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Income Over Feed Cost Analysis Of Utilizing Selected Fodder Mixture In Smallholder Friesian Dairy Farms In Kenya.

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Abstract
This research delves into the intricate dynamics of the economic feasibility of the various dietary treatments by calculating the Income Over Feed Costs (IOFC) in smallholder dairy farms in; Bomet, Nyandarua, and Nyeri, focusing on the optimization of milk production through strategic dietary supplementation. The study, conducted across diverse regions scrutinizes the economic implications of varying levels of experimental feed incorporation. Twelve Friesian dairy cows, spanning different lactation stages but with consistent parity, were subjected to four dietary treatments, each representing different percentages of experimental diet supplementation (0%, 10%, 20%, and 30%). The experiment spanned eight weeks, incorporating a backgrounding period, adaptation phase, and extensive data collection. Results unveiled intriguing regional disparities, with Bomet County showcasing optimal economic returns at a 20% supplementation level, Nyandarua favouring a 30% supplementation level, and Nyeri maximising economic efficiency at 30%. The highest overall Income Over Feed Cost (IOFC) was associated with the 30% supplementation level. The study underscores the significance of tailoring dietary strategies to regional contexts, emphasizing the economic benefits of strategic feed supplementation. This research contributes valuable insights for optimizing milk production, enhancing farm profitability, and promoting resilience in the face of dynamic agricultural landscapes.
Key Word: *Economic returns, supplementation level, fodder Bomet, Nyandarua, Nyeri*

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I. Introduction

Many countries have a low-cost production system like Kenya's, which is centred on rain-fed pasture production (Creemers & Aranguiz, 2019). Dairy products provide over 1.5 million small- and medium-dairy farmers in Kenya with a living; They account for 4.5 percent of the nation's GDP and 12 % of the GDP from agricultural (KDB, 2016). As a result, it creates 500,000 indirect jobs and 750,000 direct jobs and contributes to other service sectors such as livestock feed and processing, animal health – care, and breeding (KDB, 2016). On average, 80 to 100 kg of dairy products are consumed annually per person in Kenya, according to the Kenya Dairy Board (KDB). In contrast, in most Central and East African countries, the per capita dairy consumption is less than 30 kg (Kasirye & Ssewanyana, 2015). For more than 30 years, the average milk yield per cow had remained at 6 kg/day, according to MoLD (2010).

With a GDP contribution of roughly 4%, In Kenya, the dairy sector is the country's largest overall. The dairy subsector in Sub-Saharan Africa (SSA) makes up 3% of the global milk yield. Kenya produces 18% of this, making it a significant participant in the SSA dairy market. In 2017 Oderero-Waitituh. Smallholderdairy farmers produce 80 per cent of the milk, with large-scale dairy farms producing the remaining 20% (Ettema, 2015; Odero-Waitituh, 2017). Cattle provide 75% of the milk, with goats and camels providing the remaining 25% (FAO, 2018).

The per capita amount of milk consumed nationally is predicted to rise by 2.8% annually from 2012 to 2022 due to a growing need for milk and other milk products in town areas (USAID, 2015). The demand for convenience products has increased as a result of shifting consumer lifestyles, urbanisation, and rising incomes (Thornton & Herrero, 2010; USAID, 2015; Bebe et al., 2017). Although there are many market opportunities for dairy farmers, they still need to maintain their competitiveness and financial viability. Reducing production costs and raising milk yields are two ways to achieve this (Mugambi et al., 2015; USAID, 2015). However, there are certain barriers to enhancement, such as low animal performance due to a lack of labour, high input costs, and poor-quality feed (McNamara & McKune 2018). Forage is the primary constraint; this includes insufficient forage in terms of quantity and quality, insufficient forage conservation, and insufficient water availability (Creemers & Aranguiz, 2019; Lukuyu et al., 2011).

The profitability of dairy production can be greatly impacted by increasing the efficacy of converting feed to milk, as feed costs can account for as much as 60% of total production costs. The purpose of animal production has always been to maintain producer profitability and to guarantee an adequate supply of food. This could rise to 70% due to the present volatility in milk and feed prices (Connor, 2015). The primary determinant of sustainable dairy farming and a tool for gauging overall economic competitiveness is the cost of milk production, particularly the estimate of financial costs (Ndambi et al., 2017, 2018). Consequently, in order to maintain their competitiveness, dairy farmers and organisations need to work towards lowering farm-level expenses (Koonawootrittriron et al., 2012; Leeuwarden, 2019).

Dairy herd feed efficiency is measured and defined using income over feed cost (IOFC), which analyses feed efficiency straight from the perspective of economic viability also known as return over feed (ROF) (Bach et al., 2020). It is computed as the disparity between the total amount of money made from selling milk over a given period of time and the feed expenses related to producing it (Hemme et al., 2014). In the next month or year, the IOFC data can be utilised to evaluate the feasibility of future revenue generation plans. In addition to providing information to assess forward-pricing opportunities as well as decide when pricing dairy products and feed would be helpful to farm cash flow, this information enables the producer to make administration modifications when anticipated revenue appears tight (Fernandez-Perez et al., 2022).

Dairy farmers can use feed cost per day, feed cost per hundredweight, and income over feed cost as metrics of efficiency. This enables farmers to calculate the amount of revenue that they risk when they alter their feeding practices. or the potential financial gain from changing their feeding habits (Ferreira, 2015). Better business decisions can then be made by the farmers as a result. The financial sustainability of the dairy industry depends on regular monitoring of economic performance and production efficiency. This is especially important in periods of low milk prices, higher feed prices, or both of them. Managers can use a variety of financial performance indicators, like this one, to help them make profitable decisions (Ferreira, 2015).

With funding from the Dutch Embassy in Kenya, the Market-led Dairy Programme (KMDP) implemented various initiatives to preserve fodder and improve rationing in Kenyan dairy farms. The interventions consisted of promoting on-farm feed formulation with advisory services, as well as fodder conservation through the use of silage with assistance coming from service delivery businesses. This study sought to determine how KMDP fodder-related interventions affected dairy profitability in Kenya's Central, Eastern, and North Rift regions.

There is a strong dairy industry in Kenya, and it contributes greatly to both the nation's economy and the health of its citizens (Wambugu *et al.*, 2011). Kenya's dairy sector is one of the nation's most significant and profitable industries, accounting for 44% of the country's livestock GDP, 14% of its agricultural GDP, and 4% of the country's overall GDP (FAOSTAT, 2018) which is an increase from that recorded in 2016. Dairy production is an essential agricultural sector in Kenya's economic and nutritional aspects because it contributes to increased household livelihood, food, and nutrition and helps alleviate poverty in rural and urban areas. In Kenya, there are thought to be 4.3 million dairy cows, and each person consumes 80–100 kg of dairy products annually (KDB, 2016), especially in comparison to less than 30 kilograms consumed in most of the East and Central African countries (Kasirye & Ssewanyana, 2015).

KIHBS (2015/16) found that dairy cows contribute significantly to milk yield in Kenya, with unpackaged fresh milk being one of the most popular items consumed by the large majority of Kenyans. This sector receives credit with 4% of the nation's gross domestic product and 14% of the GDP from agriculture, respectively (KNBS, 2019a).

Smallholder Dairy Farming

For more than 30 years, the average milk yield per cow had remained at 6 kg/day, according to MoLD (2010). Kenya's thriving dairy subsector helps the nation produce about 5.3 billion litres of milk that is fresh every year, mostly from cows. For approximately 1.5 million households that are small-scale producers, milk production has proven to be a vital source of income and food for roughly 80 per cent of the entire country's population (KDB, 2016).

Small-scale farmers in Kenya own over 80% of the country's dairy cows, which yield approximately 56% of the nation's milk, according to data from Odero (2017). Some of these smallholder farmers practice intensive dairy farming, while the majority of these farmers practice integrated crop-dairy farming. About 70% of the nation's milk comes from small-scale dairy farmers, who produce milk in extensive and semi-intensive systems (Mawa *et al.*, 2014). It is common for small-holder dairy producers in Kenya's highlands to use stall-feeding systems (cultivated fodder crops supplemented with concentrates and crop residue fed in stalls) in order to accommodate the country's high population density (Njarui *et al.*, 2016).

According to estimates, over half of the small-holder farmers have less than an acre of land on which they exercise integrated dairy and crop production. Small-holder dairy production is usually carried out on several acres and usually consists of a herd of up to one and six purebred or cross-bred cows. As many as 71% of farmers have one to three dairy cows, and cash crops like coffee, tea, or pyrethrum are sometimes grown alongside grain-based agriculture (Mugambi *et al.,* 2015).

The dairy sector in Kenya sustains over 1.7 million people, which has grown by 5% per year in recent years (MoALF, 2019). Thus, if the dairy sector is properly structured, it has the potential to help Kenya achieve its development goals by creating more jobs for young people. For each one thousand litres of dairy products sold, the milk industry is estimated to generate 76 jobs (FAO, 2011a). Dairy farmers will have more opportunities for employment both on and off the farm as the of Kenya is expected to grow by 35 per cent by 2030 (KDB, 2019).

Friesian, Guernsey, Ayrshire, and Jersey cows and their crossbreeds are the most commonly reared breeds in Kenya's dairy industry; It is common practice to cross exotic breeds with the indigenous East African Zebu (Kibiego et al., 2015). Kenyan native cattle have significantly more genetic potential for milk production, However, better management and feeding practices have the potential to increase production even further (Britt et al., 2018). Eighty per cent of the milk from dairy cows made and marketed is traded off in its raw state via informal outlet channels, while only 20% is sold via regular trade channels (Muriuki, 2011).

Cost-Benefits of the Feeding Models in Smallholder Dairy Farms

According to Connor, (2015), the expenses associated with producing dairy products can be as high as 60%, thus boosting the efficiency of converting feed can entail a big impact on dairy profitability. To ensure a plentiful supply of food and fibre while maintaining producer profitability, animal agriculture has long strived to improve production efficiency.

The term "income over feed cost" (IOFC), also referred to as return on feed (ROF), is used to quantify and measure feed efficacy in dairy herds. IOFC measures effectiveness from a profit standpoint. It is calculated as the disparity between the total amount of money received from milk sales over a specific time period and the cost of feed used in its production (Hemme et al., 2014). A key indicator of long-term dairy farming and a tool for evaluating overall economic competitiveness in the factor and product markets on a local and international scale is the cost of producing milk, particularly the evaluation of cash and economic costs (Nyambe et al., 2017, 2018). Therefore, in order to stay competitive, dairy organisations and farmers must work to reduce farm-level expenses (Koonawootrittriron et al., 2012). After deducting costs from benefits, the cost-benefit analysis takes into account the value of net benefits. Costs are regarded as forfeited benefits, even though benefits can be utilised with a range of weights or different combinations of weights.

Determination of Production Costs

According to the USAID-KAVES statistics, dairy production is economically viable, with a mean gross margin of USD 0.34 per litre, which varies from USD 0.43 in Kisumu up to a low of only USD 0.24 in Uasin-Gishu. These profit margins are considerably greater than the USD 0.023 margins. every litre for stall-feeding systems and USD 0.045 per litre for non-zero-grazing systems in Kiambu. The lowest and highest production costs are, respectively, USD 0.1 in Meru and USD 0.17 in Uasin Gishu (Wambugu et al., 2011).

Ojango et al. (2011) reported that the mean yield costs in Kenya for extensive dairy systems were between USD 0.12 and 0.24 per litre, while for semi-extensive dairy systems, the range was between USD 0.09 and 0.17. According to Baltenweck *et al.,* (2012), the disparities in production intensity and geographic location were the primary causes of these discrepancies. Forage markets and production in Kenya are heavily influenced by volume and seasonality. As of now, the nutritional content of forages is of secondary importance. Price hikes on market forages (mostly Napier grass and also grass hay) are common in the dry period, with a bale of poor-quality hay fetching as much as USD 3.4-4.0. Dry matter weighs roughly USD 0.35-0.41 per kilogram (at 80 per cent DM content). Hay quality may be greatly enhanced by properly managing, fertilizing, and harvesting the crop at the proper stage of growth, and this is particularly true if more superior grass seed varieties hit the market. (Leeuward *et al.,* 2019).

Farmer profitability depends on reducing milk losses. Individual rural households can easily fulfil their annual consumption expenditures with an average dairy enterprise in this sample. The dairy industry faces threats to its financial health from a variety of potential sources, including those that could reduce or increase costs. These include the cost of milk, the cost of purchased feed, the cost of labour, and the production of crops and forages. Numerous hazards associated with the dairy industry in Kenya result in high cost of production and low yield (Prakash et al., 2017).

It is critical for a farmer to track his production costs in order to determine whether or not he is making a profit. However, determining the expenses and revenues of milk production is not as straightforward as determining the milk price. Milk production costs and profitability can be influenced by factors influencing the price of milk at the farm gate in the countryside of Kenya (Ssekibaala, 2019). Farmers' decisions on how to produce and market their goods lead to low output and increased costs of production. Therefore, the public and policymakers have continued to be interested in the competitiveness of Kenyan dairy farming. Understanding the benefits and drawbacks for small-scale dairy farmers is, therefore, a key prerequisite for the creation of policies targeted at increasing productivity levels.

II.Material And Methods

Description of the Research Area

Following © 2012–2022 www.LatLong.net, the first experimental feeding trials were conducted at the Olubutyo Dairy Cooperative Demonstration Farm, located in Tagiamin village, in Kongasis ward, Chepalungu sub-county in Bomet County—0.7942421° 47' 8.0196" S, 35.3478951° 20' 20.8968" E, 223 km from Nairobi. When Kenya Gazette Supplement No. 53 was issued in 1992 to create Bomet District from the Kericho District, it was the first time a new District had been created in Kenya since its independence.

Bomet experiences brief, warm, and cloudy summers and long, cool, mostly clear winters. The average yearly temperature is between 11.67°C and 26.11°C., with only a few exceptions when it drops below 10°C or rises above 28.89°C. There is an average daily temperature of 25.56°C during the warm season, lasting from January 13th to March 21st. February is the hottest month in Bomet, with an average of 12.22°C as the lowest temperature and 26.11°C as the peak temperature. Summer begins on April 29th and ends on August 29th, with an average daily high temperature of 22.78°C or lower. With a mean minimum temperature of 11.67°C and a maximum temperature of 22.22°C, July is the coldest month in Bomet.

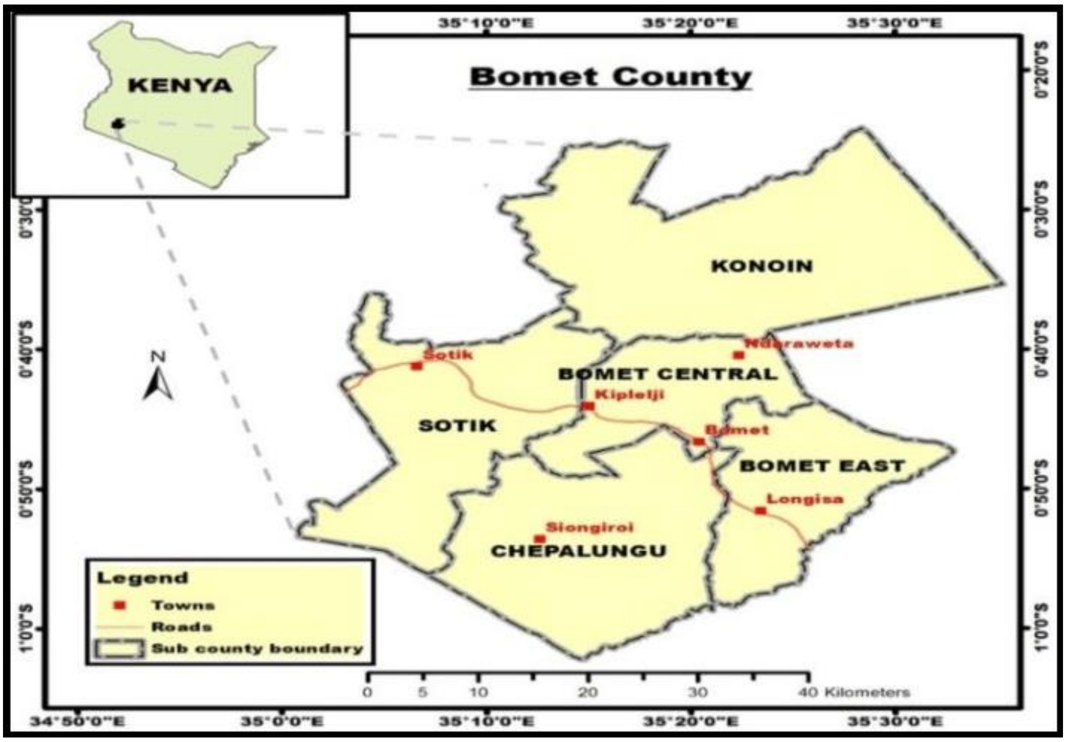

Figure 1:Map of Bomet County showing the study area for objective three
Source: *Kenya Independent Electoral and Boundaries Commission (2012*).

The second comparing experiment was done in Ndaragwa Central constituency, Ngamini Ward, Kahothia Village in Nyandarua County located between geographical coordinates -0.480098611S, and 36.54974917E. Kenya's Nyandarua County was formerly part of the Central Province. Ol Kalou is its largest town and capital. Nyahururu, which is now a part of Laikipia County, served as the capital once. Nyandarua County is 3,304 km2 in size and home to 596,268 people. The Aberdare Ranges are located in the county, which is situated in the northwest of the former Central Province.

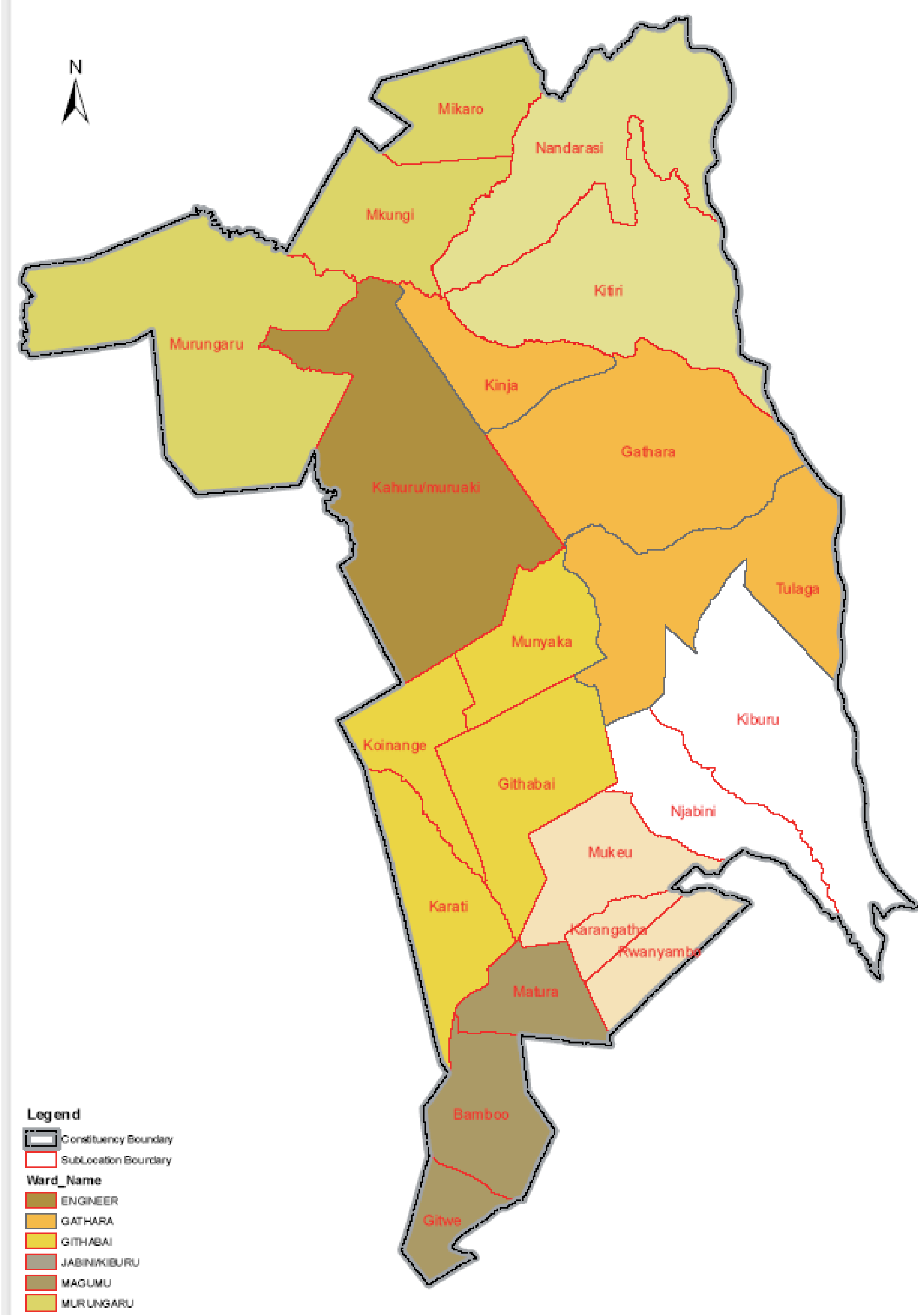

Figure 2: Map of Kinangop sub-county in Nyandarua county showing the administrative boundaries and wards

Source: *The guide.org*

The third comparison experiment was carried out in Nyeri County. Two Sub-Counties, Mathira West, Ngandu location, and Kieni East, were chosen for the study based on the population of dairy-milk farmers. A population of 759,164 residents in 207.8/km2as estimated by the Kenya National Bureau of Statistics (KNBS) in 2019 (CGN, 2013). Five counties share common borders, with Meru to the northeast and Laikipia to the north. Nyandarua to the western side, Murang'a to the southern side, and Kirinyaga county to the eastern side, which makes it a leading agricultural innovation hub, located between latitudes 0°25′12″ S and 36°56′51″ E, the county has an elevation 3,076 to 5,199 metres above sea level, in that range, making it about 150 kilometres north of Nairobi in the distance (CGN, 2013). The average temperature in the county is 12.80°C in June and July and

20.8°C in the hottest parts of the year (January-March and September-October). The county experiences both cold and hot months. 500–1600 millimetres of precipitation fall annually, with the heaviest rains occurring between April and May.

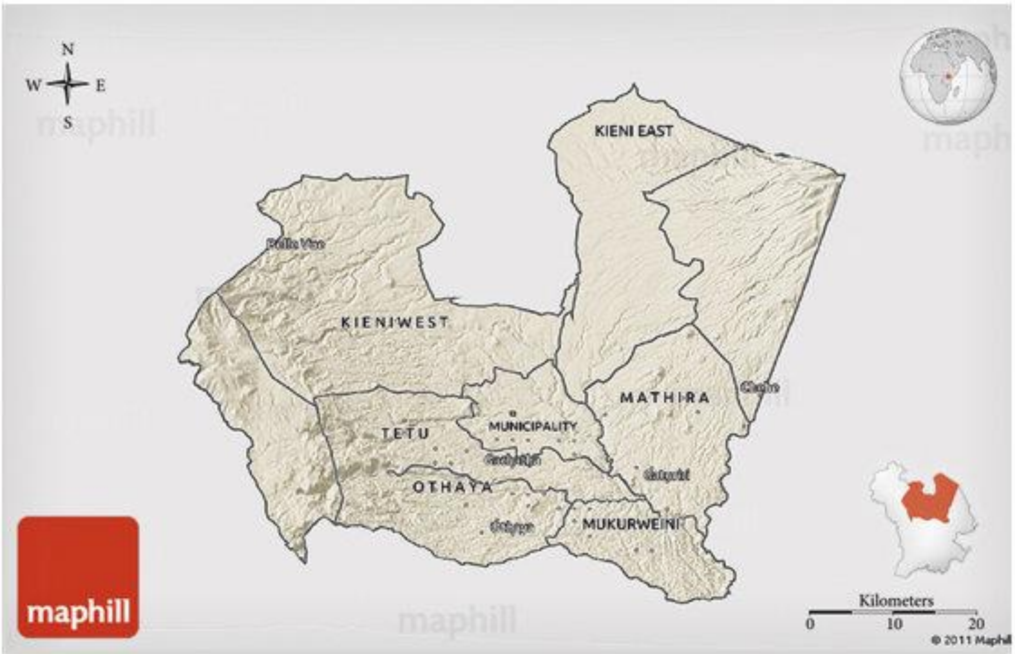

Figure 3: The municipality of Nyeri Central is represented on the map of Nyeri County, which displays the various sub-counties.
Map courtesy of Maphill.(Mathira and Kieni East)

Sampling

Twelve Friesian lactating cows with the same breed but different lactation stages weighing 400 kg ±100 live body weight, were selected randomly using the simple random technique from various dairy farms around the areas of study in Bomet, Nyandarua and Nyeri County. The sampled animals were isolated in zero grazing stalls, each block containing three dairy cows where similar dietary treatments were offered to each of the three dairy cows in each block.

Fodder Production and Selection

The selected fodders were established in a 1.2 acre of land belonging to the respective counties' Dairy Cooperative. Where the land was subdivided into units of 70 by 100 feet plot size, and each unit was used to establish a pure stand of fodder. Cattle manure was evenly broadcasted in each land unit and thoroughly mixed with soil. All the fodders were established using standard procedures of specific fodder establishment where DAP Fertilizer was used at the time of establishment and later after 30 days, the fodders were top-dressed using CAN fertilizer.

The fodders include Boma Rhode, Lucerne, desmodium, sweet potato vine and chicory. Weeding was done manually after every two weeks. Watering was done using sprinklers and watering cans on days when the rain failed. Before establishing a soil, the analysis was done to determine various soil parameters like pH, salinity and organic matter, that can affect the establishment and growth of the fodders and appropriate measures were taken where needed.

Feed Preparation

To allow for drying, Boma Rhodes was harvested approximately four weeks after blossoming after two to three days of dry weather. To preserve the quality indicator of the dried fodder, its green colour, it was dried in shade. It was stored to be used later as hay, while lucerne was harvested when it was 10 per cent flowering, dehydrated under shade and then chopped (Barnhart, 2010) greenleaf desmodium was harvested just before flowering around 110 days after establishment (Yegrem *et al*., 2019). Sweet potato vine was harvested around 120 days after establishment just before the onset of the yellowing of leaves, it was dehydrated and chopped for mixing (Jaleto, 2019). Chicory commander was harvested when the maximum leaf has been attained just before the stem elongates dehydrated and set ready for ration formulation (Deng *et al*., 2022).

Identified fodders in Bomet that were used as a supplement feed mix on top of the basal diet of Boma Rhodes; lucerne, greenleaf desmodium, sweet potato vines and chicory which was cut, dehydrated and chopped into small pieces and mixed thoroughly and stored in a storage container. A feed supplement mixture of lucerne, greenleaf desmodium, sweet potato vines and chicory, was mixed in the ratio of 1:2:3:1 respectively, because of the availability and abundance. The feeding trial's experimental diet was created to satisfy the nutritional needs of nursing cows (NAS, 2021).

Experimental Design

The feeding trial to evaluate the suitability of an admixture of lucerne, greenleaf desmodium, sweet potato vines and chicory supplementation on milk yield in small-scale dairy farms was done between August 2022 and July 2023. Twelve Friesian dairy Cows weighing 400 kg ±100 live body weight which is of different lactation stages but the same parity subsisting on a basal diet of Boma Rhodes grass hay with a dry matter content of 900 g/kg were selected and isolated in zero grazing stalls. The supplementation feed mixture with a dry matter content of 400 g/kg comprised: lucerne, greenleaf desmodium, sweet potato vines and chicory which was chopped and mixed in a ratio of 1:2:3:1 respectively and was supplemented at the following inclusion levels T1 (0%), T2 (10%), T3 (20%) and T4 (30%) of the estimated daily dry matter intake of 4 per cent of the live body weight of the dairy cows, where three (3) Dairy Cows being allocated per each dietary treatment. Each dietary treatment was made up of an iso-nitrogenous and isocaloric level.

All the experimental diets were randomized and distributed independently first in each block. This was done in Excel by generating random numbers using the RAND function, [DATA, SORT by column w/ =rand ()]. Boma Rhodes grass hay was utilised as the negative control as well as the basal diet. The feeding trial ran for 9 weeks in each region, with the 1st week being used for backgrounding all dairy cows on the basal hay diet only, followed by a two-week adaptation period where the dairy cows were under a basal diet of boma Rhodes and the supplementation with the feed mixture at various inclusion levels and finally 6 weeks of data collection.
Dietary treatments are 4 Supplementation levels of inclusion i.e., T1 (0%), T2 (10%), T3 (20%) and T4 (30%)
T1= Control only (No supplementation)
T2= Control + 10% experimental diet
T3 = Control + 20% experimental diet
T4= Control + 30% experimental diet
Dairy Cows = 4 dietary treatments each fed to each respective replicate which comprises 3 Friesian dairy cows (total no of dairy cows = 12 Dairy cows)

Table 1: Quantity of the experimental diet required for the various inclusion levels.

Experimental diets	Quantity			
	T_1	T_2	T_3	T_4
Boma Rhodes (Basal diet)	100%	90%	80%	70%
Feed Mixture(supplement)	0%	10%	20%	30%

Management of Experimental Animals

The animals were isolated in specific zero-grazing stalls where they were earmarked with an ear tag for identification. They were dewormed using 30ml Endocure® 10 % v/v Albendazole was administered to control internal parasites and sprayed with 10ml of TikDip 522.5 EC emulsifiable concentrate diluted into 10 litres containing chlorpyrifos 475g/L + cypermethrin47.5g/L acaricide to control ticks, fleas and mites after every one week. Occasionally this acaricide was alternated with Amitraz 12.5% TickBuster® an organophosphate acaricide to prevent the external parasites from developing resistance. Vaccination was also done to control East Cost Fever using 20ml Buparvex Injection® containing Buparvaquone by the intra-muscular route. Other common prevalent diseases affecting dairy cows in the Rift Valley region were also vaccinated against by veterinary officers in the case of an outbreak. 250g of Norbrook milking salve containing 0.55%w/w Dichlorophen BP with lanolin (as an emollient) was used after milkingThe California Mastitis Test (CMT) was used to check for mastitis in all of the animals, and if necessary, antibiotics were then given.

The animal weight was determined using a weigh band by utilizing the table of girth circumference (cm) to estimate the weight (kg). Adequate feeds of a mixture of lucerne, greenleaf desmodium, sweet potato vines and chicory supplemented to Boma Rhodes were supplied according to the animal nutrient requirement, and the daily dry matter intake of 4 per cent of their live body weight. Feeding was made for seven (7) days to background the dairy cows. After that, it shall be fed for fourteen (14) days for the adoption of the animal and later a thirty-one days feeding was done during which data was collected and recorded. They were fed two times a day, at 0800hrs and 1400hrs and then allowed to have access to water and Maclik Super minerals ad libitum.

Data Collection

Feed cost associated with milk yield, and revenue from milk sales, was included in the data. All of the following information was collected: Number of dairy cows per replicate, feed cost, and milk yield per block was collected

Data Analysis

The data was exported to SAS 2020 version 9.4, where the analysis was done and descriptive analysis performed. Descriptive statistics such as the mean and median were used to summarize the data. The means were considered at a 95% significance level ($p<0.05$).

The t-test was used to test the hypotheses based on the results of the data analysis, which includes descriptive statistics such as mean and standard deviation. When reviewing an enterprise's economic performance, the gross margin was the unit of analysis used in gross margin analysis at the farm level. The data collected included the prices and amount of input (feedstuffs) and output (milk yield). The study calculates Feed costs (KES/L, Cow/d), revenue from milk sales (KES/L, Cow/d), and Margin (income over feed costs).

The formula used to calculate income over feed cost (IOFC) was;

IOFC (KES/L/d) = (*P*milk*DAMP) - (DFC (KES/L/d)) (Bailey *et al.*, 2009).

where;

IOFC = income over feed cost

KES/L/d = Kenya shillings per litre per day

*P*milk*DAMP = price of milk multiplied by daily average milk production

DFC = daily feed cost

The discrepancy between the value of a farm's gross output and its variable costs—which vary based on the volume of production—is known as the farm's gross margin.

Kibiego *et al.* (2015) provided the formula:

Profit and loss were calculated as:

Profit/loss = Total Benefits (Revenue) – Total costs

Empirically this model is specified as outlined below: $\prod i = \sum_{i-1}^{i=n} PyY - \sum_{i-1}^{i=n} PxX$

where;

$\prod i$ = Profit and loss

Py = Price of dairy products sold

Y =Quantity of dairy products sold

$$\sum_{i-1}^{i=n} PyY = \text{ Total benefits from the sales of dairy products and other outputs}$$

$Px =$ Cost of inputs/variables=Quantity of inputs/variables

$$\sum_{-1}^{i=n} PxX = \text{ Total costs incurred the farmer}$$

The dairy farm's performance was gauged by the gross margin it generated. In this study, revenue was determined by valuing the milk produced on the farm. R = p.q applies to milk revenue. where q = milk output (litres), p = price of milk per litre, and R = revenue.

III.Result

IOFC = Milk Yield (litres) per cow× Milk Price per litre−Cost of Feed per cow

Number of Cows

Estimating feed costs involved: Understanding the nutritional needs of the cow, then based on the nutritional requirements, the daily feed requirements for each cow were calculated. A thorough search of the local prices of each selected fodder feed mixture price was considered before estimating the daily feed consumption for each type of feed.

Daily Feed Cost=Daily Feed Consumption× Feed Price

Estimated that one litre of milk is retailing at Ksh 60, and the cost of each fodder diet is as follows:

Daily Dry Matter Intake per cow=4%×Live Body Weight

Daily Dry Matter Intake per cow=0.04×400kg

Daily Dry Matter Intake per cow=16kg

Cost of Boma Rhode and Experimental Diet:

Daily Feed Cost per cow =Daily amount Feed Consumption per cow (kg)× Feed Price per kg

When the farm price of 1kg Boma Rhodes was Ksh 4.69, Therefore,

Daily Feed Cost per cow Ksh 4.69 × 16 = Ksh 75.

The cost per kg of the experimental diet was found to be Ksh 9.4 based on this calculation.

Cost per kg of Experimental Diet = Total weight of Diet
The overall cost of Diet

The cost of the experimental diet at Ksh 9.4 per kg was determined by considering various costs associated with fodder production. This comprehensive calculation includes expenses related to the procurement of different fodder components, their proportions in the overall diet, and additional costs associated with feed production. The goal was to incorporate all relevant expenses to arrive at an accurate and representative cost per kilogram of the experimental diet. This approach ensures a thorough understanding of the financial implications of formulating and implementing the experimental diets in the study.

Dietary treatment	Level of Supplementation			
	T1(0%)	T2 (10%)	T3 (20%)	T4 (30%)
Basal diet (Boma Rhodes) per animal/Day	16Kg (100%)	14.4Kg (90%)	12.8Kg (80%)	11.2Kg (70%)
Basal diet (Boma Rhodes) for 3 animals/Day	48Kg	43.2 Kg	38.4 Kg	33.6 Kg
Fodder supplement per Animal per day	0.00	1.6kg	3.2Kg	4.8 Kg
Supplement for 3 cows per day DM	0.00	4.8Kg	9.6 Kg	14.4 Kg

To calculate the total cost of feed :
Diet 1 (100% Boma Rhodes):
Cost per kg: ksh 4.69
Daily feed intake per cow: 16 kg
Number of cows: 1
Number of days: per day
Total feed cost for Diet 1 consumed per day/cow = (ksh 4.69/kg) × (16 kg/cow) × = ksh 75

Diet 2 (90% Boma Rhodes + 10% Experimental Diet):
Cost per kg for Boma Rhodes: ksh 4.69
Cost per kg for the experimental diet: ksh 9.4
Daily feed intake per cow: 16 kg
Number of cows: 1
Number of days: per day
Total feed cost for Diet 2 per cow per day = (90% of 16kg × ksh 4.69) + (10% of 16kg × ksh 9.4)= Ksh 83
Diet 3 (80% Boma Rhodes + 20% Experimental Diet):
Cost per kg for Boma Rhodes: ksh 4.69
Cost per kg for the experimental diet: ksh 18.8
Daily feed intake per cow: 16 kg
Number of cows: 1
Number of days: per day
Total feed cost for Diet 3 = ((80% of 16kg × ksh 4.69) + (20% of 16 kg× ksh 9.4)) × = ksh 90

Diet 4 (70% Boma Rhodes + 30% Experimental Diet):
Cost per kg for Boma Rhodes: ksh 4.69
Cost per kg for the experimental diet: ksh 28.2
Daily feed intake per cow: 16 kg
Number of cows: 1
Number of days: per day
Total feed cost for Diet 4 = ((70% × ksh 4.69) + (30% × ksh 9.4)) (42 days) = ksh 98

Diet 1: Ksh 75
Diet 2: Ksh 83
Diet 3: Ksh 90
Diet 4: Ksh 98

In this study, Table 2 presents results regarding the Income Over Feed Cost (IOFC) in dairy cow management, providing critical insights into the economic dimensions of dairy farming. These findings illuminate the factors influencing IOFC, offering valuable perspectives for optimizing feed efficiency and maximizing profitability in dairy operations. This research serves as a cornerstone for enhancing the economic sustainability and performance of dairy production practices.

Table 2: Income Over Feed Cost (IOFC) for each dietary treatment in each county: Bomet, Nyandarua, and Nyeri.

DIET	BOMET (Ksh)	NYANDARUA (Ksh)	NYERI (Ksh)
1	$8.7{\pm}1.2^{a}$	$27{\pm}4.0^{a}$	$16{\pm}3.21^{a}$
2	$25.7{\pm}5.49^{a}$	$132{\pm}11.55^{b}$	$60.7{\pm}4.91^{b}$
3	$55{\pm}2.08^{b}$	$121{\pm}5.77^{b}$	$140{\pm}6.08^{c}$
4	$59{\pm}8.54^{b}$	$169{\pm}5.77^{c}$	$159.7{\pm}6.06^{c}$
P	0.0004	<.0001	<.0001

a, b and c: means with the same superscripts in the column and raw are not significantly different (P>0.05).

In Bomet, there was no significant difference in IOFC for diets 1 and 2 at P>0.05. Diets 3 and 4 also show no significant difference in IOFC at P>0.05. However, diet 1 and 2, each showed a significant difference in IOFC from the IOFC of both diet 3 and 4 at P<0.05.

In Nyandarua, there was no significant difference in IOFC of diet 2 and diet 3 at P>0.05. However, IOFC of diet 1 and IOFC of diet 4, differed significantly at P<0.05. There was also a significant difference at P<0.05 in the IOFC of 2 and 3 and the IOFC of both diets 1 and 4 at P<0.05.

In Nyeri, the IOFC of diet 1 and the IOFC of diet 2, differed significantly at P<0.05. The IOFC of diet 3 and the IOFC of diet 4 had no significant difference at P>0.05. The IOFC of diet 3 and the IOFC of diet 4 differed significantly from the IOFC of both diet 1 and diet 2 at P<0.05.

IV.Discussion

The analysis of Income Over Feed Cost (IOFC) across the three regions reveals interesting patterns and differences. In Bomet, the IOFC for diets 1 and 2 did not exhibit a significant difference, indicating that the additional 10% experimental diet did not significantly impact the income over feed cost. Similarly, diets 3 and 4 did not differ significantly, suggesting that increasing the experimental diet from 20% to 30% did not proportionally affect IOFC. However, there was a noteworthy distinction between the IOFC of diets 1 and 2 compared to diets 3 and 4, signifying that a moderate level of supplementation (10% and 20%) might be more economically viable. This finding agrees with the findings of Buza *et al.* (2015) on the impact of dietary supplementation on IOFC in dairy cows.

Moving to Nyandarua, the comparison reveals that the IOFC of diet 2 and diet 3 showed no significant difference, emphasizing that a 10% experimental diet may be economically comparable to a 20% supplementation level. However, there were significant differences in the IOFC between diet 1 and diet 4, suggesting that extremes in supplementation levels can impact economic returns. The comparison between diets 2 and 3 with diets 1 and 4 also underscored economic distinctions, reinforcing the importance of appropriate supplementation levels for optimal IOFC.

In Nyeri, the study demonstrated that a 10% experimental diet (diet 2) significantly differed from the control diet (diet 1), emphasising the potential economic benefit of a modest level of supplementation. Diets 3 and 4 did not show a significant difference in IOFC, indicating that beyond a 20% supplementation level, there might be diminishing economic returns. The significant distinctions between diets 1 and 2 compared to diets 3 and 4 further emphasize the economic considerations of supplementation strategies. This finding agrees with the findings of Bach (2023), on the relation of feed cost to milk price and overall farm return.

The cross-regional comparison suggests that the economic impact of supplementation levels on IOFC varies across regions, emphasizing the importance of region-specific strategies for optimizing income over feed costs in smallholder dairy farms. Factors such as local feed availability, market prices, and regional variations in milk production may contribute to these observed differences. This is congruent with the finding of Cabrera & Kalantari,(2016) on factors influencing regional variation of IOFC in smallholder dairy farms. Future research could delve into these factors to provide more nuanced insights into effective dairy farm management strategies.

V.Conclusion

In conclusion, the comprehensive analysis of Income Over Feed Cost (IOFC) across the diverse regions of Bomet, Nyandarua, and Nyeri sheds light on the nuanced relationship between dietary supplementation and economic returns in smallholder dairy farming. The findings suggest that optimal supplementation levels for maximizing IOFC vary by region, emphasizing the need for region-specific strategies. In Bomet, moderate supplementation levels (10% and 20%) exhibit economic comparability, while in Nyandarua, the study highlights distinctions between a 10% and a 30% experimental diet. Nyeri, on the other hand, underscores the economic benefits of a 10% supplementation. The cross-regional differences underscore the influence of local factors on optimal dietary strategies. This research contributes valuable insights for dairy farmers and policymakers, stressing the significance of tailoring supplementation practices to specific regional contexts for enhanced economic sustainability in smallholder dairy farming.

VI.Recommendation

These findings can be valuable for farmers seeking to optimize their feeding strategies for dairy cows, as they indicate that a higher level of supplementation can lead to increased profitability, assuming the cost of supplementation does not outweigh the additional revenue generated from higher milk production. However, it's essential to consider the long-term sustainability and health of the cows when making dietary decisions. The study emphasizes the importance of optimizing dietary supplementation to enhance milk production and farm profitability. However, it is crucial to carefully assess the cost-benefit ratio, prioritize cow health, and practice sustainable and individualized farming methods to ensure long-term success in dairy farming. Additionally, a sensitivity analysis could be performed to assess how variations in these costs across the regions might impact the final IOFC results, thus providing a more nuanced perspective on the economic feasibility of each diet

Monitoring, record keeping, and expert guidance play essential roles in making informed decisions regarding dietary strategies for your dairy farm. Future research and experimentation should consider conducting additional research to explore the impact of supplementation on other aspects of dairy cow management, such as reproduction, cow longevity, and overall farm sustainability. Experiment with different feed components and combinations to identify the most cost-effective and nutritionally balanced dietary plans for your specific farm.

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