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Dairy Breed Preferences and Breeding Practices Among Smallholder Farmers in Githunguri Sub-county, Kenya

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Abstract

Dairy production plays a critical socio-economic role for most developing countries' populations. The study aimed at assessing dairy breed preferences and breeding practices among smallholder farmers in Githunguri Sub- County, Kenya. The study was conducted through a cross-sectional survey using pretested questionnaires administered to randomly selected 457 smallholder dairy farmers from the eight milk collection routes in the sub-county. Most farmers keep the Friesian breed (93%) and use artificial insemination (A.I.) to serve animals (95.7%). High milk yield was the leading parameter of breed preference. Animal breeding practices significantly differed along the milk collection routes mainly due to variations in age and level of education. Poor animal health was ranked the most critical challenge, followed by inadequate and poor-quality feeds. A large number (69.6%) of farmers do not estimate the live weight of animals. The majority of farmers (44.8%) obtained their replacement breeding stock either from their herd or bought from other farms. Notably, the milk collection route where youths (≤ 35 years of age) actively participated in dairy farming reported the highest number of lactating cows and milk production levels. Tertiary education level (46.1%) and membership in farmer organizations (70.4) had the greatest impact on the proportion of milk produced. Equally, controlled breeding programs guarantee quality breeds and replacement stock for farmers, but poor feeding strategies and animal health challenges hinder genetic progress. These findings demonstrate the need to consider appropriate feeding strategies and animal health management as a prerequisite to improvement in breeding programs. Conversely, there is a need to engage more youth in dairy production and provide technical backstopping to farmers on good agricultural practices for enhanced dairy productivity.

Keywords: Breed preferences, dairy, breeding practices, smallholder farmers, Kenya

INTRODUCTION

Dairy production plays a critical socio-economic role for most populations in developing countries (Adesogan & Dahl, 2020). It offers employment as the primary source of income, provides essential nutrients to millions of citizens, and is seen as a potential pathway out of poverty, malnourishment, and food insecurity in vulnerable societies (Koori *et al*., 2017). The success of the dairy industry in Kenya can be attributed to government initiatives, progressive policies, the availability of quality breeds, and the adoption of reproductive technologies (Rademaker *et al*., 2016). Among dairy animals, dairy cattle are the predominant species found in Kenya's highlands, estimated to be around 6.5 million, contributing to the majority (88%) of milk production in this region (Ajak, 2020). In the Central Highlands of Kenya, the Friesian breed accounts for the most significant proportion (75-82.2%) of exotic breeds, followed by Ayrshire (8%),

Guernsey (4%), and Jersey (0.8%) (Ajak, 2020). The scarcity of breeds with superior genetic potential for high milk yield and good adaptation to variations in environmental conditions due to climate change are some of the factors contributing to the reduction in economic efficiency of the dairy sector. A marked trend of variation in milk yield between breeds, animals within the same breed, and between herds is caused by genetic differences and environmental factors. The effect leads to keeping a larger herd with minimal milk production potential, raising production costs and negatively affecting the environment. Livestock contributes 70% of greenhouse emissions from agriculture in Africa. The annual growth rate in greenhouse gas emissions is 2.5% in Kenya, mainly from dairy and beef production, and is projected to increase as the sectors grow. High GHG emissions in the dairy sector of 5.6 MtCO2e in 2017 (GoK, 2020) are attributed to feed production and processing, enteric fermentation, manure management, and managed soils. The adoption and use of genetically superior dairy cattle breeds increase productivity, input use efficiency, and reduction in GHG emissions, resulting in the production of the same amount of milk by 1.2 MtCO2ey-1 (Wilkes *et al*., 2020). A few cows of superior traits will be required to produce more milk. Striving towards increased productivity will reduce CH4 emissions because less feed will be partitioned towards maintenance, and more feed will be utilized in production. Thus, a farmer can comfortably reduce the herd size and spend less money on feed resources while producing the same amount of milk. As the sector grows, there is a need to balance between the increased production of milk and mitigations against climate change arising from the emission of GHG.

Breeding plays a crucial role in dairy enterprise management as it ensures the production of high-quality breeds and replacement stock. The combination of desired reproductive indices specific to different dairy cattle breeds and the application of reproductive technologies have driven the modernization of dairy production (Seidel, 2020). Adopting and using reproductive technologies can shorten generation intervals, increase selection intensity, reduce production costs, and accelerate the reproductive rate in dairy cattle (Sagwa *et al*., 2019). Artificial insemination is the preferred method due to its accessibility and the availability of technicians in the highlands (Muraya, 2019; Ajak, 2020). However, low pregnancy rates following A.I. practice have been reported in Kenya, with a national average insemination rate estimated at 1.5 to 3 per cow per conception (Peters *et al*., 2022). Poor expression of the estrus cycle relates to the interaction between the environment and the cow's genetic potential, which can modulate gene expression (Lopera-Vasquez *et al*., 2022). Genetic selection for high milk production can lead to a herd of cattle with reduced conception rates. Several studies have demonstrated poor fertility in high milk-producing cows, although the heritability of reproductive disorders is typically weak (Rodney *et al*., 2018). Breeding practices in the Kenyan highlands are focused on high milk production, with large-body-size cattle, primarily Friesians, being the target breed, despite the technical preference for small-body-size cattle (Bebe *et al*., 2003; Lukuyu *et al*., 2019).

Good nutrition plays a crucial role in maintaining a balance of steroid hormones, which affects the conception rate of A.I. Cows that suffer from disorders such as acidosis, hypocalcemia, and ketosis show reduced conception rates (Sammad *et al*., 2022). The ability of a diet to provide an adequate concentration of nutrients required by an animal's body can significantly impact reproductive performance. The availability of exogenous nutrients can be determined mainly by dry matter intake (DMI) before or after calving (Rodney *et al*., 2018). The use of nutrients for milk production, maintenance, and growth depletes the reproductive nutrient pool through irreversible loss. Therefore, it is essential to consider the nutrients available for reproduction determined by endogenous body tissue reserves and nutrients in the diet (Sammad *et al*., 2022). Thus, knowing the difference in dietary intake and expenditure is crucial for understanding nutrient balance in the body. Any occurrence of a negative balance will lead to the depletion of endogenous reserves (Rodney *et al*., 2018). Dairy cattle feed with a higher proportion of high-quality forages can lower gastro-intestinal tract CH4 emission that animals produce by 0.6 to 3.0 MtCO2ey-1. in Kenya. Despite the use of manure in forage production, adoption and use in the biogas production system in Kenya can reduce GHG emissions up to 0.01 MtCO2ey-1 (1

MtCO2e in 10 years). Biogas is an energy source in feed processing, milking machine operations, and domestic use (Khatric-Chhetri *et al*., 2020).

On the other hand, poor feeding strategies and animal diseases have hindered dairy cattle breeding and genetic progress. Inadequate cow feeding results in low weight gain, prolonged anoestrus periods, and deficiency diseases (Njonge, 2017). Tick-borne diseases such as East Coast Fever (ECF), babesiosis, and bovine anaplasmosis harm cattle health and overall body condition, thus hindering the attainment of the necessary weight for reproductive services. Some diseases, like brucellosis, transmitted through natural mating, may result in a poor conception rate and increased services per conception (Wangila, 2016).

This study aimed at determining dairy breed preferences, breeding practices, milk production, and the associated costs and challenges among smallholder farmers in the Githunguri sub-county, which has a well-developed dairy value chain despite having smaller parcels of land for pasture production. Farmers in the area mainly rely on purchased fodder, crop residues, and industrial by-products to feed dairy animals. By understanding the prevailing breed preferences and husbandry practices, it would be possible to develop appropriate interventions and support systems to enhance dairy production and address smallholder farmers' challenges in this region and beyond.

METHODOLOGY

The study was conducted in the Githunguri sub-county within Kiambu County in Kenya. At 1600 meters above sea level, the region is situated between latitudes 1˚05" and 1˚06" south of the equator and longitudes 36˚53" and 36˚55". The soils are deep, well-drained, friable clay ranging from dark reddish to brown. There are two distinct rainfall regimes: the first begins in mid-March and peaks in April and May, while the second begins in mid-to-late October and has an average annual rainfall of roughly 1065 mm. According to Alaru *et al*. (2019), the region's mean monthly maximum temperature ranges from 22.4˚C to 27.6˚C, while its mean monthly minimum temperature varies from 11.3˚C to 14.9 ℃. Kiambu County has four different topographical zones: Upper Midland, Lower Midland, Lower Highland, and Upper Highland. Githunguri lies in the lower highland, 1500-1800 meters above sea level. Hills, plateaus, and plains define this tea and dairy zone at high elevations. The sub-county is ideal for agriculture, especially dairy farming, because of its high-level upland fertile soils formed by volcanic rocks (Jaetzold *et al*., 2010). The selection of this sub-county was purposeful due to its favourable climatic conditions, well-developed dairy value chain, and the active participation of various actors involved in the dairy industry, as extensively described by Alaru *et al*. (2023). While considering the existing knowledge base, the current study explored specific aspects related to dairy breed preferences and husbandry practices among smallholder farmers. The study aimed to provide targeted recommendations and interventions that can enhance the productivity and sustainability of the dairy sector in Githunguri and potentially serve as a model for other regions with similar characteristics.

A descriptive cross-sectional survey using structured questionnaires was administered to smallholder dairy farmers in the study area. The sample size was determined using a formula by Cochran (1963):

$$n = \frac{Z^2 pq}{e^2}$$

Where: n = sample size; Z2 = abscissa of the normal curve, which is 1.96 for a 95 confidence interval; p = estimated proportion of an attribute; q = (1-p) and e = desired level of precision set at 0.05. The non-responsive respondents were covered by a 10% increase in sample size and an additional 5% to cater for precision, as described by Alaru *et al*. (2023).

Data was collected from 457 households, sampled, and distributed across eight milk collection routes: Kiairia, Githunguri town, Ikinu, Komothai, Githinga, Ngewa, Gitiha, and Kiambaa. For the study, the formula required a minimum of 385 respondents. 10% was added to account for non-response and an additional 5% of precision. The sample size grew to 443 households as a result. The sample size was raised proportionately throughout the wards, resulting in 457 respondents to strengthen the study outcome's external validity (Alaru *et al*., 2023). A structured questionnaire was used to collect the data on farmers' demographic characteristics, breed preferences, breeding practices and challenges, milk production, and associated costs. Closed and open questionnaires underwent a pretest phase to ensure a smooth flow and the inclusion of critical variables necessary to address the study's objectives. The questionnaire was administered to respondents through face-to-face interviews using Open Data Kit (ODK) version 2022.3.6.

The collected data was analyzed using R statistics software version 4.3.1. Descriptive statistics were used to understand farmers' preferences for specific dairy breeds, breeding practices used, average milk production levels, associated costs, and challenges faced. Percentages were then calculated to identify proportions of farmer demographic characteristics and milk collection routes. Additionally, a 95% confidence level was used to determine statistical significance. Inferential analysis was performed using the one-way analysis of variance (ANOVA) to understand milk production and associated costs. The Fisher's Least Significant Difference (LSD) test was employed to identify significant differences between the means of various groups.

RESULTS AND DISCUSSIONS

Farmers Demographics

The age and level of education of Githunguri farmers displayed noteworthy variations across the eight milk collection routes, as depicted in Table 1. Ngewa route had the highest (64.15%) of household heads (H.H.) at the age of 35 years and below, whereas Komothai recorded the lowest number (8.47%). The same trend was repeated for H.H. tertiary education level at 37.74% and 6.78% for Ngewa and Komothai, respectively. Notably, Ikinu recorded the highest number of farmers (53.85%) above 50 years of age but second to Ngewa in the number of H.H. with tertiary education level. The findings point out the lesser involvement of youth in dairy production in the area because other routes reported less than 20% H.H. at ≤ 35 years involvement in dairy business. These characteristics (age and education) are essential as they are reliable indicators of farmers' experience, access to information, and technological proficiency (Dissanayake *et al*., 2022). Age reflects the accumulated knowledge and skills acquired over time, while education acts as a facilitator for accessing modern farming practices and marketing information through technological advancements. Again, youths can easily acess new technologies through smartphones that can transform and sustain the dairy sector.

However, it is worth noting that the participation of young farmers in dairy farming in Africa is relatively low (Paraffin *et al*., 2018). One of the contributing factors is the substantial capital investment required to enter and sustain a successful dairy enterprise. Purchasing heifers, investing in quality equipment, and securing adequate feed resources require significant financial resources, which may not be readily accessible to younger farmers in the initial stages of their agricultural careers or have limited financial capital.

Younger farmers' challenges can be addressed by developing tailored, friendly policies, strategies, training programs, and other interventions providing financial support to acquire and raise dairy cattle as a business enterprise. By reducing barriers to entry and fostering an enabling environment, the dairy industry can attract and retain younger farmers, ensuring the sector's long-term sustainability and growth.

Education is vital in contemporary dairy entrepreneurship, enabling farmers to stay abreast of innovative farming techniques, animal health and nutrition advancements, and effective marketing strategies. With access to education, farmers in Githunguri can harness the power of technology, such as mobile applications, online platforms, and precision farming tools, to optimize their dairy operations and make informed decisions. Farmers can improve productivity, enhance animal welfare, and explore new market opportunities by staying informed about the latest developments in the dairy industry. In the study area, a combination of the higher number of H.H. with tertiary education level and at youth age in Ngewa is expected to increase the dairy business and spur economic growth. The study outcome found no variation in membership to farmer organizations by the respondents, with over 83% of the respondents having H.H. as members in all milk collection routes, indicating the positive role of the dairy farmers' cooperative society in the area, which has led to rapid development in the value chain.

Table 1: Farmers' Demographic Characteristics Per Milk Collection Route

Farmers' characteristics		**Milk Collection Route**						
		Kiairia	**Githunguri town**	**Ikinu**	**Komothai**	**Gitiha_ Kiambaa**	**Githinga**	**Ngewa**
Age Category HHD	≤ 35 years (%)	15.63	18.52	7.69	8.47	19.64	19.70	64.15
	36 -50 years (%)	54.69	45.68	38.46	44.07	48.21	48.48	16.98
	> 50 years (%)	29.69	35.80	53.85	47.46	32.14	31.82	18.87
Education level of HHD	None	0.00	2.47	0.00	1.69	0.00	1.52	1.89
	Primary school (%)	3.13	33.33	17.95	45.76	30.36	24.24	20.75
	Secondary school (%)	85.94	40.74	52.56	45.76	53.57	54.55	37.74
	Tertiary level (%)	9.38	23.46	29.49	6.78	16.07	18.18	37.74
	Adult education (%)	1.56	0.00	0.00	0.00	0.00	1.52	1.89
Membership to F.O.	Yes (%)	92.19	93.83	91.03	96.61	96.43	90.91	83.02
	No (%)	7.81	6.17	8.97	3.39	3.57	9.09	16.98

Key: HHD= Household head; FO= Farmer's Organization

Dairy Breeds and Breeding Practices Among Githunguri Smallholder Dairy Enterprises

Findings in Table 2 show that the Friesian (93.0%) was the most preferred breed among exotic dairy cattle breeds, followed by crossbreeds (4.5%). Ayrshire were also popularly reared (2.2%). At the same time, no farmer had indigenous breeds, indicating heavy investment in dairy enterprises to generate more revenues in the study area. The results of the current study align with the research conducted by Ajak (2020), which highlighted that the Friesian breed is the predominant exotic breed chosen by farmers in the Kenyan highlands. One significant advantage of crossbreeds that was second in mean over pure Friesians is their smaller body size, which translates to lower feed requirements. Ideally, the effect of climate change requires the adoption of more resilient dairy breeds with less feed requirement while at the same time producing a sufficient amount of milk. The advocacy for a shift towards keeping small-bodied dairy cows corresponds with the technical recommendations provided for the Kenyan highlands (Bebe *et al*., 2003). By adopting this approach, farmers can address the challenge of inadequate feed resources, particularly forages, in the area that has led to overreliance on purchased feeds (Alaru *et al*., 2023). Artificial insemination was the dominant cow

service method (95.7%) employed by dairy farmers in the study areas to achieve the desired breeding outcomes. The practice involves a collection of semen from superior bulls and its subsequent insertion into the reproductive tract of the female cow. This technique allows farmers to breed their cows with high-quality genetics selectively, improving milk production and overall productivity (Mohammed, 2018). Furthermore, using A.I. eliminates the need for farmers to maintain and bear the costs of keeping a bull on their farms. It eradicates breeding diseases related to the sharing of breeding bulls among farms.

The popularity of A.I. in the study areas is attributable to several factors. First, the availability of A.I. service providers plays a crucial role. These service providers offer convenient access to quality semen and assist farmers in implementing effective breeding programs. Second, high literacy levels among dairy farmers enable them to understand the benefits of A.I. and effectively utilize the services provided by A.I. technicians. The farmers know the importance of genetic improvement in their herds and recognize A.I. as a cost-effective and efficient method to achieve their breeding goals. Additionally, the cooperative societies in the area contribute significantly to adopting A.I. Over 70.4% (Figure 1) of farmers in the study areas belong to well-established and managed cooperative societies. These cooperative societies offer comprehensive extension services to their members, including education, training, and support in various aspects of dairy farming. Farmers gain information about advancements in breeding techniques, including A.I., through these cooperative societies and receive guidance on implementing these practices effectively on their farms (Alaru *et al*., 2023). This support system further encourages and facilitates the rapid adoption of A.I. among dairy farmers in the study areas.

Table 2: Cattle Breeds and Breeding Practices among Dairy Farmers in Githunguri Sub-County

Practice	Level	Frequency (%)
Preferred dairy breed	Friesian	93.0
	Cross-breeds	4.5
	Ayrshire	2.2
	Guernsey	0.3
Cow service method	Artificial insemination	95.7
	Natural service	2.3
	Natural service and artificial insemination	2.0
Live-weight estimation method	Do not estimate	69.6
	Observation	21.4
	Heart girth	5.1
	Heart girth and observation	1.5
	Weighbridge	1.3
	Weighbridge and observation	0.7
	Heart girth, observation, and weighbridge	0.4
Source of replacement stock	Bought	25.4
	Own herd	29.8
	Own herd and bought	44.8

Mean number of the different dairy cattle breeds and breeding practices by smallholder dairy farmers in Githunguri

Most farmers (44.8%) obtained their replacement stock by either buying from other farms or by retaining their breeding stock to replace the culled ones. According to Migose *et al*. (2018), scarcity, high prices, and the inability to achieve anticipated yields hinder replacing the existing stock with high genetic potential stock. Also, seven out of every ten farmers did not estimate the live weight of cattle, meaning they do not consider weight as a factor in breeding, feed management, drug administration, or pricing on disposing of the stock. Accurate estimation of the body weight of livestock is an essential factor in deciding the slaughter weight, feeding level, and treatment dose (Tebug *et al*., 2018). Equally, weight measurement is a critical trait in breeding. The first estrus in heifers is related to weight gain rather than age. Thus, a heifer should have attained 65% of her mature weight at first service. The service weight predetermines the future performance of the offspring (Kasimanickam *et al*., 2021).

The farmers' preference for specific dairy breeds and associated reasons are in Table 2 and 3, respectively. High milk production (43.5%) emerged as the primary factor driving the selection of the Friesian breed, among other desirable traits. Farmers who opted for crossbreeds (43.6%), specifically Friesian and Ayrshire crosses, cited high milk production and disease resistance as the main reasons for their preference, indicating that the attributes remain significant to farmers when selecting their dairy breeds. Some farmers (33.3%) mentioned the combined benefits of increased milk production and reduced feed requirements as factors influencing their choice, especially for the Ayrshire breed. These findings are consistent with the results of previous studies conducted by Ajak (2020), Gitau (2013), and Bebe *et al*. (2003), which reported Friesian and Ayrshire cattle as the most preferred dairy breeds in adjacent counties of Nyeri and Nyandarua, as well as in the Kenyan highlands. Whereas the preference for Friesians is attributable to their ability to produce substantial volumes of milk per lactation, Ayrshires, with their smaller body size, require less daily dry matter intake to sustain optimal milk yield. Although less feed requirement was considered a significant factor due to less feed production from smaller farm sizes in the area, milk's high butter fat content holds less economic impact to farmers because milk payment is based on quantity delivered to collection centers or processing plants, not quality.

The scarcity of feed resources has increased reliance on industrial by-products as alternative feed resources in the study area (Alaru *et al*., 2023). The by-products are higher in energy from readily fermentable carbohydrates than fats. It can lead to low milk fat syndrome, characterized by a considerable reduction in milk fat percentage and a change in milk fat composition (Bar *et al*., 2020). Reducing fibre digestion and pH levels in the rumen due to changes in rumen fermentation caused by feeding such by-products can decrease butyric and acetic acids and increase propionic acid. The imbalance of the acids can reduce the release of free fatty acids from adipose tissues, leading to a disproportion in the composition of both short and long-chain fatty acids in milk (Mangwe *et al*., 2020). The study suggests the implementation of quality-based milk payment to strengthen the dairy sector. Proceeds from high-quality, value-added milk products can form part of payment for extension services and bonuses to farmers. The knowledge gained from previous studies reinforces the understanding of breed preferences. It assists in developing targeted interventions and support systems to enhance dairy farming practices in the Kenyan highlands for improved productivity. The previous findings further validate the preference for Friesian cattle, as revealed in the current research, establishing a coherent and robust understanding of breed preferences in the region.

Table 3: Reasons for Preference of Dairy Breeds among Dairy Farmers in Githunguri Sub-County

Reasons for choosing a dairy breed	Friesian	Ayrshire	Crossbreed (Friesian and Ayrshire)
High milk yields	43.5	11.1	0.0
High milk yield and disease-resistant	37.8	11.2	43.6
High milk yield and high butter fat	2.9	0.0	6.3

Reasons for choosing a dairy breed	Friesian	Ayrshire	Crossbreed (Friesian and Ayrshire)
High milk yield and less feed requirement	7.8	33.3	0.0
Disease resistant only	2.6	0.0	0.0
High milk yield, disease resistance, and less feed requirement	4.1	22.2	6.3
High butterfat	0.5	0.0	0.0
All the reasons stated above	0.3	22.2	43.8
Fast-maturing and marketable	0.5	0.0	0.0

Githunguri Dairy Enterprises and Associated Costs

The findings in Table 4 reveal that, on average, 39.07 L (95%) of total milk production per herd is sold, while the remaining 2.33 L (5%) is either fed to calves or consumed at home. This result highlights the significant contribution of on-farm milk production to sustainable livelihood and human and calf nutrition. Similarly, the Food and Agriculture Organization of the United Nations (FAO) acknowledged the contribution of dairy cattle production to enhanced food security through milk consumption, improved crop production through the use of manure, and increased income generation from milk sales (FAO, 2018).

The average daily milk production per farm in the study area is 41.40 L. Considering an average of four cows per farmer, the average milk production per cow is 10 L daily (Table 4). This outcome suggests that dairy farmers in Githunguri operate their enterprises at an above-average production level compared to the national dairy cattle average rated at 6 L per cow per day (Mugambi *et al*., 2015). The findings indicate that milk production in the study area is robust compared to neighbouring counties. A study conducted by Njong'e (2017) in Kirinyaga found that 25% of smallholder farmers recorded milk production levels exceeding 8 L per cow per day, while 15% achieved production levels ranging from 4 to 8 L per cow per day. The majority, 60% of the farmers, had milk production levels between 1 and 4 L per cow daily. Nyeri, another neighbouring county, reported the same average daily milk production of 10 L per cow (Wafula, 2018). About 93% of farmers in the study area prefer keeping the Friesian breed (Table 2), which is expected to produce atleast an average of about 6,000 L per 305 days of lactation (about 20 L per day). The findings indicate that the area is operating below the expected milk production potential in the region and at a very low level compared to the world's best performers, who can produce up to 9000 L per year (Technoserve, 2008). This indicates the need to put more effort towards increased productivity through enhanced breeding programs aimed at getting superior quality breeds for milk production. The effort will reduce emissions of CH4 as more feeds will be partitioned towards production and fewer feeds towards maintenance. However, other factors, such as the health condition, stocking rate and feeding regime, affect the performance of a dairy cow (Sterling *et al*., 2021). The overall economic contribution of the dairy industry among farmers of Githunguri cannot be underestimated. With an average daily sale of 39 L of milk, sold at an average price of KES. 45, Githunguri farmers earn a daily income of KES. 1,755 from the sale of milk (Table 4). This daily income translates to a gross monthly income of KES. 52,650 is way above the poverty line in Kenya, where 38.6% of people are below the poverty line (Zikhali, 2024). This reinforces the pivotal role played by agriculture in poverty reduction (Eichsteller *et al*., 2022).

Table 4: Githunguri Dairy Enterprises and Associated Costs

	Mean	Min.	Max.
Total herd size	6.00	1.00	57.00
Number of lactating cows	4.00	1.00	32.00
Total daily milk production (L)	41.40	3.00	550.00
Daily milk sales (L)	39.07	2.00	540.00
Milk-fed daily to calves (L)	5.40	1.00	24.00
Daily milk home consumption (L)	2.51	1.00	85.00
Price per L (KES)	44.70	35.00	60.00
Daily processed milk quantities (L)	0.04	0.00	5.00
Labour daily rate (KES)	336.21	200.00	600.00
Labour monthly rate (KES)	10,288.65	5,000.00	40,000.00
Monthly manure quantities (ton)	2.05	0.50	6.00
Manure price per ton (KES)	1,752.63	1,200.00	4,200.00

Key: Min= Minimum, Max= Maximum

The practice of processing raw milk into various dairy products at the farm level was almost non-existent in the study area. Instead, farmers in the region mainly sell their raw milk directly to the Githunguri Dairy Farmers Cooperative Society (GDFCS), which processes the milk into whole milk (fresh and long life), cream, butter, and ghee, mala, yoghurt and makes these products available in the market (ADSPS, 2017). Other studies conducted in Kirinyaga and Meru counties also indicated that most farmers prefer to sell their milk to cooperatives and processing factories rather than local buyers, even though the latter may offer better market prices. This preference is attributable to the assured markets the milk processors provide (Ajak, 2020; Wafula, 2018).

The findings emphasize the crucial role of milk processors and cooperatives in strengthening the dairy sector in Kenya by facilitating the value addition and marketing of dairy products. Farmers can benefit from stable and reliable markets by selling their milk to established cooperatives and processing facilities, ensuring a steady income stream. This benefit aligns with the broader objective of enhancing the economic viability of dairy farming and supporting farmers' livelihoods. Furthermore, report that milk collection route, where young farmers (below 35 years of age) actively participate in dairy farming (Table 1), had the highest significant milk production levels shows the need to support them. This finding may be attributable to the youth's accessibility to more information on good agricultural practices. The involvement of young farmers in dairy farming reflects their enthusiasm and engagement in adopting and implementing improved techniques and technologies, leading to higher milk production (Njong'e, 2017). These findings demonstrate the importance of knowledge transfer and continuous learning within the dairy farming community to improve productivity and sustainability.

Milk production and related costs significantly varied in the collection routes, as shown in Table 5. On the Ngewa route, farmers had the highest number of lactating cows and total milk production and sales. On the contrary, farmers on the Komothai collection route had the lowest number of lactating cows with less milk production and sales. Farmers on the Githunguri town collection route reported the highest selling price per cow. This could be attributed to proximity to the town. Githiga had significantly higher labour costs compared to other routes. However, the cost of labour per month in all the milk collection routes is below the minimum recommended rate in Kenya, demonstrating affordable

human resource services in the area. The results in Table 5 show that farmers from the Ngewa milk collection route are the highest producers, with an average of 74.63 litrers of the total milk produced from a mean of 4 lactating cows. This translates to an average production of 17 liters of milk per cow daily, below the expected production potential of the preferred breed, the Friesian cow.

Table 5: Milk Production and Costs in KES Per Route

Milk collection route	Total milk production	Milk sold	Milk for family use	Milk for calves	Milk price per kg	Labour per month
Komothai	14.30±14.30^{c}	11.94±8.09^{c}	1.79±0.18^{ab}	0.55±0.37^{a}	44.74±0.35^{ab}	10600±593^{b}
Githinga	30.10±7.95^{bc}	28.01±7.77^{bc}	1.51±0.17^{b}	1.27±0.53^{a}	45.90±0.34^{a}	13,607±613^{a}
Kiairia	34.18±8.15^{bc}	31.62±7.96^{abc}	2.31±0.17^{a}	0.24±0.37^{a}	44.25±0.37^{b}	8100±726^{b}
Gitiha and Kiambaa	37.85±8.50^{abc}	34.03±8.30^{abc}	2.30±0.18^{a}	1.51±0.38^{a}	44.97±0.40^{ab}	8416±468^{b}
Githunguri town	44.15±7.20^{abc}	40.93±7.08^{abc}	2.26±0.15^{a}	1.47±0.32^{a}	44.85±0.31^{ab}	9185±442^{b}
Ikinu	50.91±7.40^{ab}	46.90±7.17^{ab}	2.29±0.16^{a}	1.06±0.33^{a}	45.24±0.31^{ab}	8970±393^{b}
Ngewa	75.06±9.71^{a}	68.55±9.26^{a}	2.04±0.20^{ab}	1.18±0.44^{a}	41.88±0.42^{c}	9305±557^{b}

Key: Means with the same letter along the column are not significantly different at $p< 0.05$.

A comparison of the effect of age, education, and membership in farmer organizations on the proportion of milk produced indicated that H.H. under the youth category (below 35 years) produced more milk (38%) in the area. Education played a significant role, as farmers at the tertiary level had the highest proportion (46.1%). Moreover, membership in farmer organizations had the greatest impact (70.4%) of the total milk produced compared to non-members. The findings in Table 1, when looked at alongside those in Figure 1, illustrate a negative correlation between the age of the farmer and the level of milk production but a positive correlation between the level of education and the level of milk production. This only underpins education's very important role in contemporary dairy entrepreneurship. These findings further corroborate Reimers and Clasen (2013), who found that any additional year of schooling for the whole population would increase agricultural productivity by 3.2%. Duguma, (2022) found that those with university degrees tend to have a higher milk yield from their herds because they tend to keep relatively similar breeds of dairy animals and more uniform dairy management practices. With increased access to education, farmers in Githunguri can harness the power of technology, such as mobile applications, online platforms, and precision farming tools, to optimize their dairy operations and make informed decisions. Farmers can improve productivity, enhance animal welfare, and explore new market opportunities by staying informed about the latest developments in the dairy industry.

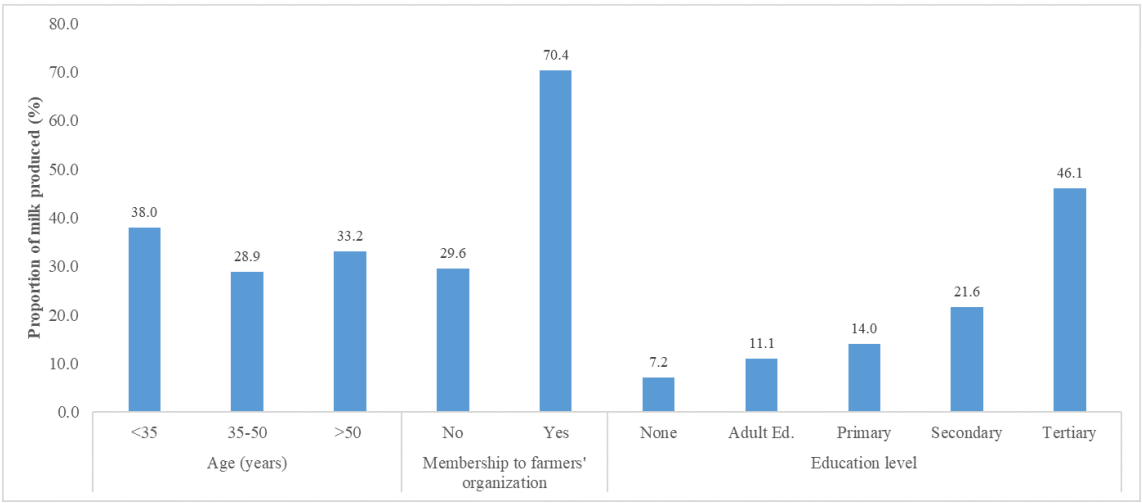

Figure 1: Effects of Age, Education, and Membership in Farmers' Organization on Milk Production in Githunguri Sub-County

The Government of Kenya targets youth empowerment and development through bottom-up economic transformation (BETA) policies and structural reforms that promote investment in agricultural transformation and focus on end-to-end investment in the dairy value chain with a higher impact at the bottom of the economy (Njora & Yilmaz, 2022).

Challenges Faced by Dairy Farmers

The challenges in dairy farming are extensive. A few of them related to the study area were selected, as demonstrated in the result in Table 6. Poor animal health was ranked as the primary challenge facing dairy farmers in the Githunguri area. This is characterized by a high incidence of endemic infectious and parasitic diseases, insufficient veterinary care, irregular vaccinations, improper disease preventive techniques, and the spread of diseases transmitted by ticks. The postpartum depressed performance of dairy cows affected by diseases is widely recognized in several studies (Wangila, 2016; Njonge, 2017). The impact ranges from reproduction negative effects such as lower fertility levels and higher risk during calving to a decrease in milk production (Manriquez *et al*., 2021). This finding aligns with a study conducted by Sang (2021) in the same region, which reported that 54.6% of California mastitis test (CMT)-positive quarters and 81.3% of CMT-positive cows were infected with S. aureus. Moreover, Kagira *et al*. (2023) reported varied resistance of isolated bacteria in the area to commonly used antibiotics, with a prevalence of S. aureus and E. coli being 30.8% and 12.1%, respectively. The findings further exacerbate the farmers' poor animal health concerns. Additionally, the results are consistent with the research conducted by Ajak (2020) in neighbouring Nyeri County, where health issues were identified as challenging factors faced by smallholder farmers. Thus, it is recommended that farmers regularly vaccinate against the most frequent infectious diseases as guided by the directorate of veterinary services, provide them with enough veterinary care and drug supply, and train them on disease control and optimal health practices.

Table 6: Distribution of Farmers on Ranking Challenges

Challenges	Frequency (%)			
	1	2	3	4
Poor animal health	92.1	3.9	3.0	1.0
Inadequate and poor-quality feeds	49.3	14.1	19.1	17.5
Poor markets and marketing channels	26.8	4.8	28.4	40.0
Inadequate finances	29.0	14.7	27.9	28.4
Lack of technologies and dissemination	11.5	8.5	31.4	48.6
Breeds and breeding	13.4	10.1	21.7	54.8
Socio-cultural issues	0.5	0.2	3.7	95.6

Key: 1= very important, 2=important; 3=less important; 4=not important.

Githunguri dairy enterprises face other critical challenges. The second most important challenge is inadequate and poor-quality feeds due to small farm sizes. This could be caused by shrinking grazing lands, extreme feed scarcity during the dry season, towns growing and encroaching on nearby grazing lands, high costs and unavailability of commercial feeds, low forage production, and a lack of understanding about the most effective ways to use locally available feed resources. Optimization of feed quality through enhanced nutrition management is essential in increasing dairy productivity. Inadequate and poor-quality feeds often lead to stunted growth, reduced fertility and milk production, and increased animal disease susceptibility (Baris, 2023). Alternative feeding methods must be implemented, such as the economical use of locally accessible feed resources, feed conservation, and appropriate handling of crop residues. Moreover, the adoption of urea-molasses-mineral blocks, proper use of industrial by-products, supplementing lactating cows with concentrate when cost-effective, and preparing feed on-site from locally available feeds in place of pricey commercial concentrates, particularly for lactating cows, are some of the best options as reported by Gelila (2017). Another critical challenge identified as a significant hurdle by farmers despite well-established dairy cooperative societies in the area is inadequate finances. Poor markets and marketing channels influence milk prices. Most farmers sell their milk to a cooperative society, which sets the farm gate price, thereby impacting the profitability of a dairy business. Dairy farmers who are not members of the cooperative society should be encouraged to join to improve their bargaining power and enjoy a stable price. Credible microfinance institutions are encouraged to offer long-term, low-interest loan programs that enable the acquisition of input resources for improved productivity and income.

These facts highlight the need for targeted interventions and support systems to address these specific challenges and improve the region's overall sustainability and profitability of dairy farming. Furthermore, addressing the challenges of inadequate and poor-quality feeds requires interventions to enhance feed availability, quality, and overall management practices. Access to adequate finances and robust market and marketing channels are crucial to ensure the economic viability of dairy farming in the area (Gelila, 2017).

Socio-cultural issues, breeds, and breeding practices were ranked as unimportant challenges to dairy farming in the area. Dairy production is a family enterprise where members, including men, women, and children, contribute to production and marketing activities. Farmers use the high literacy level, well-developed dairy value chain, and elaborate A.I services in the area to get a superior dairy genetic pool into their farms. Lack of technologies and dissemination was ranked as not an important challenge, a demonstration that farmers promptly receive information on good agricultural practices.

CONCLUSION

Friesian was the most preferred cattle, followed by crossbreed. The driving factors to breed preference were high milk production, disease resistance, and less feed requirement. The milk collection route where youths (< 35 years of age) actively participated in dairy farming reported the highest number of lactating cows and milk production levels. Education level and membership in farmer organizations had the greatest impact on the proportion of milk produced. Equally, controlled breeding programs guaranteed quality breeds and replacement stock for farmers, but poor feeding strategies and animal health challenges hindered genetic progress.

RECOMMENDATION

There is a need for farmers to keep small body-sized genetically superior dairy cattle breeds that are more resilient while producing sufficient amount of milk. By adopting this approach, farmers can address the challenge of inadequate feed resources, particularly forages, in the area. The engagement of more youth to join farmer organizations and actively participate in dairy production can spur economic growth in the sector. Overall, providing technical backstopping to farmers on developed technologies, innovations, and management practices for enhanced dairy productivity is inevitable.

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