processing factories spend money in disposing off by-products such as maize cobs, broken maize grains, and bean hulls that accumulate in order to create working space. These by-products may be used to compound diets to meet the lactating cow's nutrient needs at an affordable cost. The objective of this study was to formulate a diet from the by-products and evaluate its performance using lactating Holstein Friesian cows, which were in the same stage of lactation and not a wide range in milk production. The diet was formulated using the seed processing by-products from different companies. The ingredients were; male maize lines of corn, molasses, milling maize chaff, cotton seed cake, limestone and dairy premix. The formulated diet was coded (Y). Two feeding trials were carried out concurrently using ten Holstein Friesian lactating cows; in each experiment, five cows were used. Both studies used 5 x 5 Latin Square experimental design. The First trial was to evaluate the milk yield and the milk composition from the cows fed at different supplementation levels of diet Y. The cows were fed on chopped Napier grass as a basal diet, mineral supplement of 100g/day/cow and water was provided *ad libitum.* The supplementary diets formed the five treatments, which were; 0, 0.5, 0.75, 1.0, and 1.25 Kg/L of milk per day, for treatment 1,2,3,4 and 5 respectively. The second trial was to evaluate the performance of lactating Holstein Friesian cows fed on the formulated and three different commercial diets. The commercial diets were coded W, X, & Z, formulated diet was coded Y, and diet C was the control, this formed the five treatments 1,2,3,4 and 5 respectively. Proximate analysis was carried out on the feed samples. Milk yields were measured daily and composition determined weekly for each treatment. The data obtained was analyzed using ANOVA, and significant means were separated using Standard Error Mean. The first trial showed significant difference in all the treatments, with different milk yield at all supplementation levels, with the highest mean of 7.30L/day in treatment 5 with 1.25Kg/L/day of supplementation, and lowest mean yield of 4.40L/day at treatment 1with no supplementation. Treatments 2, 3 and 4 of Supplementation (0.5, 0.75, and 1.0Kg/L) resulted in mean milk yield of 5.1, 5.70, and 6.54 L/day respectively. In the second trial, there was significant increase in milk yields in all the cows fed on both the formulated and commercial diets. The highest mean yield was in treatment 2, of diet X with 6.15L/day, and the lowest was in treatment 5, with mean yield of 4.05L/day in the control (C). Treatment 4, 3 and 1 with diet Y, Z, and W had a mean milk yield of 5.27, 5.61, and 5.98L/day respectively. There was no significant difference in milk composition in all the treatments of the two trials. There was significant difference in all the supplementation levels of diet (Y), but the highest was observed at supplementation level of 1.25Kg/l/day. When compared to the commercial concentrates, diet X was better in milk yields. It is concluded that the formulated diet (Y) can be used as a supplement to improve on milk yield of dairy animals.

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ACRONYMS AND ABBREVIATION

ADF – Acid Detergent Fibre

AOAC – Association of Official Analytical Chemists

ARC – Agriculture Research Council

BD – Basal Diet

BF – Butter Fat

BW – Body Weight

CP – Crude Protein

DM – Dry Matter

DMI – Dry Matter Intake

FAO – Food and Agriculture Organization

GDP – Gross Domestic Product

GoK – Government of Kenya

ME – Metabolizable Energy

MY – Milk Yield

NDF – Neutral Detergent Fibre

NFC – Non Fibre Carbohydrate

NRC – National Research Council

SNF – Solids Not Fat

TDN – Total Digestible Nutrient

TMR – Total Mixed Ration

USA – United States of America

VFA – Volatile Fatty Acids

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CHAPTER ONE

INTRODUCTION

1.1 Background information

The Kenyan economy is highly dependent on agriculture, which contributes about 26% of the Gross Domestic Product of which 25% comes from the livestock sub-sector (GoK, 2010). The agriculture sector provides employment for about 70% of the Kenyan population. The livestock subsector is the major source of food, income, services and foreign exchange to the Kenyan economy, and contributes 10% of the agricultural GDP, it also accounts significantly to the total export earnings according to FAOSTAT, (2007). Among the 20 major food and agricultural commodities ranked by value in Kenya , milk is estimated at about 1.2 million Litres per day (Muriuki and Thorpe, 2001, Muriuki, 2003), amounting to 48 million shillings per day. A major outcome of such price increases, in a nation where at least one out of every five citizens live below the poverty line, is a substantial decline in demand and a declining profitability (Bigsten and Levin, 2001). This has caused many dairy farmers to reduce investment in the dairy industry and worst some exiting the industry (Atieno and Kanyinga, 2008). With ever increasing human population in Kenya and virtually static livestock productivity, the per capita milk consumption among Kenyans may have reduced in the past few years (Republic of Kenya, 1999).

Present-day high-producing cows are the result of years of genetic improvement programmes. However, poor feed, which is inadequate in quality, is a major constraint in efforts to improve the productivity of livestock in many smallholder production systems in East Africa. The principal sources of feed for ruminants in mixed crop–livestock systems are crop residues complemented with forage collected from communal land, forests, roadsides or fallow land, or by grazing animals on those lands. This feeding regime often does not meet the nutritional requirements for maintaining high milk production of dairy cows. Adding a supplement of concentrates helps meet the dairy cow's high demand for nutrients needed to assure high milk production (Kellaway & Harrington, 2004).

There are several agricultural grains processing industries in Kenya that have a lot of by-products which accumulate taking a lot of space. High costs are incurred in trying to eradicate these by- products such as maize cobs, maize and bean chaff, broken beans and maize, sugarcane baggase from sugar industries, bran and germs from cereal processing industries. These by- products can be utilized to produce cost effective nutritive dairy feeds. Western Seed is a seed processing company situated in Kitale town, Kenya which releases huge quantities of these by-products, accumulating within its premises. For this reason, the company supported this research which focussed on the utilization of their by-products in feeding dairy animals.

This study aimed at providing an adequate supplement formulated from seed by-products produced by Western Seed Company.

1.2 Statement of the problem

Seed processing companies have a lot of seed by- products that accumulate forming heaps which occupy a lot of space and create storage problems; these by-products include; maize wastes, sunflower wastes, soybean wastes and wheat chaff.

A lot of money is spent to remove the by-products in order to clear working space. Burning of these wastes would result in energy losses and cause air pollution and contribute to the global warming.

Seed companies wonder how best to utilize the by-products.

1.3 Justification

By-products from seed processing companies can be used to formulate a feed ration that is affordable and nutritious for dairy production.

In recent times, developing countries have increased their share in global dairy production. This growth is mainly the result of an increase in numbers of producing animals rather than a rise in productivity per head. Dairy productivity is constrained by poor-quality feed. Despite the use of commercial concentrates, quantity and quality of milk is still low (Odero-Waitituh, 2017) because of the quality of feeds in the market. In order for the cow to be more profitable, affordable feeds supplements are needed.

In most developing countries, milk is produced by smallholders, and milk production contributes to household livelihoods, food security and nutrition. Milk provides relatively quick returns for small-scale producers and is an important source of cash income.

The feeding of dairy animals is often based on crop residues, hay, and pastures which a times are of low quality; this therefore raises the need for protein and energy supplements.

Crop by-products are valuable roughage feeds for ruminant animals. Seed companies produce huge amounts of these by-products, their disposal can be a problem, however these by-products are useful animal feeds when mixed with other feed materials that improve their nutritional values, Furthermore, a dairy cow is able to convert these by-products such as maize cobs and bean chaff into highly nutritious products through rumen fermentation processes. Therefore, it is important to utilize by-products from seed processing industries which could otherwise be destroyed to formulate feed ration that is affordable and shall meet the full nutritional requirements for the cows in order to get increased milk yield.

1.4 Objectives

1.4.1 General objective

To compound a dairy concentrate from seed processing by-products and evaluate using lactating Holstein Friesian cows.

1.4.2 Specific objectives

In this study, the specific objectives were:

i. To determine the nutritive values of the formulated and commercial diets.

ii. To determine effects of supplementation levels of formulated ration Y on milk quantity and quality, among lactating Holstein Friesian cows.

iii. To compare milk quantity and quality from lactating Holstein Friesian cows fed on formulated and three commercial diets.

1.5 Hypotheses

The study tested the following null hypotheses:

H_o There are no significant differences on the nutritive values of the formulated diet Y and commercial diets.

H_a There are significant differences on the nutritive values of the formulated diet Y and commercial diets.

H_o There is no significant effect of the different supplementation levels of formulated ration Y (based on seed by-products) on milk quality and quantity of Holstein Friesian cows.

H_a There are significant differences on the effect of different supplementary levels of formulated ration Y (based on seed by-products) on milk quality and quantity of Holstein Friesian cows.

H_o There are no significant differences on the milk quality and quantity when Holstein Friesian cows are fed on formulated and commercial diets.

H_a There are significant differences on milk quality and quantity when Holstein Friesian cows are fed on formulated and commercial diets.

CHAPTER TWO

LITERATURE REVIEW

2.1 Dairy Farming

Dairy farming is an important source of income to small scale farmers and in addition to milk, the manure from the cattle provides a good source of organic matter for improving soil fertility and crop yields. The cow dung can successfully provide biogas fuel. The surplus fodder and agricultural by-products are gainfully utilized for feeding the animals. Since agriculture is mostly seasonal, there is a possibility of finding employment throughout the year for many persons through dairy farming. Thus, dairy provides employment throughout the year (Ngongoni *et al.*, 2007). Milk production in the smallholder dairy sector is mostly constrained by shortage of affordable nutritional regimes and supplementation. The ever skyrocketing cost of commercial feed supplements makes it difficult for the smallholder farmers to look for and turn to relatively cheap feed sources for their cows or to be more efficient in their rationing of energy to their low to medium producing dairy cows (Ngongoni *et al*., 2007).

In Kenya, milk production increased during the 1990s at an annual rate of 4.1% (Ngigi, 2004) whereas per capita consumption stood at 145 litres (Wambugu *et al.*, 2009). The total production was estimated at about 4 billion Litres in 2003 (EPZ, 2005). Although only about 35% of milk production is marketed, at a retail price of US$0.75 per litre, the Kenya dairy sector is estimated to generate $2 billion per year (Gitau, 2013).

Most smallholder farms are found in high potential areas (at above1200 meters above sea level), where two rainy seasons prevail and can support year-round feed-production systems (Place *et al.*, 2009). The dairy producer evaluates different methods to reduce the cost of production depending on input levels. In particular, they evaluate the nutrient composition of different feeds to determine if a more expensive feedstuff can be substituted in the ration to reduce input costs while maintaining nutritional requirements for a specified milk production level (Hadrich *et al*., 2008).

2.2 Dairy cattle feeding and nutrition

Dairy cattle nutrition is essentially an understanding of the nutrient requirements of dairy cows at various physiological stages and combining various feed ingredients to meet those requirements in a cost-effective manner. During lactation, dairy cows have high nutritional requirements relative to most other physiological states. Meeting these nutrient requirements, especially for energy and protein, is challenging. Diets must have sufficient nutrient concentrations to support production and metabolic health, while also supporting conductive rumen environment for the efficiency of fermentative digestion (Hall & Huntington, 2008).

Nutrition in terms of quantity and quality are the most critical constraints to milk production. Providing proper nutrition to dairy cows is important for health and optimal milk production (Thanh & Suksombat, 2015). Dairy cow rations must contain good quality forages, a balance of grains and crude proteins plus minerals and vitamins. The feeds that provide sufficient nutrients are needed by the dairy cow for milk production, growth and reproduction. Feeds must be supplied in the right amount and combination to provide a balance of nutrients avoiding excesses or deficiencies (Chiba, 2014). Formulated rations should meet the nutrient requirements of the cow and optimum digestion and utilization. This is because feeding a total mixed ration (TMR) that contains all the nutrients required by the cow is an effective, efficient and profitable way to feed dairy cows. Animal nutrition entails feeding to obtain optimum production at least cost. It involves approximately 70% forages and 30% concentrates to produce a total mixed ration (TMR). The cost of feed is typically 50 to 70% of the total cost of milk production, and has greater impact on animal health, production, reproduction and enterprise profitability.

Intensive and semi-intensive dairy production system depends on formulated feeds, as a supplement to forage. The cost of feed ingredients is high and competitive. In addition, price variability in dairy feeds depends on the brand and location of the farmer (Ter-Hemen, 2015). Although there are farm-made feeds that are normally cheaper than commercial feeds, the question is how integrated they are in commercial feed markets?

2.3 Nutrient requirement for dairy cattle

Nutrient requirements for lactation are based on the amount of milk at peak lactation and the composition of the milk. Cows that produce more milk more fat and protein will have higher nutrient requirement (Ter-Hemen *et al.*, 2015).

Although different countries have evolved their own standards based on experiments conducted with farm animals in the agro-climatic and economic condition prevailing in their country, Sen *et al.*, (1978) (De Boer and Bickel, 1988), NRC and ARC (1988) and Ranjhan, (1990)there are available feeding standards. The NRC and ARC standards were formulated for animals raised under temperate conditions with feedstuffs of high quality, while the standards of Sen *et al.,* (1978) and Ranjhan, (1990) are standards which are based on poor quality forages under tropical conditions.

2.3.1 Dry matter intake (DMI)

The willingness or ability of an animal to consume a particular feed is the key factor in determining the amount of nutrient available to the animals. The feed intake is influenced by many factors, including feed characteristics, animal species, physiological state, ambient temperature, management practices the way of feed presentation and also on milk production of the animal. Several workers have tried to predict intake of animals either empirically or from biological parameters (Ketelaays and Tolkamp, 1991; NRC, 1978). These predictions are generally based on intakes measured under controlled experimental conditions rather than on farm feed intake.

2.3.2 Energy requirements

To determine the energy requirement of dairy animals it has been customary to partition the requirements into that required for maintenance and that for production, on the other. Thus factors associated with differences in the body-weight, breed and sex can be considered under the former while the quantity, quality and nature of deposited materials can be considered under the later. Since both the maintenance requirement and the extent of production influence the animal's thermal losses, it is necessary that these losses be considered in the calculation of the requirements and the results expressed in terms of metabolizable energy (ME). The ME system was developed in the United Kingdom by Blaxter and adopted by the ARC in 1965. In the USA, feed rationing for ruminants is also based on energy but the standards are expressed as Net Energy (NE). In Asian countries the use of TDN has been well practiced since these values are available for a wider range of feed. Sen *et al.,* (1978) and Ranjhan, (1990).

2.3.3 Crude protein requirements

Proteins represent a very important group of nutrients in the feed which are used for a variety of purposes within the body. Their most important function is the supply of amino acids for the production of body proteins and for the synthesis of enzymes. Thus the efficiency with which dietary protein is utilized will depend upon its amino acid composition. For efficient utilization, the feed must supply the correct levels of the essential amino acids and sufficient quantities of the non-essential amino acids to meet the metabolic demands of the dairy animals (Kellems and Church, 1998).

The level of feeding and composition of the diet affect the volume and composition of milk. Because of their limited rumen capacity, cows in early lactation require top quality feed. High levels of feeding in early lactation do not make up for poor condition at calving. Therefore it is important to feed cows well in early lactation approaching peak lactation and peak intake.

Cows put on condition more efficiently in late lactation when they are still milking, rather than when they are dry are likely to have high milk production during their next lactation. Cows close to calving and those in early lactation need high quality diets with adequate supplies of energy, protein and fibre. Abrupt changes to the diet should be avoided since diet has considerable influence on the fat and protein content of milk, but relatively little effect on its lactose content. Milk fat test falls when the diet is low in fibre. High energy, starch-based diets increase lactose production, milk volume and milk protein production simultaneously (Walker *et al.,* 2004).

The crude protein requirements of lactating dairy cows are high because of the demand for amino acids for milk protein synthesis. Two systems of describing the dietary protein supply and requirements for dairy cows are in general use: the crude protein system and the metabolizable protein system. The crude protein system considers only the total amount of dietary protein, or protein equivalent from non-protein nitrogen sources. Crude protein values are based on the measurement of total dietary nitrogen and the assumption that protein is 16% nitrogen (6.25 x N). The crude protein system is relatively simple to use and has provided a traditional means of formulating dairy cow rations. Cows are not able to store much protein in their bodies and so it must be supplied in the daily ration in order to maintain high milk production. For milking cows, there will be a rapid drop in milk production if the amount of protein in the ration is suddenly reduced (Lukuyu *et al.*, 2007).

2.4. Concentrate

Concentrates are feeds that contain relatively higher concentration of nutrients than forages. Concentrates are rich in nutrient energy or crude protein or both and provide far more nutrients than an equivalent weight of forage, low in fibre and their dry matter content is usually high. They are feed supplements that supply more energy, crude proteins and minerals/vitamins to enable the cow meet its daily requirements, low in fibre and easy to digest. Concentrates contain feed ingredients such as the milling by-products, example wheat bran, maize germ, maize meal, cottonseed cake, sunflower cake and dairy premixes. Concentrates are mainly sources of energy and protein, but they usually also contain minerals and other important nutritional requirements that cannot be met from forage (Kellaway & Harrington, 2004).

In dairy production, concentrate mix is always used to supplement a basal diet, which is normally forage. A concentrate mixture contains grains, mill feeds, protein supplements, and minerals. The kind of mixture to feed vary with the kind of forage availability (Muriuki *et al.,* 2003)

2.4.2 Carbohydrate requirement for lactation

Carbohydrates are the major source of energy for rumen microorganisms and the single largest component of a dairy cow’s diet. Carbohydrate nutrition supports maintenance and milk production and influences milk composition. In order for high producing dairy cattle to meet their high energy demands, feeding diets containing large amounts of concentrates and high quality forages are necessary, usually at the expense of fibre intake. However, adequate levels of fibre are required to maintain normal rumen function and milk fat percentage (Allen, 2001).

2.4.3 Raw materials for dairy concentrate

Raw materials for concentrate feeds are commonly classified into the following categories, first are the cereal grains, these include corn, wheat, barley, rye, sorghum and millet. Corn is widely fed as shelled corn or ear corn. These grains have to be adequately prepared or broken to increase digestibility. Second are the protein sources, this are either from plant or animal sources, plant sources include sunflower, whole cottonseed, soybeans screening and alfalfa. Animal sources include bone meal, fish meal and blood meal (Ishler et al., 2002; Allen, 2000). Thirdly, are the milling by-products, this are by-products from the milling of cereals and pulses manufactured for human use. These include brans, germs and pollards. Fourth are feed-grain substitutes, dried roots and tubers (chiefly cassava and sweet potatoes), fifth are by-products of crop processing such as molasses, maize gluten feed, distillery and brewery grains and dried citrus pulp. In some classifications, 'roots and tubers' are classified separately while the latter kinds of feeds may be regarded as 'other concentrates' or 'non-conventional concentrates.

Oil cakes: products of oilseeds (including copra, cotton seed, groundnuts, linseed, palm kernels, rapeseed, sunflower seed and soya beans) and fish after extraction of their oil component either by expeller methods (oilcakes) or solvent-extraction methods (oil meal).

Other energy or protein concentrates including processed livestock products (inedible fats and oils, meat, blood and bone meal and milk products) and industrial products such as urea and single-cell protein.

Corn, oats, barley, and milo (sorghum grain) are the most important energy-rich grains that contain about 70 to 80 percent of TDN (total digestible nutrients) including 7 to 10 percent of digestible protein. Wheat bran, rice bran, wheat middling, rye middling, and rice polish are by-product feeds from the grain milling industry that can be used to formulate feed ration. Examples of concentrates include commercially formulated and processed feeds such as dairy meal, and cereal by-products (Pollard, wheat and maize germ meal, wheat and maize bran, etc) and other high energy and/or high protein feed stuffs (e.g. molasses, fish meal and brewer spent grains or ‘machicha’). Cereal grains (maize, wheat and barley) also fall in this category but their use depends on whether they are economical to feed. Concentrates are relatively expensive and hence are fed in small amounts (Lukuyu *et al.*, 2013).

Non-conventional feeds and processed harvested forages: these include a variety of feeds not widely used in commercial livestock diets; some may be considered as concentrate feeds after processing, such as dried Lucerne (alfalfa) leaf meal, dried cassava leaf, cassava pulp, processed pea and bean meals, rubber seed meals, citrus pulp and wastes.

2.4.4 Effect of concentrate supplementation on milk production

About 77% of the total dairy cattle population in Kenya is kept by small scale farmers and about 80% of milk produced comes from smallholder farmers (Biwott *et al*., 1998) most of who are found in the high potential areas, in these areas, feeding of dairy cattle is often based on crop residues and hay and pasture. Since these are often low both in protein and energy, supplemental feeding is done to meet the nutrient requirements. The feeding practice for most of the smallholder dairy farmers in Kenya is to give their dairy cows a constant amount of dairy concentrate of 2Kg per day or less throughout lactation (Omore, 1997; Kaitho, 2001). However, cows do not achieve their potential peak milk yield; therefore, do not attain optimum returns for their inputs. Because of low milk yield, total lactation yields are lower by significant amounts. This is thought to be affected by feeding levels during lactation (Broster *et al.*, 1997).

In Bangladesh, dairy farmers are recommended to feed 1 kg concentrate for 2-3 kg of milk yield (Khan *et al.,* 2009). The amount of concentrate feeds depend on the amount and quality of forage consumed and amount of milk produced. The composition (fat %) of the milk produced limit the percentage of concentrates to a maximum of about 60% regardless of comparative cost of grains and roughages. Rations with more than 60% of concentrates may result in changes in proportion of ruminal (rumen volatile acid) VFA, which in turn can result in the reduction of milk fat (Li et al., 2014).

The best way to feed concentrates to dairy animals is to base the feeding on milk production. Concentrates can be fed either by giving the same rate throughout lactation or by challenge feeding. In challenge feeding, the cow is given a low level of concentrate at calving and is increased gradually until further increase does not result in increased milk (Chik *et al.*, 1981). Targeted concentrate feeding is another method that has been shown to increase net returns for some smallholder dairy farmers in Kenya. Findings from the Kenya smallholder dairy project have shown that most farmers feed 2 kg of concentrate per cow per day and get 5–7 litres of milk. When this amount was raised to 8 kg of concentrate per day for a targeted period the total milk yield increased by 24%. Coupled with inadequate dry matter intake from forage, these feeding practices result in lactation curves that display a low peak yield and a long calving interval. Flat lactation curves with low peak yields imply that farmers do not realize the benefits that can be derived from the physiological potential of a cow to increase its milk yield in early lactation.

Research conducted under temperate conditions demonstrates that increasing levels of concentrate feeding result in an overall increase in milk yield, more so if a high level of concentrate is fed during early lactation. The underlying cause of this phenomenon is that the level of nutrition during the first few weeks of lactation has a major effect on total lactation performance (Lucy, 2008). Poor feeding especially during the first few weeks of lactation results in a low peak yield (Beever, 2006) which leads to a low lactation yield.

2.4.5 Amount of concentrate to supplement lactating dairy cattle

The type and amount of concentrate to feed an individual cow will depend on the quality of forage the cow is given and the level of milk production. Forages vary in quality: generally legumes are of high quality, fresh grasses medium and crop residues, such as straw, low quality, containing high, medium and low levels of protein, respectively. If the milking cow is fed on forage with low protein content, such as tall, overgrown Napier grass or dry maize stalks, then concentrates with a high protein content need to be given to provide a balanced diet and support a high milk yield (Erasmus *et al.*, 2000; Garg & Makkar, 2012).

If the cow is fed on good protein forages having 12% CP and above, such as good quality pasture, or also receives supplementary forages, such as Lucerne, lower protein concentrates can be used or no concentrates may be needed, depending on the cows' milk yield. Concentrates are expensive and therefore should be fed carefully to get the best return to investment. The amount of concentrates fed should depend on the level of milk production and the quality of forage. The most economical level of feeding concentrates is the point at which the last amount of additional concentrate added to the ration is just paid for by the extra milk produced by that unit of concentrate. But this point may be difficult to determine for individual cows – it requires careful measurement of the amount of concentrate given and milk produced. Also, it is influenced by changes in milk and feed prices – if the milk price drops, it may no longer be economical to feed as much concentrates (Chamberlain *et al.*, 1996).

2.5 Fibre Digestibility

Fibre digestibility is usually defined as the proportion of consumed fibre that is not excreted in the faeces. Fibre contains both indigestible fraction and potentially digestible fractions, each of which is degraded at its own rate. The extent of fibre digestion depends on the size of the indigestible fraction and the competition between the rates of degradation and passage out of the rumen (Martin *et al.*, *2008*; Mertens, 2009).

Ruminal fibre digestibility is affected by the passage rate of particulate matter out of the rumen. Rate of passage is affected primarily by intake. However, feed particle size, particle buoyancy, concentrations of dietary fibre and NFC, and rate of digestion of the potentially digestible fibre fraction may affect passage rate. The non-fibre carbohydrate (NFC) portion of the diet is highly digestible and can influence both fat and protein in milk. Excessive amounts of NFC can depress fibre digestibility, which reduces the production of acetate and leads to low milk fat (1% or more reduction). At the same time, greater propionate production allows higher milk protein levels of 0.2 to 0.3%. Generally an NFC of 32 to 38% of ration dry matter is recommended to optimize production of milk fat and protein (Heinrichs *et al.*, (1997).

An increase in the intake of concentrates causes a decrease in fibre digestion and acetic acid production (Tafaj, 2005). This creates an increase of propionic acid production. Propionic acid production encourages a fattening metabolism that is in opposition to milk fat. Addition of buffers to some rations may help to prevent acidosis; this does not change milk protein, but increases milk fat content. Animals that eat a substantial amount of concentrates or a low ratio of dietary forage to concentrate may develop acidosis even when buffers are added to the ration (Heinrichs *et al*., 1997).

2.6 Ration formulation

Diet formulation involves matching the feed supplied with the specific requirements of the herd in the most cost-effective way and should be viewed in conjunction with pasture feed planning. In order to provide the nutrients calculated as being required, it is important to know how much feed a cow is capable of eating. Intake capacity depends primarily on size and weight of the cow, digestibility of feed on offer and stage of lactation. Supplements should be compared by comparing the cost of the nutrients they contain. Unbalanced diets may lead to metabolic disorders.

Rations for lactating dairy cows are usually formulated based on protein (CP) and energy (net energy for lactation) requirements. However, to achieve maximum production, dairy rations should be balanced for effective fibre, non-structural carbohydrates, ruminal undegraded protein and soluble protein. Dairy rations are usually formulated to maximize microbial yield and for requirements for ruminal undegraded amino acids (Hall, 2005).

Ration formulation is truly a balancing act requiring a careful combination of various feedstuffs to ensure that nutrients are not over- or underfed to each animal class in a dairy herd. Routinely using available mathematical models to optimize rations for each animal class in the herd is highly encouraged. Ration formulation has a significant impact on profitability and enteric emissions because it directly affects feed intake, fermentable energy availability, passage rate, feed efficiency and other factors that influence ruminal digestion, enteric methane formation and nutrient supply in dairy cattle. The implementation of ration formulation practices requires consideration of rumen function, animal requirements, the net energy system and energy partitioning, metabolizable protein and concepts of feed efficiency, dilution of maintenance, and ingredient and diet nutritional analyses (i.e., composition and digestibility (Oetzel, 2003).

Diets are formulated to provide specific level of nutrients that are needed for optimum performance. The production criteria looked into is feed conversion ratio, growth rate, health of the animals and their body conformation. The major determinants of these are the energy and crude protein contents of the diets (Uchegbu *et al.,* 2009). For non ruminants particularly broilers, diets of high energy content promote fast growth, and, therefore, their metabolizable energy (ME) contents should generally not be less than 12.2MJ/kg (Whitehead, 2002).

The objective in formulating ration is to provide animals with a consumable quantity of feedstuffs that will supply all required nutrients in adequate or greater amounts and do so in a cost effective way. Successful rationing involves achieving the best possible balance between a number of key nutritional, practical and financial factors.

The most important priorities in rationing are to deliver an adequate supply of the nutrients required to meet the cows' needs, to achieve a balance of ingredients that will optimise rumen function and nutrient utilization, to ensure the ration can provide the required nutrition within the cows' intake capacity, to make the most at the lowest cost (often home grown) feeds for the greatest economy and finally, to provide rations which can be fed effectively with the equipment and facilities available.

2.6.1 Rule of thumb of ration formulation

Rule of thumb for lactating cows is that, DMI will depend on the body weight of the animal and milk yield. The more the body weight and milk yield, the more the unit of dry matter intake per unit body weight and vice-versa.

There is a recent formula based on the dairy cows total dry matter requirement. The 3% based on body weight will account for maintenance and some level of milk production; however, high milk producing cows will require more feed DM.

The formula by (Iwaniuk *et al.,* 2015)

Allow for milk production is as follows

$$DM = 6\ Kg + ({}^{B.W}/_{100} + {}^{M.Y}/_{5})$$

Where B.W = Body Weight

M.Y = Milk Yield

Generally DMI of dairy animals vary between 2.5 to 3.0 kg per kg per 100kg body weight. Forage DM should have a minimum of 40% of total DMI or approximately 1.5 % of B.W. The crude- protein level should be provided at 14-16% in early lactation ration, urea should be limited to 200g/ day. The maximum fat in the ration should not be more than 7% of the DM. Mineral supplement is crucial for lactating cows and therefore mineral source should be included in the grain mixture at 1 to 2 per cent per Lit of milk, This includes macro elements such as calcium and phosphorus, micro elements such as vitamin A, D, E and trace minerals should be included in the ration to meet the requirements (Jaetzold *et al.,* 2006).

Diet formulation is an important aspect of dairy production. The success of any animal production enterprise depends greatly on proper feeding and nutrition based on economic rations. Animal production practitioner should have a good knowledge of different aspects of nutrition, feeding, nutrient interaction and limitations, as well as the economics of production and feeding. Feed ingredients for making different rations can be cheaply sourced from the farm's by-products after harvesting such as, maize cobs, maize stovers and bean by-products .Harvested grains such as maize, wheat, sorghum and barley may be added into the formulation. Legumes, lucern, desmodium, and vetch may be grown in the farm specifically for dairy total mixed ration formulation. By-products from grain milling and oil extraction by-products can also be used to formulate feed rations; including maize germ, maize bran, wheat bran, wheat pollard, cotton seed cake, sunflower cake and soybean cake. By-products from seed processing companies can also be used to formulate a low cost dairy diet. Therefore the objective of the study was to evaluate the performance of the formulated diet from the by-products from seed processing company and compare with three commercial diets in Western Kenya region using lactating Holstein Friesian cows.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study site

This study was carried out at Kenya Agricultural and Livestock Research Organization (KALRO) Kitale Centre in Trans Nzoia County from 11th August 2014 to 22nd September 2014.The two trials were carried out concurrently with a precondition period of one week.

The research centre is located at the outskirts of Kitale town at an altitude of 1800-1900 M above sea level, with temperatures ranging from 8^{o}C to 27^{o}C, annual bi-modal rainfall pattern of 1100 to 1200 mm per year. The long rainy season start from March/ April to October/November and peaks in May, while the short rains begin in October to November of every year. December to February is relatively dry months and is characterized by scarcity of fodder for cattle (Jaetzold *et al.*, 1996).

3.2 Formulation of experimental Ration (Y).

The formulation and mixing of the diet was done at Western Seed Company where weighing and mixing machines are available. The ration formulation was done using trial and error methods with the support of standard nutrient feed composition table and computer software. The formulation was done basing on the Kenya Bureau of standards (KEBS, 2016), where it requires that a dairy concentrate should have a minimum of 16% CP. The experimental diet was prepared, packed in 70kg bags, and labelled Feed Y. The feed ingredients and their quantities were as shown in table 1 below. A sample was taken from each bag mixed thoroughly and a sub sample taken for laboratory analysis to determine the following contents; dry matter (DM), crude protein (CP),neutral detergent fibre (NDF), acid detergent fibre (ADF) and ash according to methods described by AOAC (1994).

Table 1: Ingredients of the formulated diet Y

Ingredients	Composition (%)
Maize on cob (male lines)	59.14
Molasses	14.29
Sunflower hulls	8.57
Soya bean cake	1.47
Soya beans	8.57
Cotton Seed cake	5.71
(Mac Lick Super)	1.43
Limestone	0.72
Dairy Premix	0.20
Total	**100**

ME=2.81 Mcal/Kg CP= 17.86% Ash=6.84%

**** Dairy premix- A standard vitamin mix supplement for dairy cows***

****Mack-lick super® -A commercial name of a Kenyan accredited mineral supplement available for dairy cows.***

Plate 1: (a) Experimental cattle on different diets: (b) Experimental cattle on different supplementary levels of diet Y

(Source: Author, 2015)

Plate 2: (a) Diet Y (b) Diet Z (c) diet W (d) Diet X (e) Soya meal ingredients for diet Y (f) Feed mixers and hammer mill (Source: Author, 2014)

3.3 Sampling of the three Commercial Dairy Feeds

There were a total of 3 different commercial feeds. These feeds were coded W, X, Z. the formulated feed was coded (Y). There are over ten commercial diets available in the market in this region, but the three diets were identified based on their frequency of purchase and availability as the most bought in Western region.

Commercial dairy diets were bought from the three out of seven manufacturers directly; this was done in two batches, at an interval of two weeks, this was done to avoid variations which may occur due to different ingredients used in different batches,

The two batches from each manufacturer were mixed together for uniformity. A sub sample was collected for nutrient analysis according to methods described by AOAC, (1994).

3.4. Basal diet

The basal diet that was used was Napier grass, and it was coded (C).Napier grass plantation has been established at the KALRO centre, mainly to be used in animal experiments, the grass are all at the maturity stage of growth. The grass was cut ones because the grass was enough to last through for the two experiments. The grass was cut by a panga then was chopped into 2.5-3.5cm using a chaff cutter; this was done to facilitate easy feeding.

A sample was picked from the chopped grass for nutrient analysis; the samples were oven-dried at 60^{0}C for 48 hours to determine moisture content. The samples were then subjected to nutrient analysis according to methods described by AOAC, (1994).

EXPERIMENT 1

Nutrient contents of diet W, X, Y, Z and the basal Diet

The samples picked from the four different diets coded W, X, Y, Z and the basal diet , coded (C), were determined according to standard methods of AOAC, (1994).Nutrients determined were, moisture content, crude protein, neutral detergent fibre, acid detergent fibre and ash.

EXPERIMENT 2

Determination of the supplementation levels for diet Y.

Five multiparous lactating Holstein Friesian cows at the same stage of lactation and similar in milk production were selected and moved to the experimental pens. Cows were kept in individual but adjacent experimental units in a 5x5 Latin Square designed experiment. The five cows were randomly assigned to the four supplementary treatment levels of 0.5, 0.75, 1.0, and 1.25Kg/l per day. The fifth treatment was (control), and the experimental cow received no supplementation, this formed treatment 1, 2, 3, 4 and 5 respectively. The experimental animals were preconditioned for seven days to the diet, and were allowed free access to the basal diet of chopped Napier grass but offered the formulated concentrate at milking time. Each cow was given 100gms of mineral supplement daily while water was provided *ad libitum*. The cows received the specific diet during milking time for seven days, and then changed to the next experimental diet.

Milk yields were recorded twice daily in litres(L) and a sample taken weekly before change-over to analyse for; butter- fat (BF),crude protein, solids-not fat(SNF) and density.

The data was subjected to analysis of variance (ANOVA) and Tukeys test used to separate significant means.

The identification and the weights of the selected animals were as shown in table 2 below

Table 2: Identification and the estimated weight of cows before the experiment

Cow Tag No.	**(Girt weight in Kg)**
GF 605	395
GF 586	491
GF587	475
GF598	434
GF 597	413

Table 3: Latin Square arrangement for experiment 2

Period(week)	T1	T2	T3	T4	T5
1	0.0	0.5	0.75	1.0	1.25
2	0.5	0.75	1.0	1.25	0.0
3	0.75	1.0	1.25	0.0	0.5
4	1.0	1.25	0.0	0.5	0.75
5	1.25	0.0	0.5	0.75	1.0

Key: Period (week) - each period took seven days

(0.0, 0.5, 0.75, 1.0, 1.25)-Supplementation levels of feed Y

EXPERIMENT 3

Evaluation of milk quantity and quality from cows fed on rations W, X, Y, Z and C.

This trial evaluated milk yield and quality from cows fed on Napier grass and supplemented with the dairy rations W, X, Y, Z and C. Five cows at the 3rd stage of lactation and similar in milk production were used. Preconditioning period of 7 days was done .Chopped Napier grass was fed as basal diet, clean water was provided *ad-libitum.* Each cow was given 100gms of mineral supplement daily. Each period took one week before the change-over to the next treatment. The experimental design used was a 5x5 Latin square arrangement, where there were five supplements and five experimental Friesian cows used, as shown on table 4 below. The experiment lasted for 25 days excluding the pre-conditioning period.

Table 4: 5x5 Latin square layout

Period	**T1**	**T2**	**T3**	**T4**	**T5**
1	Y	X	W	Z	C
2	X	W	Z	C	Y
3	W	Z	C	Y	X
4	Z	C	Y	X	W
5	C	Y	X	W	Z

Key: Period-weeks

T1-T5-Treatments; representing the 5 cows

Y -Formulated diet

C -Control (basal diet)

W,X,&Z-The commercial diets

Supplementation level used for all the four treatments was 0.75 Kg/L of milk produced per day per cow. The cow on control was fed on the basal Napier grass only.

Data on milk yield (Kg) was taken twice a day, at 6:00 PM and at 5:00 PM during milking session. The cows were observed for health conditions, vigour and vitality. Occurrence of oestrus and any other observation that was likely to affect production was noted. Milk samples were taken weekly for quality analysis at the laboratory, for protein, butter fat, solid not fat, and the milk density.

CHAPTER FOUR

RESULTS

4.1 The nutritive values of the formulated and commercial diets

The experimental diets; formulated diet Y and the commercial diets W, X and Z, and the basal diet C which acted as the control were subjected to proximate analysis according to standard methods of (AOAC), (1994) and the results are shown in table 5 and the findings are shown below;

Table 5: The Nutrient content of the formulated and the commercial diets

Type of Diet	Dry Matter (%)	Crude Protein (%)	Neutral detergent Fibre (%)	Acid detergent Fibre (%)	Ash (%)
W	92.55	13.71	43.34	22.64	10.54
Y	93.86	17.82	28.94	11.55	6.84
Z	93.34	8.9	48.15	23.88	19.18
X	93.05	15.51	50.16	17.29	10.09
C	89.0	5.54	67.45	37.9	6.38

4.1.1 Dry matter

Dry matter is the moisture- free content of the sample. Control diet C, had the lowest DM content of 89, whereas diet Y had the highest DM content of 93.86. Diet Z, W and X had a DM of 90.34, 92.55, and 93.05 respectively as shown in Figure 1.

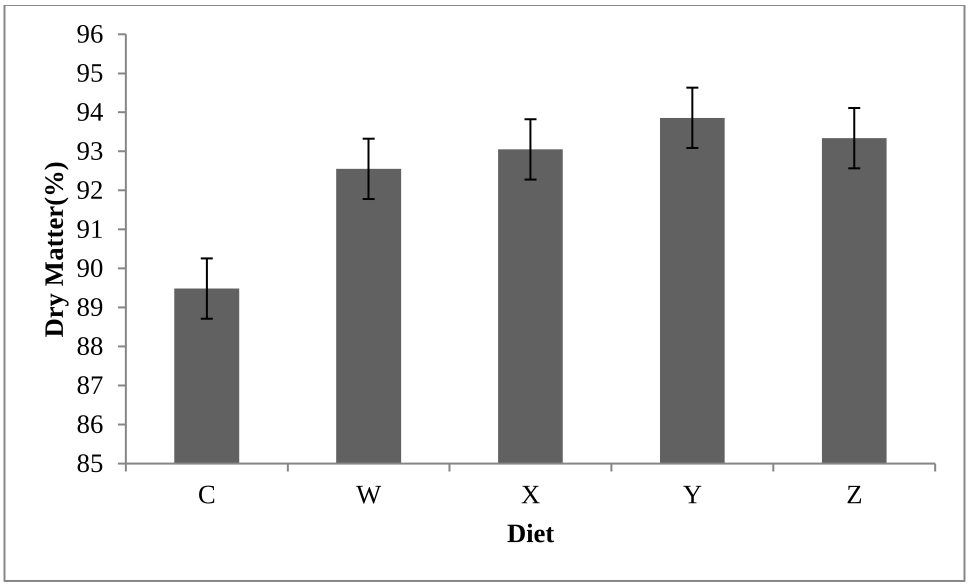

Figure 1: %Dry matter content in the diets

4.1.2: Crude Protein

Diet Y had the highest CP of 17.82%, while diet C (control) had the lowest CP of 5.54%. Diet W, X, and Z had a CP of 13.71, 15.51 and 8.9 % respectively as shown in Figure 2.

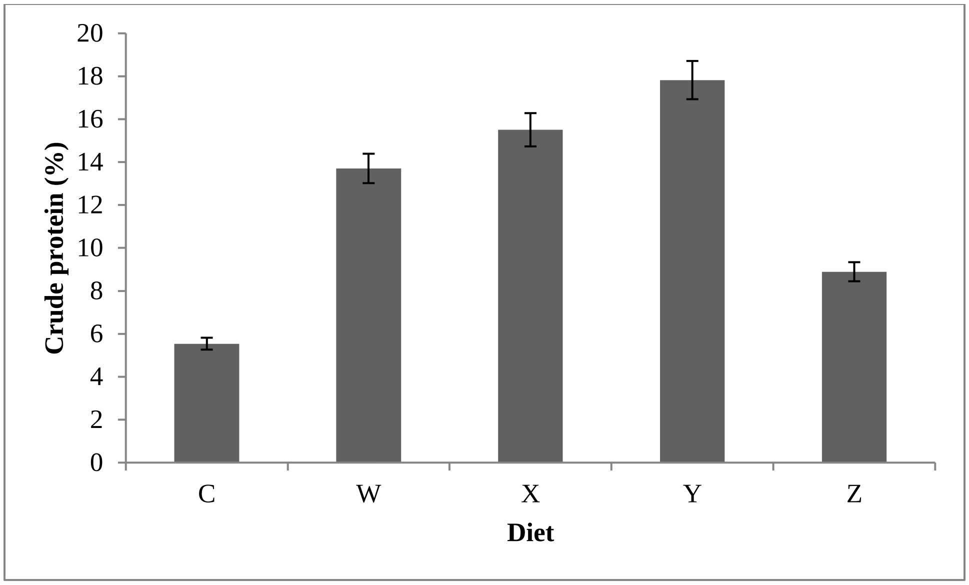

Figure 2: Crude protein content in the diets

4.1.3: Neutral Detergent Fibre

Neutral detergent fibre (NDF) is the value that consisted of all the cell wall contents.

Diet C (control) had the highest NDF of 67.45%, while diet Y had the least NDF of 28.94%, Diet X, Z, and W, had an NDF of 50.16, 48.15 and 43.34% respectively as shown in Figure 3.

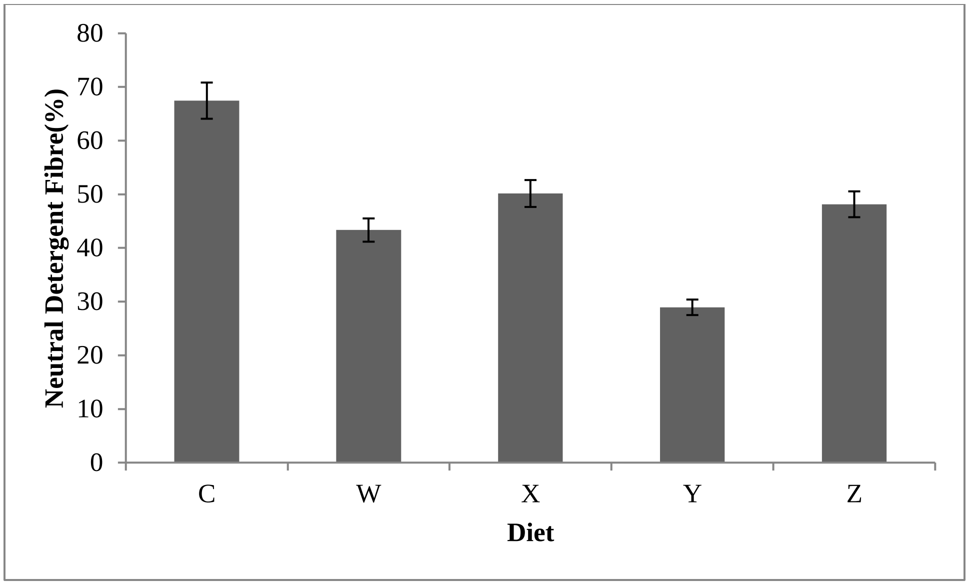

Figure 3: Neutral detergent fibre in the diets

4.1.4: Acid Detergent Fibre

Acid detergent fibre constitutes the least digestible plant components, which includes cellulose and lignin. Diet C (control), had the highest ADF of 37.9% while diet Y had the lowest ADF of 11.55%. Diet Z, W, and X had an ADF of 23.88, 22.64 and17.29% respectively as shown in Figure 4.

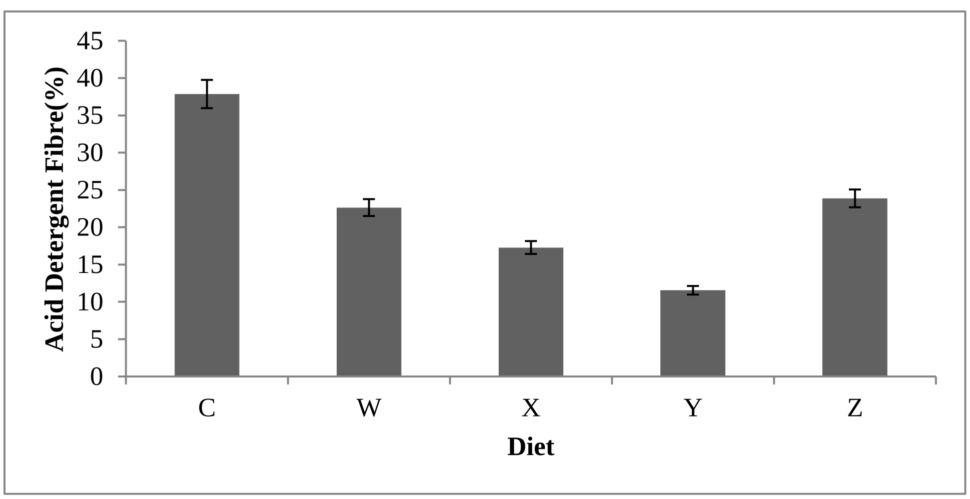

Figure 4: Acid detergent fibre in the diets

4.1.5: Ash

This is the total mineral contents in the feed. Diet Z had the highest mineral content of 19.18 % while Diet C (control) had the least mineral content of 0.4%. Diet W, X and Y had a mineral content of 10.54, 9.99 and 6.83% respectively, as shown in Figure 5.

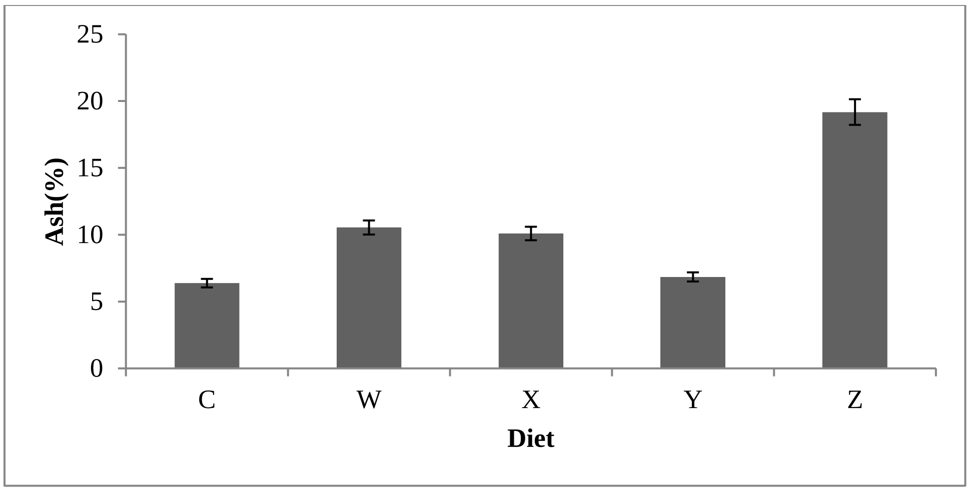

Figure 5: Ash in the diets

4.2 The effects of supplementation levels of ration Y on Milk yield

There was highly significant (*p* <0.01) effect among the treatments of the formulated ration Y on milk yield of the lactating Friesian cows. In this regard, it was observed that the milk increased gradually with increasing level of ration Y as shown in Table 6. The highest increase of 66.03% was recorded when the cows were fed with supplementation level of 1.25 kg/l of milk produced compared to the control (0 kg/l).

There was no significant difference between treatments 1 and 2, 2 and 3, 3 and 4, and 4 and 5 as shown in table 4.2. Treatment 4 and 5 produced significantly ($p \leq 0.05$) higher amount of milk compared to treatments 1 and 2. Treatment 5 performed ($p \leq 0.05$) better than treatments 1, 2 and 3.

Table 6: Milk yields for each treatment for diet Y

Treatment	Supplementation level (Kg)	Milk quantity (Litres)
1	0.00	4.40^{a}
2	0.5	5.14^{ab}
3	0.75	5.70^{bc}
4	1.00	6.54^{cd}
5	1.25	7.30^{d}
	SEM	± 0.434

Means with different superscripts are significantly different ($P < 0.05$)

4.2.1 Effect of supplementation level of ration Y on milk quality

The quality of milk from the cows fed on the different treatments of ration Y were as shown in Table 7.

There was no significant difference on the butter fat content in milk from cows fed on the different supplementation level of diet Y as shown in table 7. The mean butter fat contents were 4.457, 4.520, 4.643, 4.505, 4.510 and 4.527 for supplementation 0, 0.5, 0.75, 1.0 and 1.25Kg/L respectively. The crude protein, Solid not fat and density were similar across all treatments as indicated in table 7.

Table 7: Milk components (%) from cows fed on 5 Treatments.

	Treatments					
Factor	**0.00**	**0.5**	**0.75**	**1.00**	**1.25**	**SEM**
Butter-Fat	4.46	4.52	4.64	4.51	4.51	± 0.166
Protein	3.36	3.41	3.37	3.29	3.43	± 0.058
SNF	8.56	8.68	8.6	8.63	8.74	± 0.055
Density	28.85	29.49	29.07	29.29	29.71	± 0.231

4.3: Milk quantity and quality from cows fed on formulated and commercial concentrates

4.3.1: Milk quantity

Milk production was as shown in table 8. Supplement X had significantly ($P<0.05$) higher milk production of 6.15L, but was similar to supplement W which had 5.98 L. Supplement C (control) had the lowest milk production of 4.05 L. Diet Z, and Y, had a mean milk production of 5.61L and 5.27L respectively which were similar. There was a significant ($P<0.05$) difference in milk production in all the supplementary diets compared to the control.

Table 8: Milk yields (L) from cows fed on the formulated and commercial diets.

Type of feed supplement	Average milk production
C	4.05 [a]
Y	5.27 [ab]
Z	5.61 [b]
W	5.98 [bc]
X	6.15 [c]
Mean	5.41

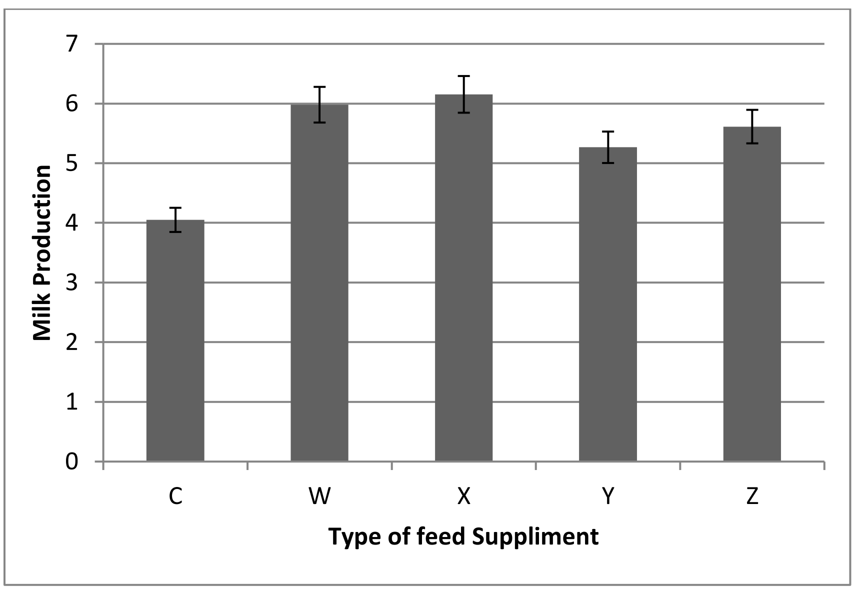

Figure 6: The effect of formulated and commercial diet on milk quantity.

4.3.2 Milk quality

Milk quality was determined by analyzing its components from lactating cows fed on the different diets. There was no significant difference in the butter fat content of the milk from animals fed on the different diets as indicated in table 9. The mean butter fat contents were, 4.876, 4.962, 5.174 and 5.207 for diets, Z, Y, W and X, respectively.

The Solid- not-fat (SNF) component in milk from the cows fed on the different diets was not significantly different as indicated in table 9.The protein component in the milk from cows fed on different diets was not significantly different. There was no significant difference in the density of milk from animals fed on the different diets as indicated in table 9.

Table 9: Milk components (%) from cows fed on formulated and commercial diets

Factor	C	W	X	Y	Z	SEM
Butter-Fat (%)	5.12	5.17	5.21	4.96	4.88	± 0.108
Protein (%)	3.42	3.42	3.47	3.43	3.43	± 0.033
SNF (%)	8.7	8.7	8.84	8.74	8.72	± 0.088
Density (g/dl)	29.02	28.99	29.51	29.26	29.29	± 0.292

CHAPTER FIVE

DISCUSSION

5.1 The nutritive values of the basal, formulated and commercial diets

Nutritive values of feeds are determined by a number of factors including composition, odour, texture and taste (Schneider *et al.*, 1975).The formulated and commercial diets were analysed based on their composition. The analyzed results showed significant difference between all the feed nutrients that were analyzed.

The basal diet Napier grass had the lowest levels in nutrient components, with 89.0, 5.54, 67.45, 6.38% for DM, CP, NDF, and Ash respectively, this could be as a result of the Napier grass over maturity, which was the best diet available in terms of quantity and was able to sustain the experiment until its conclusion being the basal diet. ADF was high at 37.9%. The nutritive values of most Napier grass varieties in Kenya has 8-10, 20, 70, 45 and 0.4% for CP, DM, NDF, ADF and ash respectively (Mukisira *et al.*, 1989). The Napier grass used in the experiment as a basal diet was fair nutritionally and was within the same nutritional level as Napier grass varieties in Kenya.

5.2 Influence of supplementation levels of ration Y on milk yield and quality

The current findings showed that, milk production increased as the level of the concentrate diet was increased. This was also observed by Meeske *et al*., (2006). However, this was contrary to the findings of Kitilit *et al* (2013) who reported significant improvement of milk production over time when supplementation is given at a lower level of 2.0 Kg per day. Supplementation level of 1.25 Kg/L produced mean milk yield of 7.30 L of milk per day. This showed that as the concentrate level was increased, the nutrient intake especially for energy and crude protein also increased, resulting into an increase in milk yield. This was also observed by Meeske *et al.*, (2006) when lactating cows were fed with different concentrates, it was observed that, increasing nutrients in feeds resulted in increase in milk production.

Dairy cow rations must contain good quality forage, a balance of energy, crude protein plus minerals and vitamins, to meet nutrients requirement for milk production, growth and reproduction, (Linn ,(2016). reported that Friesian cattle that feed to appetite during lactation give significantly more milk but slightly lower butter fat.

Dairy farmers gain revenue from the production of large quantities of milk and therefore, the incentive to improve productivity has dominated the farmer efforts in the dairy industry. Feeding strategies that ensure fresh, adequate dietary supply are likely to stimulate the cow`s appetite and maximize dry matter intake and may maximize milk yields, Kitilit *et al.,* (*2015*).

Most formulated dairy concentrates have more ingredients containing energy because lactating cows require in their diet. Energy is the major nutrient whose impact on milk production cannot be disputed (Lupton, 2008). Generally milk yield and components are indicators of cow health and nutrition. It is also important to note that they differ among breeds, with Friesian cattle having high milk yield ranging 25- 40L/day and low fat and protein while Jersey have the highest butter fat, But because Friesians produce huge volumes of milk, they have high total fat and proteins than other breeds(*http://extension.psu.edu).*

There were no significant changes in the milk composition from the cows fed on the different supplementation level of the diet, a similar observation by Faverdin *et al*., (1991) where increased concentrate feeding, did not affect butter-fat and protein content.

5.3 Milk quantity and quality from cows fed formulated and commercial diets

There was a significant difference of the milk quantity from the lactating cows fed on the different concentrate diets. The study had hypothesized that there was no differences in terms of quantity of milk from lactating Friesian cows fed on formulated and the commercial diets; hence the null hypothesis is rejected. The Napier grass was used in the experiment as a basal diet because it was readily available at the research station. Napier grass is the most popular perennial fodder crop recommended for intensively managed crop-livestock farming systems in Kenya where 80% of the national milk output is derived (Nyambati *et al.*, 2010). The lactating Friesian cows that consumed the basal diet only without concentrate supplementation had the lowest milk yield, this was as a result of lack of additional nutrients that they could have received from the concentrate supplementation, and also due to the Napier grass that had over matured thus had more lignin and high acid detergent fibre as shown in figure 5.

CHAPTER SIX

CONCLUSIONS

1. The formulated diet was highest in crude protein with 17.82%, and lowest in fibre of 11.55%, therefore, it is a better diet than commercial diet W and X.
2. Milk yield increased at 0.5Kg diet/L of milk, Supplementation level of 1.25Kg/L per day resulted to 7.30 Litres of milk on average.
3. The formulated diet was equal to commercial diet W and Z in milk yield.
4. The formulated diet was equal to the other diets in maintaining the milk quality.
5. The formulated diet increased the milk yield of the lactating cows fed on the diet.

RECOMMENDATIONS

1. These results indicate that it is beneficial to supplement pasture and hays with concentrates to lactating cows.
2. The formulated diet from seed waste is a good supplement for dairy animals.
3. Seed companies can use the seed processing waste products to compound feeds for the dairy industry
4. Further work should be done to determine the performance of the formulated diet under various feeding systems and different forages.

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APPENDICES

Appendix I: Analysis of variance of the effect of the level of supplement Y on the milk quantity of lactating Friesian cows

Variate: Total Milk Production

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
PERIOD stratum	4	7.3439	1.8360	1.95	
Cow stratum	4	197.4035	49.3509	52.32	
PERIOD. Cow stratum					
Supp	4	78.3109	19.5777	20.76	<.001
Residual	12	11.3183	0.9432	6.20	
PERIOD. Cow.*Units* stratum					
	50	7.6083	0.1522		
Total	74	301.9849			

Appendix II: Analysis of variance of the effect of the level of supplement Y on the butter fat content.

Variate: butterfat

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
PERIOD stratum	4	0.3753	0.0938	0.69	
TAG_NO stratum	4	9.7246	2.4311	17.75	
PERIOD.TAG_NO stratum					
LEVEL_OF_SUPL	4	0.0959	0.0240	0.18	0.947
Residual	12	1.6433	0.1369		
Total	24	11.8391			

Appendix III: Analysis of variance of the effect of the level of supplement Y on the milk SNF

Variate: SNF

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
PERIOD stratum	4	0.02068	0.00517	0.34	
TAG_NO stratum	4	0.51450	0.12863	8.43	
PERIOD.TAG_NO stratum					
LEVEL_OF_SUPL	4	0.10401	0.02600	1.70	0.214
Residual	12	0.18311	0.01526		
Total	24	0.82231			

Appendix IV: Analysis of variance of the effect of the level of supplement Y on the milk Protein

Variate: PROTEIN

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
PERIOD stratum	4	0.04205	0.01051	0.63	
TAG_NO stratum	4	0.23240	0.05810	3.46	
PERIOD.TAG_NO stratum					
LEVEL_OF_SUPL 4	0.05739	0.014			
35	0.85	0.518			
Residual	12	0.20152	0.01679		
Total	24	0.53337			

Appendix V: Analysis of variance of the effect of the level of supplement Y on the milk density

Variate: DENSITY

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
PERIOD stratum	4	0.4764	0.1191	0.45	
TAG_NO stratum	4	5.1734	1.2933	4.87	
PERIOD.TAG_NO stratum					
LEVEL_OF_SUPL	4	2.2904	0.5726	2.15	0.136
Residual	12	3.1892	0.2658		
Total	24	11.1294			

Appendix VI: Analysis of variance of the effect of the formulated and commercial diets on milk quantity of lactating Friesian cows

Variate: Milk Quantity

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
PERIOD stratum	4	1.7458	0.4364	0.39	
TAG_NO stratum	4	105.4991	26.3748	23.48	
PERIOD.TAG_NO stratum					
TYPE_OF_SUPP	4	41.8335	10.4584	9.31	0.001
Residual	12	13.4804	1.1234	7.65	
PERIOD.TAG_NO.*Units* stratum					
	50	7.3417	0.1468		
Total	74	169.9005			

Appendix VII: Analysis of variance of the effect of the formulated and commercial diets on milk butter fat content

Variate: Butterfat

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
PERIOD stratum	4	0.57414	0.14354	2.46	
TAG_NO stratum	4	21.39592	5.34898	91.73	
PERIOD.TAG_NO stratum					
TYPE_OF_FEED	4	0.40429	0.10107	1.73	0.207
Residual	12	0.69978	0.05832		
Total	24	23.07414			

Appendix VIII: Analysis of variance of the effect of the formulated and commercial diets on milk SNF content

Variate: SNF

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
PERIOD stratum	4	0.24253	0.06063	1.57	
TAG_NO stratum	4	3.57586	0.89396	23.11	
PERIOD.TAG_NO stratum					
TYPE_OF_FEED	4	0.06841	0.01710	0.44	0.776
Residual	12	0.46420	0.03868		
Total	24	4.35099			

Appendix IX: Analysis of variance of the effect of the formulated and commercial diets on milk Protein content

Variate: Protein

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
PERIOD stratum	4	0.037256	0.009314	1.76	
TAG_NO stratum	4	0.553126	0.138281	26.19	
PERIOD.TAG_NO stratum					
TYPE_OF_FEED	4	0.009316	0.002329	0.44	0.777
Residual	12	0.063368	0.005281		
Total	24	0.663066			

Appendix X: Analysis of variance of the effect of the formulated and commercial diets on milk density

Variate: Density

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
PERIOD stratum	4	2.4204	0.6051	1.42	
TAG_NO stratum	4	26.6809	6.6702	15.68	
PERIOD.TAG_NO stratum					
TYPE_OF_FEED	4	0.9279	0.2320	0.55	0.706
Residual	12	5.1047	0.4254		
Total	24	35.1339			

Appendix XI: Analysis of variance of dry matter content of the rations

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
REP	2	15.3	7.63	0.133	0.877
DIET	4	35.8	8.96	0.156	0.955
Residuals	8	458.0	57.25		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Appendix XII: Analysis of variance of protein content of the rations

	Df	Sum Sq	Mean Sq	F value	Pr (>F)	
REP	2	9.91	4.96	0.545	0.59997	
DIET	4	300.10	75.03	8.249	0.00612	**
Residuals	8	72.76	9.10			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Appendix XIII: Analysis of variance for NDF of the rations

Df Sum Sq Mean Sq F value Pr(>F)

REP 2 44.8 22.4 1.161 0.361

DIET 4 2301.4 575.3 29.8337.4e-05 ***

Residuals 8 154.3 19.3

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Appendix XIV: Analysis of variance for ADF of the rations

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
REP	2	8.9	4.47	0.374	0.69926	
DIET	4	1154.6	288.65	24.156	0.00016	***
Residuals	8	95.6	11.95			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Appendix XV: Analysis of variance for NDF content of the rations

	Df	Sum Sq	Mean Sq	F value	Pr (>F)	
REP	2	3.0	1.52	0.623	0.56	
DIET	4	317.5	79.38	32.599	5.32e-05	***
Residuals	8	19.5	2.43			

Signif. Codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’