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Effect of Selected Fodder Intervention on Milk Yield in Friesian Dairy Cows in Selected Counties in Kenya

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Abstract

Over three decades, the mean daily milk production per cow in these regions has remained stagnant at a mere 6 kg/day with most smallholder farmers yielding a mere 3.67 litres of milk per cow daily, it's evident that their productivity falls well below par. In an effort to address this issue, a study conducted delves into the second objective, which revolves around assessing the effects of diverse dietary supplements on milk yield across the distinct geographical areas of Nyandarua, Bomet, and Nyeri. The study involved the utilization of a supplementary feed mixture which was 400 g/kg DM of dry matter content, comprising; lucerne, greenleaf desmodium, sweet potato vines, and chicory, which was chopped and mixed in a ratio of 1:2:3:1. Supplementation was done at the following inclusion levels; T_1 (0%), T_2 (10%), T_3 (20%) and T_4 (30%) of the estimated daily dry matter intake of 4% of the live body weight of the dairy cow. A basal diet of boma Rhodes which was 400 g/kg DM of dry matter content was used. This study ran for nine weeks in each region; one week of backgrounding all the animals, followed by fourteen days of adaptation and a month and a half of data collection. The research scrutinizes the outcomes of milk production resultant from diets featuring supplementation levels ranging from 10% to 30% in Friesian dairy cows. The findings reveal that, in Bomet, There isn't a significant variation in milk production between diets exhibiting 10% and 30% supplementation, suggesting a potential plateau in response to heightened supplementation levels. Conversely, in Nyandarua, diets supplemented with 20% and 30% show no significant variance in milk yield, spotlighting the efficacy of a moderate supplementation level. In Nyeri, noteworthy disparities in milk yield emerge between diets with 10% and 30% supplementation levels.

Keywords: Dietary supplement; Friesian; fodder intervention; zero grazing

Introduction

Countries, both developing and developed benefit greatly from the global dairy industry [1]. The production systems and efficiencies of the two economies differ significantly. A large-scale dairy production system in developed countries is characterised by high adoption of new technology and large capital investment. On the other hand, smallholder farmers in developing countries with limited management, specialist skills, and access to limited resources are largely constrained in their dairy production [2].

Some studies estimate that the dairy cattle sector in developed nations produces an average of 150-200 tonnes litres of milk per year, compared to developing nations whose average milk yield per year is 35-45 tonnes litres of milk per year, [3]. Total milk production in EU member countries is regulated by quotas assigned to each country; as a result, production is pre-determined [4]. Animal husbandry is important to many countries' economies [5]. Livestock production accounted for 40% of total agricultural output in 2014 in developed countries, according to [5], and only 20% in developing countries. Africa's milk production is among the best globally, and Kenya is one of Eastern Africa's top milk producers [2]. While Uganda, Tanzania, and Kenya all produce milk per cow per year that is far lower than South Africa; the country's production system is the most efficient in Africa, producing 2.5 times as much milk per cow per year, much more than the three countries combined [4, 6, 7].

Many countries have a low-cost production system like Kenya's, which is centred on rain-fed pasture production. Dairy products, which make up 12% of the Gross Domestic Product (GDP) of agriculture and 4.5 per cent of Kenya's gross domestic product, are the source of livelihood of over 1.5 million small- and medium-dairy farmers in the country [8]. 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 [8]. 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 [9]. For more than 30 years, the average milk yield per cow had remained at 6 kg/day, according to MoLD.

Kenya has a thriving dairy subsector that produces about 5.2 billion litres of raw milk annually, mostly from milking cows. Milk production provides 80% of the nation's total milk output, making it a significant source of food and income for approximately 1.6 million smallholder farmers [8]. There are quotas for total milk production in the EU member states, which means that production is pre-determined. Livestock husbandry is important to many countries' economies [5]. Livestock production accounted for 40% of the total agricultural output in 2014 in developed countries, according to [5], and only 20% in developing nations. About 20% of the global population, who primarily reside in the countryside or periurban regions, rely on small-holder dairy farming (SDF) for their livelihood [10].

For a 100-cow herd, productivity losses in 2015 were approximated to be between 70 and 550 kilograms of milk per day in the European Union alone. In 2014, losses based on current milk prices were estimated at $670 million yearly; by the end of the century, this will likely rise to $2.2 billion annually [10]. The UN Food and Agriculture Organization's statistics indicate that US cow milk yield accounted for 14.2 per cent of global production in 2014, with India, China, Germany, and Brazil rounding out the top five. Geographic variation is among the factors that affect the declining trend in milk production [11].

Kenya has the second-biggest dairy industry in Sub-Saharan Africa in terms of milk yield as well as consumption. In the dairy industry, there are around 2,209,980 alien cattle and 13,005,664 native cattle. Dairy cows produce about 88%, while camel and dairy goat production accounts for the rest of the milk supply. Kenyans consume an average of 90 kilograms of milk per person each year. To put it another way, Kenya is regarded as among the most milk-producing countries on the continent of Africa [12].

Even though small-holder production of milk is a profitable business in Kenya, It is hindered by insufficient feeds, both quantitatively as well as qualitatively [13]. In market price support (MPS) in the tropics, one of the most significant difficulties that producers face is livestock nutrition, which is directly associated with environmental factors like temperature and rainfall [14]. These two main issues plague tropical MPS. The period of drought, which can extend up to half a year, reduces pastures' quantity and quality.

Their low crude protein content (80g/ kg) and a high percentage of digestibility neutral detergent fibre content are quite apparent during this time [15]. High-potential agroecological zones can yield up to 4575 kilograms of milk per cow per year [16]. In response to variations in animal breeds and production systems, agroecological zones had an impact on production owing to the accessibility of high-quality feeds [17].

To support the production of milk proportions, reserved proteins in the body of an animal must be mobilised due to nutritional stress in cattle. Because of that, milk yield decreases, and The ability of animals to produce even better breeds is not optimally exploited [18]. On the other hand, smallholder dairy farmers only yield 3.67 litres of milk daily, which indicates that they are not very productive [19]. Poor feeding techniques and a lack of technical support for dairy and crop farming are to be blamed for this low productivity [20].

Supplements of commercial protein concentrate are commonly used to counteract the seasonal nutritional deficit. This practice drives up production costs for small producers and reduces their profit margins [14, 21]; Low productivity and high production costs are other important difficulties for the dairy sector, according to the [22]. Due to the rapidly urbanising Kenyan population, growing milk demand, and rising incomes, there is an urgent need to boost the country's dairy productivity [12, 23] discovered that, as opposed to the anticipated 12 litres, the mean daily milk output for each cow was only 5.46 litres. According to MoD Over the previous thirty years, the average yield per cow has stayed at 6 litres, even though each cow is capable of producing up to 15 litres of milk daily. The dairy industry's inefficiency is evident in this situation. Small-scale dairy farmers in the country may be experiencing inefficiencies as a result of high input costs and low productivity.

The level of milk production in the country has been the subject of several studies [24]. Even though milk production has remained low while costs have risen, very few researchers have attempted to ascertain whether small-scale farmers could profitably produce dairy products. Consequently, no assessment of the dairy farmers' economic effectiveness following the 2013 nutritional training from Farmer Helping Farmers, a Canadian organisation, has been conducted. Kenyan researchers set out to ascertain the small-scale dairy farmers' milk production's economic efficiency. identified dietary restrictions as a primary cause of ineffectiveness and consequently offered solutions to lessen the ineffectiveness. The Malabo Declaration's goal of eradicating world hunger by 2025 was made easier with increased milk production. Furthermore, the findings highlight factors that improve the production capacity of farmers and, as a result, the income and standard of living of rural residents.

A study was conducted to evaluate the effect of supplementing Friesian dairy cows fed on Boma Rhodes grass hay with a feed mixture of lucerne, greenleaf Desmodium, chicory, and sweet potato vines on milk yield in the smallholder-dairy.This is to attempt to address nutritional constraints in dairy cow farming which have been cited as the primary cause of low milk productivity: inadequate feeds, high feed costs, lack of supplements, poor feeding practices and low-quality feedstuffs have all contributed to low milk productivity.

Material and Methods

Description of the Research Area

The initial trial occurred at Olubutyo Dairy Cooperative Demonstration Farm in Chepalungu sub-county, Bomet County, located at coordinates -0.7942421° S, 35.3478951° E, about 223 km from Nairobi. Bomet District, established in 1992, was Kenya's first new district since independence (Kenya Gazette Supplement No. 53). Bomet experiences brief, warm, and cloudy summers, with temperatures ranging from 11.67°C to 26.11°C annually. The warm season lasts from January 13th to March 21st, with February being the hottest month. Summer runs from April 29th to August 29th, featuring an average daily high temperature of 22.78°C or lower. July is the coldest month, with a mean minimum temperature of 11.67°C and a maximum of 22.22°C.

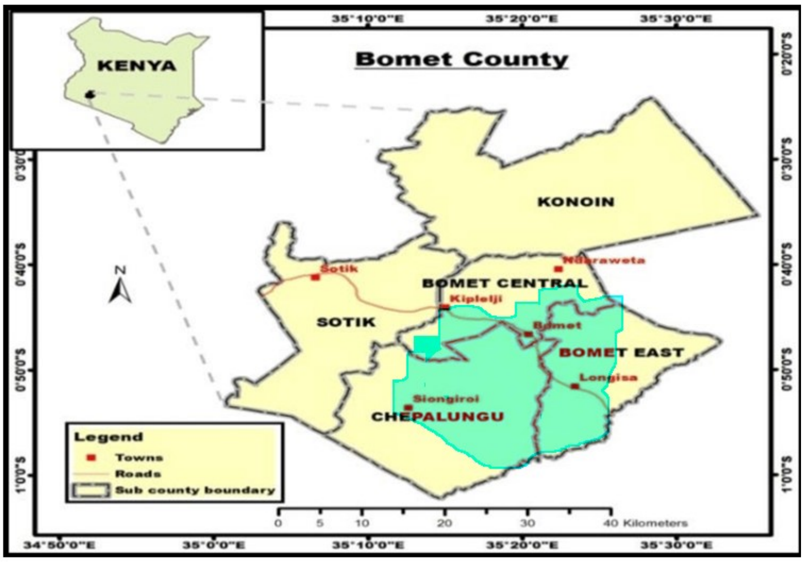

Figure 1: Map of Bomet County showing the study area Source: Kenya Independent Electoral and Boundaries Commission (2012)

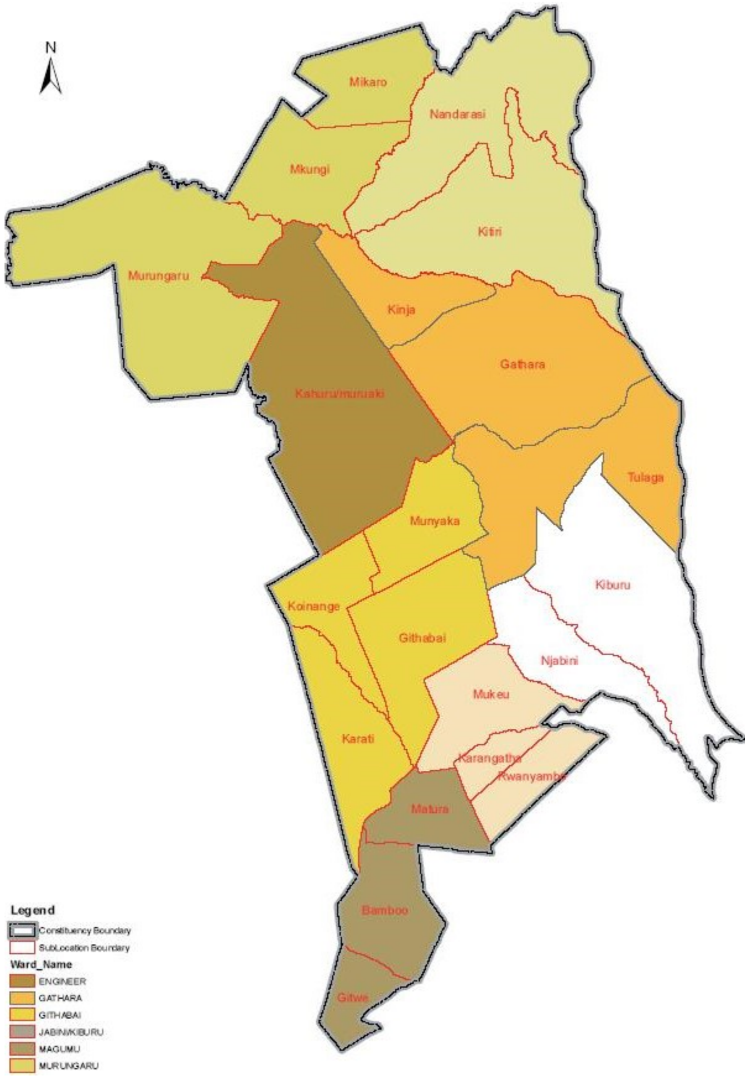

Figure 2: Map of Kinangop sub-county in Nyandarua county showing the administrative boundaries and wards

Source: The guide.org

The second experiment occurred in Ndaragwa Central constituency, Nyandarua County, Kenya. Nyandarua, formerly part of the Central Province, spans 3,304 km2 and is known for agriculture, including potato farming and dairy production. The region features various soil types and has a population of 596,268. It has a Cfb climate, an average temperature of 15.8 °C, and an annual rainfall of 2276 mm. The distance between Nyandarua and Nakuru is 48 km, with a road distance of 295.4 km. The most prevalent soil types include zitosols, andosols, leptosols, luvisols, phaezems, and planosols.

The third experiment took place in Nyeri County, specifically in Mathira West (Ngandu location) and Kieni East Sub-Counties, selected based on milk producer numbers. Nyeri County, an agricultural hub with a population of 759,164 and a density of 207.8/km2, is situated between latitudes 0°25′12″ S and 36°56′51″ E. It shares borders with Nyandarua, Murang'a, Meru, Laikipia, and Kirinyaga, experiencing varied temperatures (12.80°C to 0.8°C) and an annual precipitation of 500–1600 millimetres, heaviest in April and May.

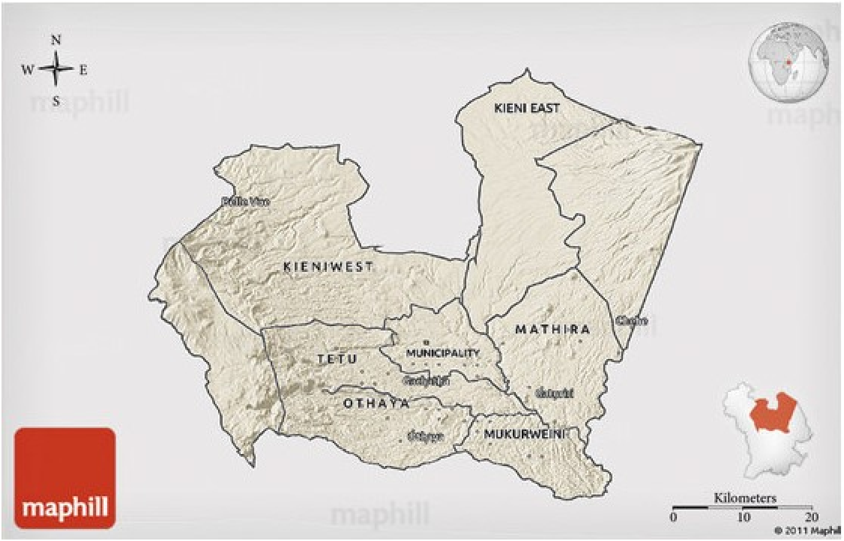

Figure 3: The municipality of Nyeri Central is represented on the map of Nyeri County, which displays the various sub-counties. Map provided by Maphill.(Kieni East and Mathra)

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 soil, the analysis was done to determine various soil parameters like pH, salinity and organic matter, which can influence the establishment and growth of fodders and appropriate measures were taken where needed.

Feed Preparation

To allow for drying, Boma Rhodes was harvested a month after flowering 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 [25] greenleaf desmodium was harvested just before flowering around 110 days after establishment [26]. 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 [27]. Chicory commander was harvested when the maximum leaf has been attained just before the stem elongates dehydrated and set ready for ration formulation [28].

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 lactating cows [29].

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. 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 of 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 T_1 (0%), T_2 (10%), T_3 (20%) and T_4 (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 used as the negative control as well as the basal diet. The feeding trial run for a period of 9 weeks in each region, with the 1^{st} 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., T_1 (0%), T_2 (10%), T_3 (20%) and T_4 (30%)

T_1= Control only (No supplementation)

T_2= Control + 10% experimental diet

T_3 = Control + 20% experimental diet

T_4= 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 bone 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 be 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 milking. All animals were tested for mastitis using the California Mastitis Test (CMT) and then administered antibiotics where appropriate.

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 at, 0800hrs and 1400hrs daily and then allowed to have access to water and Maclik Super minerals *ad libitum.*

Data Collection

After 14 days of adapting, the milk yield of each experimental animal was collected and recorded in an Excel sheet separately on a daily basis. This was done daily at 06:00 hr and 15:00 hr.

Statistical Analysis

All variables were subjected to analysis of variance (ANOVA) in a randomised complete block design (RCBD) utilizing the SAS (2020) version 9.4 Statistical Package's General Linear Model Procedures (proc glm).

H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

H_a: $\mu i \neq \mu j$ for at least one pair i, j

Model:

$Y_{ij} = \mu + \theta_j + \tau i + \tau Bij + \varepsilon_{ji}$

where:

Y_{ij} is the random variable representing the response for treatment i observed in block j, μ is a constant (which may be thought of as the overall mean)

θ_j is the (additive) effect of the j^{th} block {j= 1, 2,3}

τi is the (additive) effect of the i^{th} treatment {i = 1, 2,3,4}

τBij is the Interaction between i^{th} treatment and j^{th} block

ε_{ji} is the random error for the i^{th} treatment in the j^{th} block.

Fixed effects: Treatment

Random effects: Block, Block *treatment

Table 2: Table showing the random distribution of treatment in the blocks by use of random numbers

BLOCK 1	1 **T2**	2 **T1**	3 **T4**	4 **T3**
BLOCK 2	5 T4	6 T2	7 T3	8 T1
BLOCK 3	9 T3	10 T4	11 T1	12 T2
BLOCK 4	13 T1	14 T3	15 T2	16 T4

Legend: The numbers in the upper left-hand corner are stall numbers. Letters T1, T2, T3, and T4 are the treatment

An ANOVA table was constructed to show how the sum of squares is distributed according to the source of variation, and hence the mean sum of squares.

Table 3: Table of Analysis of Variance

Source of Variation		Sum of square	Mean sum of square	Degree of Freedom
Block	r-1			3
Treatment	t-1			3
Error	(r-1) (t-1)			9
Total	(rt)-1			15

Significant Mean Separation was done if we rejected the null hypothesis (H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$). This helped us to know which group or groups are different and where the difference is and the nature of the difference. All the means from the four treatments were separated using Tukey's procedure which uses the distribution of the studentized range statistic by utilizing the Statistical Analysis System (SAS).

Results

In Bomet, there was no significant difference between the milk yield of experimental animals fed on diet 1 and experimental animals fed on diet 2 at p>0.05. There was also no significant difference in milk yield between the experimental animals fed diet 2, and 3 and the experimental animals fed diet 4 at p>0.05. However, there was a significant difference in milk yield between the experimental animals fed on diets 1 and those fed on diets 3 and 4 at p<0.05.

In Nyandarua, there was no significant difference in milk yield for the dairy cow fed on diets 2 and 3, at p>0.05. However, milk yield from the experimental animals fed on diet 4 had a significant difference from that of the cattle fed on diets 1, 2 and 3 at p<0.05. Milk yield from the experimental animals fed on diet 1 had a significant difference from that of the milk yield of experimental dairy cows fed on diets 2, 3 and 4 at p<0.05.

In Nyeri, there was no significant difference in milk yield from the experimental dairy cow fed on diets 3 and 4 at p>0.05. There was a significant difference in milk yield from the experimental animal fed on diets 1 and 2 at <0.005, also milk yield from the experimental animal fed on diets 3 and 4 differed significantly from milk yield from the experimental animal fed on diet 1 as well as those which were fed on diet 2 at p<0.005.

Table 4: Analysed Data of Dairy performance in different experimental animals under different Intervention levels in Bomet, Nyandarua and Nyeri

Treatment(Diets Intervention)	Milk Yield (Litres)Bomet	Nyandarua	Nyeri
1	1.7±0.07[a]	2.6±0.20[a]	2.2±0.17[a]
2	2.7±0.26[ab]	8.0±0.58[b]	4.5±0.29[b]
3	4.1±0.09[b]	7.5±0.29[b]	8.0±0.29[c]
4	4.1±0.68[b]	10.0±0.29[c]	8.5±0.29[c]
P	0.0033	<.0001	<.0001

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

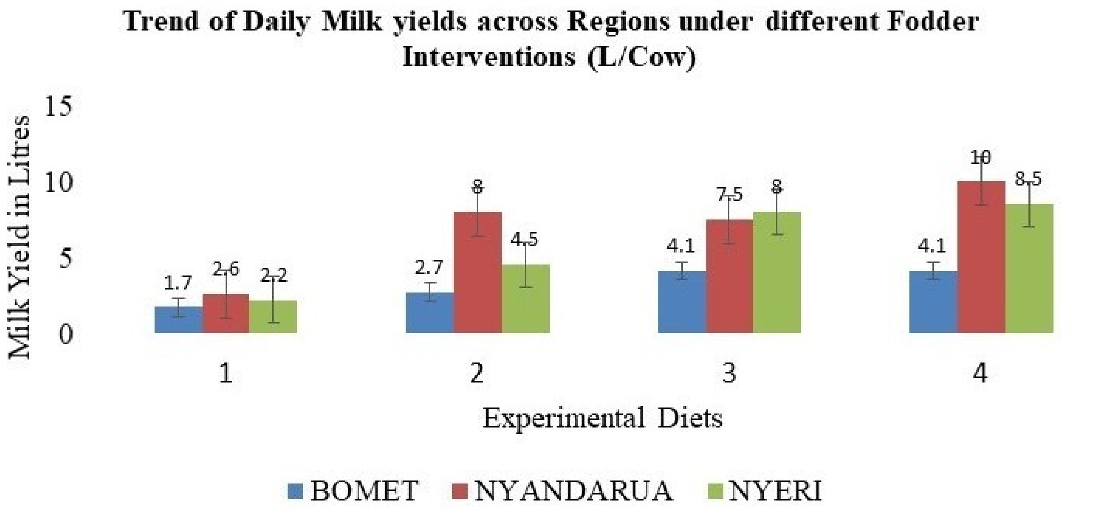

Figure 4: Trend of Daily Milk yields across Regions under different Fodder Interventions (L/Cow); Diet 1,2,3 &4

Discussion

Milk Yield/ Quantity

Bomet County

In the comparison between Diet 1 (the control diet with no supplementation) and Diet 2 (basal diet + 10% experimental diet) in Bomet County, there was no significant difference in milk yield at p>0.05. This implies that a 10% supplementation level did not lead to a substantial increase in milk production. For Friesian dairy cows in the specified lactation stages and parity, this suggests that a 10% supplementation might not be sufficient to significantly impact milk yield. Similarly, when comparing Diet 2 (basal diet + 10% experimental diet), Diet 3 (basal diet + 20% experimental diet) and Diet 4 (basal diet + 30% experimental diet), there was no significant difference in milk yield at p>0.005. This finding indicates that elevating the supplementation level from 10% to 20% or 30% did not proportionally increase milk production. The study suggests that a moderate supplementation level, around 10 %, could be a practical and effective approach to enhancing milk yield in this region. The absence of a significant difference between milk yield due to Diet 3 and Diet 4 suggests the possibility of a plateau in the cow's ability to utilize the supplemented nutrients. These findings agree with the results of Barros [30] on the possible plateau in the cow's ability to utilize supplemented nutrients.

The most significant finding in Bomet County is the substantial and statistically significant difference in milk yield between milk yield due to Diet 1 and milk yield due to Diet 2, Diet 3 and Diet 4. This implies that a considerable increase in milk production can be achieved by supplementing the basal diet with higher levels of the experimental diet (10%, 20% and 30% supplementation). This finding agrees with research done by Kitilit [31] in Bomet County, found that a better supplementation of dairy cows had positive effects on milk yield which are enhanced when cattle are fed enough crude proteins, which are highly digestible energy.

Nyandarua County

In Nyandarua County, the evaluation of different dietary treatments on milk yield revealed noteworthy distinctions among the experimental animals. The comparison between milk yield due to Diet 1 (control diet) and milk yield due to Diets 2 (basal diet + 10% experimental diet) and Diet 3 (basal diet + 20% experimental diet) demonstrated a significant difference, suggesting that a 10% and 20% supplementation level resulted in a statistically significant change in milk yield. However, Diet 4, with the highest supplementation level at 30%, exhibited a substantial increase in milk yield, demonstrating a significant difference from Diet 1 (basal diet only), Diet 2 (basal diet + 10% experimental diet), and Diet 3 (basal diet + 20% experimental diet). This outcome underscores the positive impact of higher supplementation levels on milk production in this specific region, this agrees with what Hanrahan [32] found. on the impact of dietary supplementation in different inclusion levels on milk production.

Furthermore, the comparison between Diet 1 and the supplemented diets (Diets 2, 3, and 4) revealed that the absence of supplementation led to a significantly lower milk yield. Additionally, there was no significant difference in milk output between Diets 2 (basal diet + 10% experimental diet) and 3 (basal diet + 20% experimental diet), indicating that increasing the supplementation level from 10% to 20% did not lead to a statistically significant change in milk production. These findings highlight the importance of carefully selecting the appropriate level of dietary supplementation to optimize milk yield in Nyandarua County.

Overall, the study emphasizes the nuanced relationship between dietary supplementation and milk production, providing valuable insights for dairy farmers in Nyandarua County. The results suggest that a strategic approach to supplementation, particularly at higher levels, can significantly enhance milk yield, contributing to more informed decision-making in dairy farming practices in this region which agrees with the research done in 2015 by Pirondini [33]. on the significance of higher supplementation on milk yield on dairy farms.

Nyeri County

In Nyeri County, the comparison between Diet 1 (control) and Diet 2 (basal diet +10% experimental diet) showed a significant difference in milk yield, suggesting that a relatively low level of dietary supplementation (10%) led to a significant increase in milk production at $p< 0.005$. The comparison between Diet 3 (basal diet + 20% experimental diet) and Diet 4 (basal diet + 30% experimental diet) also resulted in no significant difference in milk yield at $p> 0.005$. This implies that increasing the supplementation level from 20% to 30% did not lead to a proportional increase in milk production for Friesian dairy cows in Nyeri County. The study suggests that, in this region, higher supplementation levels, such as 20% and 30%, can be more effective in boosting milk yield. The absence of a significant difference between Diet 3 and Diet 4 (20% and 30% supplementation) suggests that the cow's ability to utilize the supplemented nutrients may have reached a plateau at these levels and any additional supplementation may not be economical and effective. Thus, this study suggests that a moderate supplementation level, around 20%, could be a practical and effective approach to enhancing milk yield in this region, this finding goes hand in hand with the research findings of Duguma & Janssens [34] on the need to find the optimum level of supplementation for maximum milk yield.

The most significant finding in Nyeri County is the substantial and statistically significant difference in milk yield between Diet 1 and Diet 2 (10% and 20% supplementation respectively) and the supplemented diets Diet 3 and Diet 4 (20% and 30% supplementation). This indicates that a significant increase in milk production can be achieved by supplementing the basal diet with higher levels of the experimental diet (20% and 30% supplementation).

Nyandarua and Nyeri Counties both showed no significant differences in milk yield between diets 1 and 2 (10% and 20% supplementation), as well as Bomet and Nyeri which showed no significant difference in Diet 3 and 4 (20% and 30% supplementation respectively) suggesting a unique response in the pattern. These findings agree with Mwendia et al 2017 research in Nyandarua which highlights the importance of high-quality on-farm fodder to realize a peak in milk yield. Nyandarua County demonstrated a significant difference only between diet 4 and diet 1. However, all three counties showed a significant difference in milk yield due to diet 1, and milk yield due to diet 4. This indicates a distinct result pattern in this region thus emphasizing a notable regional variation in response to supplementation. This distinct result pattern may necessitate further investigation into local factors influencing the observed discrepancies as it is in the findings of Bateki [35].

Differences in soil types, climate, and altitude among the counties could lead to variations in forage quality and cow adaptability, while disparities in the availability and quality of local forage resources may impact the effectiveness of the experimental diet about milk yield which is the same as the finding of Liu [36]. Despite all breeds being Friesian dairy cows, variations in the individual Friesian dairy cows' characteristics across regions may contribute to different milk-yield responses to the experimental diet. Differences in dairy farm management practices, including feeding protocols and healthcare, may influence the overall milk–yield response to supplementation.

Bomet County is known for varied agroecological zones, potentially leading to differing responses to supplementation in milk production. Local factors such as soil composition and climate could influence the availability and effectiveness of the supplemented forage. Nyandarua County, characterized by diverse climatic conditions, may exhibit varied responses to supplementation. Local feed availability and cow adaptability to the supplemented forage could contribute to the observed differences. These findings agree with the results of Ajak [37] research in Nyeri where they realised that there was a correlation that is favourable between the amount of additional diet and milk production during various stages of lactation in Friesian dairy cows.

Conclusion

In conclusion, the detailed examination of the experimental results from Bomet, Nyandarua, and Nyeri Counties yields nuanced insights into the relationship between dietary supplementation and milk yield in Friesian cows. Across the counties, the study reveals that a 10% supplementation level did not consistently lead to a significant increase in milk production, suggesting that this proportion might not be sufficient to impact yield significantly. Furthermore, elevating the supplementation level to 20% and 30% did not consistently result in proportional increases in milk yield, indicating a potential plateau in the cows' ability to utilize the supplemented nutrients. Notably, the absence of significant differences between the Diet 3 which had 20% dietary supplementation levels and Diet 4 which had 30% dietary supplementation levels in Bomet and Nyandarua Counties suggests a point of diminishing returns, emphasizing the importance of moderation in supplementation. In contrast, Nyandarua County exhibited proportional increases in milk yield with higher supplementation levels, suggesting a region-specific response.

Economic considerations are paramount, as highlighted in the analysis. While the goal is to maximize milk yield, farm profitability must be carefully weighed against the costs associated with higher levels of supplementation. A tailored cost-benefit analysis is recommended for farmers to make informed decisions based on their unique circumstances. The study underscores the need to acknowledge individual variations in cow responses to dietary changes, encompassing genetic factors, health status, and other individual characteristics. Moreover, the regional specificity observed in the study emphasizes the importance of considering local conditions, including soil, climate, and farming practices, when formulating effective supplementation strategies.

In summary, a moderate level of supplementation, around 20%, emerges as a practical and effective approach for enhancing milk yield in Friesian dairy cows. However, the study underscores the complexity of these relationships, urging continuous monitoring and further research to refine recommendations and address the diverse contexts of individual cow responses in varying environments. These insights are valuable for informing both farmers and policymakers in optimizing dairy production practices.

Limitations of the Study

This study faced several limitations that could have influenced the results. Firstly, the availability and quality of the feedstuffs used for supplementation varied across the different regions, potentially affecting the consistency of the diet provided to the cows. Secondly, environmental factors such as climate and soil quality, which can impact forage growth and nutritional content, were not uniformly controlled across the study sites. Additionally, variations in individual cow health, age, and lactation stages were not fully accounted for, which might have introduced variability in milk yield responses. The study's duration was also relatively short, limiting the ability to observe long-term effects of dietary supplementation on milk production. Lastly, logistical constraints and resource limitations restricted the sample size, which could impact the generalizability of the findings to a broader population of smallholder dairy farms.

Recommendation

This study may prompt further research into the specific nutritional requirements and response to supplementation of Friesian dairy cows at different lactation stages and parity. The results may also be applicable to other dairy cattle breeds or under different environmental conditions. It might be worthwhile to investigate whether specific nutrients or the timing of supplementation play a role in affecting milk production. Further research could explore the nutrient utilization efficiency and metabolic pathways involved in milk synthesis. Considering that dairy farming is not only about maximizing milk yield but also profitability, a cost-benefit analysis should be integrated into decision-making. Farmers should weigh the costs associated with higher supplementation levels against the potential increase in milk production.

Data Availability

The data used to support the findings of this study are included in full within the article

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper

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