Influence of milk price and selected factors of production on milk supply in Matayos Sub-County, Busia County, Kenya

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ABSTRACT

The dairy sector plays an important role in Kenya's rural economy and contributes approximately 14% to the national agricultural Gross Domestic Product (GDP). Despite its economic importance, milk production in many regions remains below its potential due to production constraints affecting smallholder dairy farmers. In Busia County's Matayos Sub-County, dairy production is largely dominated by small-scale farmers operating under low-input and low-output systems, which limit productivity and milk supply to the market. This study examined the effect of milk price and selected production factors on milk supply in Matayos Sub-County, Busia County, Kenya. The study was guided by Value Chain Theory, Demand and Supply Theory, and Positional Advantage Theory, which explain how production factors and market structures influence milk supply. The study adopted a cross-sectional correlational research design within a mixed-methods approach, integrating both quantitative and qualitative approaches. The target population comprised 16,000 smallholder dairy farmers together with extension officers and dairy value-chain stakeholders in Matayos Sub-County. A total of 400 respondents, comprising dairy farmers, extension officers, and other value chain stakeholders, were purposively sampled across selected wards of Matayos Sub-County. Data were collected using structured questionnaires, observations, focus group discussions, and key informant interviews. Quantitative data were analyzed using the Statistical Package for the Social Sciences (SPSS) Version 28.0, while qualitative data were analyzed through thematic analysis. Pairwise comparison of means was conducted using the Least Significant Difference (LSD) test at a significance level of $P \leq 0.05$. The results showed that most farmers sold milk at relatively low farm-gate prices, with 62.9% selling at KSh 40–50 per litre, 31.6% selling at KSh 51–60, and only 5.5% accessing higher-value markets offering KSh 61–70 per litre. Correlation analysis revealed a weak and negative relationship between purchased feeds and milk yield ($r = –0.035$, $p = .483$), indicating that purchasing feeds alone does not necessarily lead to increased milk production. The findings suggest that milk price and selected production factors such as feed availability, grazing access, and market accessibility influence milk supply among smallholder farmers. The study concludes that improving dairy management practices, strengthening cooperative marketing systems, and enhancing farmers' access to markets and production inputs are critical for increasing milk supply and improving the sustainability of dairy farming in Matayos Sub-County. The study recommends strengthening dairy cooperatives, investing in milk collection and cooling infrastructure, enhancing extension services on feed and herd management, and improving access to market information systems to increase milk supply and improve market outcomes for smallholder dairy farmers.

Keywords: Dairy Production Factors, Dairy Value Chain, Kenya, Milk Price, Milk Supply, Smallholder Dairy Farmers

I. INTRODUCTION

The dairy sector plays a significant role in Kenya's agricultural economy and rural livelihoods. It contributes substantially to national food security, employment creation, and household income, particularly among smallholder farmers who dominate the dairy production system. According to the Government of Kenya, the dairy industry contributes approximately 14% of the agricultural gross domestic product and supports more than one million rural households engaged in milk production and marketing (Government of Kenya, 2010; Onono & Ochieng, (2018).). Dairy farming has therefore been recognized as a strategic enterprise under national development frameworks such as Kenya Vision 2030 and the Bottom-Up Economic Transformation Agenda, which emphasize agricultural transformation as a pathway to economic growth and poverty reduction (Government of Kenya, 2007; National Treasury and Planning, 2023).

Despite its economic importance, milk production in many parts of Kenya remains below its potential due to structural and operational constraints affecting smallholder dairy farmers. Studies indicate that the majority of dairy farmers operate under low-input and low-output production systems characterized by limited access to quality feeds, inadequate veterinary services, weak infrastructure, and poor market linkages (Food and Agriculture Organization

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[FAO], 2011, 2020; Kahi & Wasike (2019). These challenges limit productivity and reduce the volume of milk supplied to the market. In addition, increasing demand for dairy products driven by population growth and urbanization has placed greater pressure on the dairy sector to improve productivity and supply efficiency (FAO, 2020).

A combination of economic, institutional, and production factors influences milk supply. Among the most significant determinants are feed availability, labor efficiency, infrastructure, breeding practices, and animal health management. Feed costs alone account for a large proportion of the total cost of milk production and significantly influence milk yield and farm profitability (Kimenchu, et al., 2014; Goopy & Gakige, 2016). Similarly, effective labor management and mechanization can enhance productivity by improving farm efficiency and reducing operational costs (Hamilton, et al. (2022); Ogola et al., (2023). Infrastructure such as cooling facilities, milking equipment, and transportation networks also plays a critical role in maintaining milk quality and ensuring that milk reaches markets efficiently (Henchion, et al., 2022.; Wu, et al., 2019).

Another key factor influencing milk supply is the price received by farmers for their milk. Milk price serves as an important incentive that influences farmers' production decisions, investment in improved dairy technologies, and participation in dairy markets. Stable and favorable milk prices encourage farmers to increase production, while price volatility and limited market access may discourage investment in dairy farming (Dizyee et al., 2019). Furthermore, access to financial resources, agricultural extension services, and supportive government policies can enhance farmers' ability to adopt improved dairy practices and increase milk supply (Prajapati, et al., 2025; Maina et al., 2020).

In Busia County, particularly in Matayos Sub-County, dairy farming is predominantly practiced by smallholder farmers operating under resource-constrained conditions. Although the region has potential for dairy production, milk supply remains relatively low due to challenges such as high production costs, inadequate infrastructure, and limited access to reliable markets. Additionally, there is limited empirical evidence on how milk price and production factors jointly influence milk supply among smallholder dairy farmers in the area. Understanding these relationships is essential for designing effective interventions that can enhance dairy productivity, strengthen value chains, and improve rural livelihoods. Therefore, this study sought to determine the effect of milk price and selected production factors on milk supply in Matayos Sub-County, Busia County, Kenya.

1.1 Statement of the Problem

The dairy sector remains a critical component of Kenya's agricultural economy and rural livelihoods; however, milk production among smallholder farmers continues to fall below its potential despite rising demand driven by population growth and urbanization. In Busia County, particularly in Matayos Sub-County, dairy farming is dominated by small-scale producers operating under resource-constrained conditions characterized by high feed costs, fluctuating milk prices, limited access to veterinary services, weak infrastructure, and poorly organized market systems. These challenges not only constrain productivity but also limit farmers' ability to respond effectively to market incentives. While existing studies have examined individual determinants of dairy productivity such as feed availability, animal health, and market access, there is limited empirical evidence on how milk price interacts with key production factors to influence milk supply within smallholder systems, particularly at the local level. Most prior studies treat production factors and market variables in isolation, leaving a gap in understanding their combined and context-specific relationships. In addition, little is known about how these interactions operate within informal and semi-structured dairy markets such as those found in Matayos Sub-County. This lack of integrated, location-specific evidence constrains the ability of policymakers and development practitioners to design targeted interventions that simultaneously address production inefficiencies and market constraints. Therefore, this study examines the relationships between milk price and selected production factors and their association with milk supply among smallholder dairy farmers in Matayos Sub-County, Busia County, Kenya.

1.2 Research Objective

This study examines the relationships between milk price and selected production factors (feed purchase, grazing, animal costs, and cooperative participation) and milk supply among smallholder dairy farmers in Matayos Sub-County, Busia County, Kenya.

II. LITERATURE REVIEW

2.1 Theoretical Review

This study is anchored on three key theoretical perspectives: Value Chain Theory, Demand and Supply Theory, and Positional Advantage Theory. These theories collectively explain how production factors, market forces, and value chain interactions influence milk supply.

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2.1.1 Value Chain Theory

Value Chain Theory was advanced by Porter (1985) to explain how value is created through a sequence of interconnected activities within a production system. According to the theory, organizations gain a competitive advantage by optimizing activities such as input procurement, production processes, distribution, marketing, and after-sales services. In agricultural sectors, including dairy production, value is created through coordination among actors involved in the supply chain, such as farmers, input suppliers, processors, distributors, and retailers. In the dairy sector, the value chain begins with input provision, including feed supply, veterinary services, breeding technologies, and farm equipment. These inputs influence the productivity of dairy farms and determine the quantity and quality of milk produced. Subsequent stages include milk collection, processing, distribution, and retailing to consumers. Each stage contributes to value addition and affects the final market price of milk (Goopy & Gakige, 2016; Prajapati et al., 2025).

The theory is relevant to this study because milk supply depends not only on farm-level production decisions but also on the efficiency of the broader dairy value chain. Inefficiencies in input supply, milk collection systems, processing capacity, or marketing channels can reduce farmers' incentives to increase milk production. In the context of Matayos Sub-County, understanding the functioning of the milk value chain helps identify constraints affecting milk supply and pricing structures within the dairy sector. However, critics argue that Value Chain Theory primarily emphasizes internal operational processes and may overlook external influences such as technological change, institutional dynamics, and market volatility that also shape production outcomes (Lusweti et al., 2004).

2.1.2 Demand and Supply Theory

Demand and Supply Theory is a fundamental economic framework explaining how market prices and quantities of goods are determined through the interaction between producers and consumers (Milios et al., 2002). According to this theory, the quantity supplied of a commodity increases when its price rises, while demand decreases when prices increase. In the dairy sector, milk prices play a central role in influencing farmers' production decisions. When milk prices rise, dairy farmers are motivated to increase production by expanding herd sizes, improving feeding regimes, and adopting productivity-enhancing technologies. Conversely, when milk prices decline, farmers may reduce production due to reduced profitability.

Despite this relationship, milk supply tends to be relatively inelastic in the short run because dairy production involves biological processes such as breeding cycles, gestation periods, and lactation intervals. As a result, farmers cannot quickly adjust production levels in response to price changes. In the long run, however, supply becomes more responsive as farmers invest in improved genetics, feeding systems, and farm management practices (Porter, 1985). Household income levels, urbanization, dietary preferences, and population growth also influence demand for milk. In many developing countries, rising incomes and urbanization have increased demand for dairy products, leading to expansion of milk markets and opportunities for dairy farmers (Dizyee et al., 2019). This theory, therefore, provides an important framework for analyzing how milk prices and production factors interact to influence milk supply among dairy farmers.

2.1.3 Positional Advantage Theory

Positional Advantage Theory originates from strategic management literature and explains how firms or actors achieve superior performance by occupying favorable positions within a market or value chain (Porter, 1985). In agricultural value chains, actors who control critical nodes such as processing, marketing, or distribution often capture greater value compared to primary producers. Within the dairy value chain, different actors, including farmers, milk collectors, processors, wholesalers, and retailers, occupy different positions that determine their bargaining power and share of profits. Farmers who operate individually often face limited bargaining power when negotiating milk prices with processors or traders. In contrast, actors involved in milk aggregation and processing may exert greater influence over pricing and market access (Waithaka et al., 2002).

Positional advantage can also be improved through collective action, such as farmer cooperatives, vertical integration, and the adoption of technology that enhances productivity and market access. For instance, dairy cooperatives enable farmers to pool milk volumes, access cooling facilities, and negotiate better prices in the market. However, the theory assumes ideal market conditions, including perfect mobility of labor and capital, which may not exist in rural agricultural systems. Structural constraints such as limited infrastructure, information asymmetry, and financial barriers often restrict the ability of smallholder farmers to improve their market position (Lusweti et al., 2004).

2.2 Empirical Review

Empirical literature demonstrates that milk supply among smallholder dairy farmers is shaped by a complex interaction of production, economic, and institutional factors. Recent studies (2019–2024) emphasize that, beyond traditional inputs such as feed and labor, market access, price incentives, and value chain integration play a critical role in determining milk supply outcomes. Evidence from East Africa further shows that these relationships are highly context-specific, varying across production systems and market structures in Kenya, Uganda, Tanzania, and Ethiopia.

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2.2.1 Feed Costs and Milk Supply

Feed availability and cost remain the most significant determinants of milk production in smallholder dairy systems, accounting for approximately 60–70% of total production costs (Goopy & Gakige 2016.; Kahi & Wasike, 2019). Recent studies confirm that improved feeding strategies, including silage production, fodder cultivation, and concentrate supplementation, significantly enhance milk yield (Thapa et al., 2019; Njarui et al., 2011). However, evidence from East Africa shows mixed outcomes. In Kenya and Uganda, improved feed use is positively associated with milk productivity, but not always with profitability due to rising input costs (Omore et al., 2019; Balirwa & Waholi, 2019). In Ethiopia, studies indicate that limited access to quality feed markets constrains productivity despite high demand for dairy products (Guadu & Abebaw, 2016). Similarly, research in Tanzania shows that seasonal feed shortages significantly reduce milk output, particularly among smallholder farmers relying on rain-fed systems (Swai & Karimuribo, 2011). These findings suggest that while feed investment is necessary, its effectiveness depends on feed quality, management practices, and broader market conditions.

2.2.2 Labor Costs and Milk Supply

Labor remains a critical input in dairy production, particularly in smallholder systems where mechanization is limited. Recent studies show that efficient labor allocation and skill levels significantly influence milk productivity (Hamilton et al., 2022); Ogola et al., 2023). Comparative evidence across East Africa highlights structural differences. In Kenya and Uganda, family labor dominates dairy production, reducing direct labor costs but often limiting efficiency due to skill gaps (Balirwa & Waholi, 2019). In contrast, studies in Tanzania and Ethiopia indicate that labor shortages and high hired labor costs constrain farm expansion and productivity (Addis, 2019.; Swai & Karimuribo, 2011). Overall, labor contributes to productivity, but its impact depends on skill levels, access to technology, and farm scale.

2.2.3 Infrastructure and Milk Supply

Infrastructure development remains a key determinant of milk supply through its effect on market access and post-harvest handling. Recent studies show that access to milk collection centers, cooling facilities, and reliable transport significantly reduces spoilage and improves farmer participation in formal markets (Onono & Ochieng, 2018; Omore et al., 2019). Across East Africa, infrastructure gaps remain a major constraint. In Uganda and Tanzania, weak rural road networks and limited cold-chain systems reduce farmers' ability to access high-value markets (Balirwa & Waholi, 2019; Swai & Karimuribo, 2011). In Ethiopia, inadequate processing and storage facilities limit value addition and market integration (Guadu & Abebaw, 2016). These findings highlight that improving infrastructure is essential not only for increasing milk supply but also for enhancing price realization among farmers.

2.2.4 Animal Health and Breeding

Animal health and breeding practices are consistently identified as key drivers of dairy productivity. Recent studies show that improved veterinary care, disease control, and artificial insemination significantly increase milk yield and herd performance (Omore, et al., 1998; Chawala, et al., 2021). However, access to these services remains uneven across East Africa. In Kenya, extension services and veterinary access have improved in some regions, but gaps persist among smallholder farmers (Goopy & Gakige, 2016.). In Ethiopia and Tanzania, limited access to veterinary services and improved genetics continues to constrain productivity (Addis, 2019).; Swai & Karimuribo, 2011). This suggests that productivity gains depend not only on the availability of technologies but also on accessibility and affordability.

2.2.5 Economic and Policy Factors

Economic incentives, particularly milk price, play a central role in shaping dairy production decisions. Recent studies show that stable and competitive milk prices encourage farmers to invest in improved production practices, while price volatility discourages long-term investment (Dizyee et al., 2019; Omore et al., 2019). However, empirical evidence across East Africa indicates that milk prices are often determined by market structures rather than production costs. In Kenya and Uganda, informal markets dominate milk trade, limiting farmers' bargaining power and weakening the link between production investment and price realization (Balirwa & Waholi, 2019; Omore et al., 2019). In Tanzania and Ethiopia, weak cooperative systems and limited market integration further constrain price incentives (Guadu,& Abebaw, 2016; Swai & Karimuribo, 2011). Policy interventions such as extension services, credit access, and infrastructure development have shown positive effects on dairy productivity. However, inconsistent implementation and institutional weaknesses continue to limit their impact across the region (Fuglie & Rada, 2020; Maina et al., 2020). Overall, these studies demonstrate that milk supply is influenced not only by farm-level production factors but also by broader market and institutional dynamics.

Despite the growing body of empirical literature, most studies examine production factors and market variables independently, with limited focus on how milk price interacts with key production inputs to influence milk supply at the household level. Furthermore, few studies provide localized evidence from specific sub-counties such as Matayos,

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where informal market structures dominate dairy trade. This study addresses this gap by examining the combined relationships between milk price and selected production factors within a smallholder dairy context.

III. METHODOLOGY

3.1 Research Design

The study employed a cross-sectional correlational research design, which combined both quantitative and qualitative approaches. This dual approach is aimed at obtaining a comprehensive understanding of the milk production dynamics, pricing mechanisms, production factors, and strategic options to enhance milk supply in Matayos Sub-County. Given the cross-sectional and correlational nature of the data, the study does not establish causal relationships but rather identifies statistically significant associations between variables.

3.2 Study Area

The study was carried out in Matayos Sub-County, Busia County, Kenya. Matayos Sub-County is one of the Sub-Counties in Busia County in the western region of Kenya. There are two rainy seasons in this area, namely long rains from March to June and short rains from September to November, and the climate is tropical. The annual rainfall is between 1200 to 1800 mm and the temperature is in the range of 18°C to 30°C which is good for agriculture and animal husbandry. The primary economic activity in the sub-county is agriculture, and households make livelihoods from crop farming and dairy farming. Dairy production is smallholder and farmers have indigenous and improved dairy cattle kept in mixed crop-livestock production systems. The dairy sector is very important to the local community in terms of employment, income and food security. Although the dairy sector is vital, it is also beset with significant problems such as low milk prices, poor market access and infrastructure, shortages in quality feeds, and high production cost. Matayos Sub-County was chosen for the purpose of this study because of its high involvement in dairy production, which enabled one to study the effect of dairy milk prices, dairy production factors and milk supply for the smallholder dairy farmers in Matayos Sub-County.

3.3 Study Population

The target total population included 16000 dairy farmers, from which a sample size of 400 was used in this study, as well as key stakeholders comprising extension officers, primary and support value chain actors involved in the dairy cattle milk production and marketing.

3.4 Sampling Strategy

A multi-stage sampling technique was employed to select respondents for the study. In the first stage, three wards within Matayos Sub-County were purposively selected based on their agro-climatic suitability for dairy farming and their level of market access. These wards represent areas with active smallholder dairy production and varying degrees of integration into formal and informal milk markets.

In the second stage, the target population of 16,000 dairy farmers was stratified into three categories based on farm scale, defined by herd size: small-scale (1–3 cattle), medium-scale (4–10 cattle), and large-scale (more than 10 cattle). Stratification was necessary to ensure representation of different production capacities and management systems within the study area. In the third stage, proportionate random sampling was used to select respondents from each stratum across the three wards. The allocation of the sample was based on the relative population size of dairy farmers within each ward and farming category to ensure representativeness. This approach minimized sampling bias and allowed for comparison across different farm scales and market access conditions.

Table 1

Summary of Purposive Sampling Strategy for the Milk Price and Milk

Study Unit	Sampling Method	Sample Size
Smallholder Farmers	Multi-stage random	400
Key Informants	Purposive	40
Focus Group Discussions	Quota (8–12 per group)	8–12
Observations	Purposive	40

Production Supply Chain in Matayos Sub-County, Busia County, Kenya.

The sample size was determined using Yamane's (1967) formula, which is a commonly used statistical formula for calculating sample size when dealing with a known population size.

Yamane's Formula:

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

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Where:

n = Sample Size of the Study Population
N = Total Population of Dairy Cattle Farmers
e = Margin of Error and Level of Precision

Using the formula, a population of 16,000 yielded a sample size of 390 respondents at a 5% margin of error. To account for possible attrition and non-response, 10 additional participants were added, resulting in a final sample size of 400 respondents.

In addition to the household survey, 40 key informants (including extension officers, cooperative leaders, and milk traders) were selected purposively based on their knowledge of the dairy value chain. Focus group discussions consisting of 8–12 participants per group were conducted using quota sampling to capture diverse farmer experiences, while observational data were collected from 40 selected farms using purposive sampling. To address non-response, replacement sampling was conducted within the same stratum and ward where selected respondents were unavailable or declined participation. Follow-up visits were also made to increase response rates and ensure completeness of data.

Despite these measures, the study may be subject to limitations related to generalizability. The findings are specific to Matayos Sub-County and may not fully represent dairy production systems in other regions with different agro-ecological conditions, market structures, or institutional support systems. Additionally, the cross-sectional nature of the data limits the ability to capture seasonal variations in milk production and pricing.

3.5 Validity and Reliability of Data Collection Instruments

3.5.1 Validity

Validity refers to the extent to which a research instrument accurately measures the concept it is intended to measure. The validity of the research instruments was ensured through pilot testing, expert review, and literature-based design of the questionnaire items. A pilot study was conducted in Nambale Sub-County, which was not included in the main study area. The pilot study helped identify ambiguous questions, improve the clarity of the questionnaire, and ensure that the instruments captured the intended research variables.

3.5.2 Reliability

Reliability refers to the consistency of results produced by research instruments. The Reliability of the questionnaire was assessed using Cronbach's alpha coefficient, which measures internal consistency among survey items. A Cronbach's alpha value of 0.80 was considered acceptable, indicating a high level of internal consistency among the questionnaire items. In addition, trained research assistants administered the questionnaires uniformly across the three wards to ensure consistency in data collection.

3.6 Data Collection

Data were collected using multiple instruments to capture both quantitative and qualitative information. Structured questionnaires were administered to dairy farmers, extension officers, and other value chain actors to obtain data on milk prices, production costs, milk volumes, and marketing channels. Key Informant Interviews (KIIs) were conducted with extension officers, veterinary officers, cooperative leaders, and milk traders to obtain expert insights on milk price fluctuations, market dynamics, and value chain challenges. In addition, Focus Group Discussions (FGDs) with farmers were organized to explore shared experiences regarding milk pricing and market access. Observation checklists were also used to document farm production practices, infrastructure, and resource use across selected dairy farms in Matayos Sub-County.

3.7 Data Processing, Analysis, and Presentation

Quantitative data collected through structured questionnaires were coded and analyzed using the Statistical Package for the Social Sciences (SPSS) Version 28.0. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize key variables such as milk yield, milk price, feed expenditure, and production costs. Inferential analysis was conducted in three stages. First, Pearson correlation analysis was used to examine the direction and strength of relationships between milk supply (measured as average daily milk yield in litres) and selected production factors, including feed purchase, grazing contribution, animal costs, and cooperative participation. Second, multiple linear regression analysis was performed to examine the association between milk price (dependent variable) and selected production factors. The regression model was specified as:

$$\text{Milk Price} = \beta_0 + \beta_1 (\text{Feed Purchase}) + \beta_2(\text{Grazing}) + \beta_3(\text{Animal Cost}) + \beta_4 (\text{Cooperative Cost}) + \varepsilon$$

Where β_0 is the intercept, β_1–β_4 are coefficients, and ε is the error term.

Prior to estimation, diagnostic tests were conducted to assess the assumptions of linear regression, including multicollinearity (Variance Inflation Factor), normality of residuals, and homoscedasticity. Variables with high intercorrelation were carefully examined to avoid distortion of model estimates. Third, chi-square tests were used to

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examine associations between categorical variables such as market channel and milk price categories. The strength of association was assessed using Cramer's V. Qualitative data obtained from key informant interviews and focus group discussions were analyzed using thematic analysis. Emerging themes were used to complement and explain quantitative findings. All statistical tests were conducted at a 5% level of significance ($p \leq 0.05$), and both statistical and practical significance were considered in the interpretation of results.

3.8 Ethical Considerations

A clearance certificate was sought from the MMUST postgraduate studies directorate. A research permit was obtained from NACOSTI using the clearance certificate (Appendix 11). The researcher then sought a permission letter from the Busia County director of Agriculture and the Nambale Sub-County Agricultural officer, where the pilot study was carried out. The researcher then planned with the farmers on the dates and times of data collection. The researcher and research assistants introduced themselves to the farmers on the day of data collection and thereafter explained the importance and nature of the study to the farmers. A collection of standardized and quantifiable empirical data was collected since the area has a large number of people who depend on the dairy production; hence, a large sample size was used. The farmers did not write their names on the questionnaire to ensure their confidentiality.

IV. FINDINGS & DISCUSSION

4.1 Introduction

This section presents and interprets the empirical findings on the effect of milk price and selected production factors on milk supply among smallholder dairy farmers in Matayos Sub-County, Busia County, Kenya. The results are organized around the key variables examined in the study, namely milk yield, milk price, feed purchase, grazing practices, animal costs, and cooperative participation. Quantitative data were analyzed using Pearson correlation and regression analysis, while qualitative insights from focus group discussions and observation checklists were used to complement and explain the statistical findings. The discussion integrates the results with Porter's Value Chain Theory (Porter, 1985) and existing empirical literature on dairy production systems and milk markets. The objective is to understand how production inputs, value chain participation, and market structures jointly influence milk supply and pricing outcomes among smallholder dairy farmers.

4.2 Correlation Analysis of Production Factors and Milk Supply

The relationship between production factors and milk supply variables was examined using Pearson correlation analysis. Table 2 presents the correlation matrix showing the direction and strength of relationships among milk yield (G1), milk price (G2), feed purchase (D1), grazing contribution (E1), animal cost, and cooperative cost.

Table 2

Pearson Correlation Matrix of Production Factors and Milk Supply Variables

Variable	G1	G2	D1	E1	Animal Cost	Cooperative Cost
G1 (Milk Yield)	1	-0.039	-0.035	0.085	-0.127*	-0.337**
G2 (Milk Price)	-0.039	1	-0.121*	-0.161**	-0.020	0.129**
D1 (Feed Purchase)	-0.035	-0.121*	1	0.643**	-0.047	-0.205**
E1 (Grazing)	0.085	-0.161**	0.643**	1	0.056	-0.276**
Animal Cost	-0.127*	-0.020	-0.047	0.056	1	-0.468**
Cooperative Cost	-0.337**	0.129**	-0.205**	-0.276**	-0.468**	1

*Significant at 0.05 level
**Significant at 0.01 level

Note: G1 = Milk Yield (average litres per day per household); G2 = Milk Price (KSh per litre); D1 = Feed Purchase (monthly expenditure on feeds); E1 = Grazing Contribution (proportion of feed from grazing).
$p < 0.05$ (*), $p < 0.01$ (**)

The results reveal several notable patterns in the dairy production system in Matayos Sub-County. Milk yield (G1) exhibits a weak negative relationship with animal costs ($r = –0.127$, $p = .011$). This suggests that increased expenditures on livestock acquisition or maintenance do not necessarily lead to higher milk production. Similar findings have been reported by Wambugu et al. (2011). who argue that livestock investment must be complemented by appropriate feeding regimes, disease management, and breeding practices to achieve productivity gains. Milk yield also shows a moderate negative relationship with cooperative costs ($r = –0.337$, $p < .001$). This finding suggests that increased

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cooperative-related financial obligations may reduce resources available for farm-level production activities. However, cooperatives still play an important role in marketing and value chain integration, as discussed later in the section.

Milk price (G2) demonstrates weak negative correlations with feed purchase (r = –0.121, p = .016) and grazing contribution (r = –0.161, p = .001). These results indicate that increased investment in production inputs does not automatically translate into higher milk prices. Instead, milk pricing is influenced by market structures, buyer relationships, and collective marketing arrangements. Similar observations were made by Swai and Karimuribo (2011)) as well as Omore et al. (2019), who found that milk prices in smallholder systems are often determined by market access and bargaining power rather than production costs. The analysis further shows a strong positive relationship between feed purchase and grazing contribution (r = 0.643, p < .001). This suggests that farmers often combine grazing and purchased feeds as complementary feeding strategies. According to Njarui et al., (2011), integrated feeding systems are common among smallholder farmers because they help reduce feeding costs while maintaining productivity.

4.3 Regression Analysis of Production Factors and Milk Price

Regression analysis was conducted to examine the combined effect of production costs on milk price.

Table 3

Regression Analysis of Animal Costs and Cooperative Costs on Milk Price

Model	df	Sum of Squares	Mean Square	F	Sig.
Regression	2	2.673	1.337	3.811	.023
Residual	396	138.896	0.351		
Total	**398**	**141.569**			
R^2 = 0.019					

Dependent Variable: Milk Price (G2)

The regression results indicate that the model is statistically significant (F(2,396) = 3.811, p = .023), suggesting that animal costs and cooperative costs are jointly associated with milk price. However, the model explains only a small proportion of the variation in milk price (R^2 = 0.019), indicating limited practical significance. This implies that other factors within the dairy value chain, such as market access and buyer structures, play a more substantial role in determining milk prices. From the perspective of Porter's Value Chain Theory (Porter, 1985), value creation in agricultural systems occurs not only at the production stage but also through downstream activities such as storage, transport, processing, and marketing. Therefore, while production costs influence milk supply, market structures and cooperative networks also play a major role in determining final price outcomes.

4.4 Relationship Between Feed Purchase and Milk Yield

The study examined whether the purchase of feeds significantly influences milk production.

Table 4

Correlation between Purchased Feeds and Milk Yield

Variable	G1	D1
G1 (Average milk yield)	1	-0.035
D1 (Purchased feeds)	-0.035	1

Pearson correlation: r = –0.035, p = .483

Pearson correlation analysis was used to evaluate the correlation between purchased feeds and milk yield. The results suggest a very weak and statistically insignificant negative correlation between feed purchase and milk yield (r = -0.035, p = 0.483). Such a discovery suggests that the use of purchased feeds does not guarantee higher milk yield as is expected among the smallholder farmers in Matayos Sub-County. There was no significant relationship between the intake of each feed and the output of milk solids, indicating inefficiencies in feed utilization; this may stem from the use of feeds of varying quality, from inadequate rationing or from using feeds that are not suitable for the nutritional needs of dairy cattle.

In practical terms, this finding suggests that feed purchases are not the key to milk productivity but rather how milk production can be managed with feeds and how feeds can be integrated into grazing systems. In many smallholder systems, farmers adopt a mixed feeding programme; however, if purchased feeds are not formulated and fed correctly, the anticipated benefits from the use of purchased feeds may not be achieved.

This finding supports Thapa et al. (2019), who suggested that supplementation of feeds alone does not increase milk production unless it is complemented with good ration formulation and feeding management. Likewise, Goopy and Gakige (2016). mentions that to achieve productivity benefits, feed investment should be supported by good

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management of the herd. The results overall indicate that at the Sub-County level of Matayos feed management practices affect milk yield more than expenditure of feed.

4.5 Grazing Contribution to Milk Yield

Grazing practices remain a central component of dairy feeding systems in Matayos Sub-County.

Table 5

Correlation between Grazing Contribution and Milk Yield

Variable	G1	E1
G1 (Milk yield)	1	0.085
E1 (Grazing contribution)	0.085	1

Pearson correlation: r = .085, p = .091

The relationship between grazing contribution and milk yield was examined using Pearson correlation analysis as presented in Table 5. The correlation between grazing and milk production is found to be weak positive (r = 0.085) and the p-value (0.091) is not significant at 5%.This means that grazing has a small effect on the production of milk, but this had little significance for the statistical relationship in the study area. The low correlation indicates that differences in grazing practices of the smallholder farmers do not significantly account for differences in milk yield in Matayos Sub-County.

Practical implications of this result might be attributed to the fact that the grazing systems studied are primarily extensive and unmanaged, and management of pasture quality, grazing duration, and nutrient balance is very limited. This means that grazing has an inconsistent impact on productivity within households.

The lack of significance of the relationship (p = 0.091) further implies that grazing alone is not a good indicator of milk yield. However, the situation is typically more complex involving feeding management (grazing and supplementary feeding) and herd management.

The result agrees with the result of Njarui et al. (2011) who found that grazing only contributes to milk production when pasture quality and management is improved. Likewise, Mugumya et al. (2026) state that grazing systems should be supported by better management of their food and feed to realize substantial productivity gains. The results as a whole imply that the role played by grazing in Matayos Sub-County is supportive but not statistically significant in determining milk yield.

4.6 Relationship Between Feed Purchase and Milk Price

Table 6

Correlation between Feed Purchase and Milk Price

Variable	D1	G2
Feed Purchase (D1)	1	-0.121*
Milk Price (G2)	-0.121*	1

Pearson correlation: r = –0.121, p = .016

As per the correlation table, feed purchase (D1) is negatively correlated with milk price (G2) and has a weak correlation with r = -0.121 and p = 0.016. The correlation between the two is statistically significant at 5%.

This means that higher expenditures on purchased feed is associated with slightly lower farm-gate milk prices. But this is a weak relationship and little impact on milk pricing. The findings indicate that the price of milk in Matayos Sub-County is largely influenced by market conditions and the bargaining power of the buyers rather than the cost of production which is mainly that of feed expenditure. This is typical of non-cost-based markets, such as informal dairy markets. Higher feed investments were also reported to improve productivity, but this is not necessarily to raise milk prices in informal market systems, because of Swai and Karimuribo (2011)

4.7 Relationship Between Animal Costs and Milk Yield

Table 7

Correlation between Animal Costs and Milk Yield

Variable	G1	Animal Cost
G1 (Milk yield)	1	-0.127*
Animal Cost	-0.127*	1

Pearson correlation: r = –0.127, p = .011

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The animal costs and milk yield correlation matrix shows that there is weak negative correlation with r = -0.127 and p = 0.011. The correlation is statistically significant at 0.05 level. The negative value of r (-0.127) suggests that there exists a weak relationship between animal related costs and milk yield, with a slight decrease in milk yield as costs increase. Even though the relationship is small, the significance value p = 0.011 (< 0.05) shows the relationship that is statistically significant.

This indicates that the investments made in the animal (and other animal-related costs) do not always lead to an improved milk production by the smallholder farmers. The weak negative relationship could be due to inefficiencies in the herd management practices, as there is an increase in input expenses without any commensurate increase in the productivity output. As is true for other production factors studied, milk yield seems to be more related to management practices than just costs. This finding supports the argument by Wambugu et al. (2011). that productivity gains depend on integrated herd management strategies rather than isolated investments in livestock.

4.8 Cooperative Participation, Milk Yield, and Milk Price

Cooperatives play an important role in the dairy value chain by facilitating collective marketing and improving market access.

Table 8

Relationship between Cooperative Costs, Milk Yield, and Milk Price

Variable	G1	G2	Coop Cost
Milk Yield (G1)	1	-	-0.337**
Milk Price (G2)	-	1	0.129**
Cooperative Cost	-0.337**	0.129**	1

The cooperative cost is weakly negatively correlated with milk yield (r = -0.337, p < 0.01) and weakly positively correlated with milk price (r = 0.129, p < 0.01) as indicated in the correlation results. The value r = -0.337 indicates a moderate negative correlation between the cooperative costs and milk yield, that is, higher value of cooperative cost is related to lower milk production. There is a relationship between these that is statistically significant and thus may be seen as an effect in the data. The value 0.129, on the other hand, indicates that there exists a weak but significant positive relationship between cooperative participation cost and milk price, implying that farmers who join cooperatives are likely to get slightly higher price for milk.

The results indicate that there is a dual impact; cooperative participation may increase costs and hence decrease the production capacity slightly, but it can also enhance the bargaining power and market access and subsequently result in better milk prices. This suggests that although cooperative participation may impose financial obligations on farmers, it also enables them to access better market prices through collective bargaining and improved market linkages. Studies by Omore et al. (2019) and Thorpe et al., 2000) similarly show that cooperative membership improves farmers' access to formal markets and enhances price negotiation power.

4.9 Distribution of Milk Prices Across Market Segments

This study focused on the farmer's milk pricing pattern in Matayos Sub-County. The results showed that most of the farmers (62.9%) sold milk at KSh 40 – 50 per litre. Another 31.6% of the farmers sold their milk for KSh 51 to KSh 60 per litre and just 5.5% of the farmers got between KSh 61 and KSh 70 per litre. These results suggest that the majority of the farmers are in the lower price segment of the dairy market with a small minority in the higher price segment of the market opportunities.

This distribution indicates that most farmers operate within lower price segments of the dairy market. Limited market access and dependence on informal traders contribute to these pricing patterns. Similar findings were reported by Goopy and Gakige (2016) and Makoni et al. (2014), who observed that smallholder farmers often receive lower milk prices due to weak bargaining power and limited access to formal dairy markets.

4.10 Market Participation and Milk Supply: Chi-Square Results

Focus group discussions provided additional insights into the relationship between milk production and market participation.

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Table 9
Chi-square Analysis of Market Participation

Variable Pair	df	χ^2	p-value	Relationship
Milk Yield × Market Channel	3	28.724	0.000	Significant
Price per litre × Market Channel	2	42.551	0.000	Significant
Duration of Selling × Market Channel	2	12.347	0.002	Significant

Note: Cramer's V values indicate strength of association (0.1 = weak, 0.3 = moderate, 0.5 = strong). All expected cell counts were greater than 5. Standardized residuals were examined to determine the direction of associations.

The chi-square results in Table 9 show statistically significant associations between market channel and milk yield ($\chi^2 = 28.724$, df = 3, p = 0.000), milk price ($\chi^2 = 42.551$, df = 2, p = 0.000), and duration of selling ($\chi^2 = 12.347$, df = 2, p = 0.002). The results showed that all the relationships are statistically significant ($p<0.05$), thus, the differences of milk yield, milk price and duration of selling among the farmers are related with the market channel.

Price per litre has a moderate association with market channel ($V \approx 0.32$) and milk yield ($V \approx 0.27$) has a weak to moderate association, whereas duration of selling ($V \approx 0.18$) shows a weak association. In other words, the impact of market channel is significant, but not significant enough to be considered a strong effect. The standardized residuals show that farmers in formal market channels are more likely to be in higher milk price categories, while farmers in informal market channels are more likely to be in lower price categories. This pattern is directly related to the strong association between market channel and price as indicated by the χ^2 result (42.551, p = 0.000). Overall, the results presented in the tables indicate that participation in the market is strongly related to milk production and pricing outcomes but the relationship is weak to moderate in some cases.

4.11 Observed Production Factors Influencing Milk Supply

Observation data were used to assess key production factors influencing milk supply.

Table 10
ANOVA Results for Production Factors

Factor	F	p-value
Dairy breed type	2.684	0.070
Feed availability	4.415	0.013
Animal health status	5.373	0.005

Dairy breed type is not statistically significant for milk supply because the p-value (0.070) is > 0.05. Table 10 shows the ANOVA results for the dairy breed type. This suggests that there is no significant difference in milk supply, which is due to differences in breed type, between farmers in the study area. The availability of feed on the other hand has a statistically significant effect on milk supply (F = 4.415, p = 0.013). The result is that the level of milk production can vary considerably depending on the availability of feed and greater access to feed correlates with higher milk production.

Similarly, health status of animals (F = 5.373, p = 0.005) had a significant impact on milk supply, meaning that better managed herds are able to produce more milk than poor managed herds. In general, the findings indicate that feed availability and animal health are factors with significant impacts on milk supply, but the dairy breed type was not statistically significant in this study scenario. These findings support the work of Goopy and Gakige (2016. and Njarui et al. (2011), who emphasized that proper feeding systems and veterinary care are essential for sustaining dairy productivity in smallholder farming systems.

4.12 Overall Interpretation of Findings

The findings demonstrate that milk supply in Matayos Sub-County is shaped by an interaction of production inputs, cooperative participation, and market structures, rather than by any single factor. While feed purchase, grazing systems, and animal-related investments influence milk yield, their effect on milk price is limited, indicating a weak transmission between production decisions and market outcomes. A notable and somewhat unexpected finding is the weak or negative relationship between feed purchase and milk yield, as well as between production costs and milk price. Variations in feed quality, inefficient feeding practices, and the absence of standardized rationing systems among smallholder farmers may explain this. In addition, increased expenditure on inputs does not guarantee higher returns in contexts where buyers within informal market systems largely determine milk prices. As a result, farmers who invest more in production do not necessarily benefit from higher prices, reflecting structural inefficiencies within the dairy value chain.

The positive association between cooperative participation and milk price suggests that collective marketing improves bargaining power and access to more stable markets. However, the negative relationship between cooperative

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costs and milk yield indicates that financial obligations associated with cooperative membership may constrain farm-level investment in productivity. This highlights a trade-off between market access and resource allocation at the household level. From a policy perspective, the findings point to the need for integrated interventions that address both production and market constraints. First, there is a need to strengthen dairy cooperatives through improved governance, transparency, and pricing mechanisms to ensure that farmers receive fair and consistent returns. Second, investments in rural dairy infrastructure, including milk collection centers, cooling facilities, and transport networks, would reduce post-harvest losses and enable farmers to access higher-value markets. Third, extension services should focus on improving feed quality, ration formulation, and herd management practices rather than simply promoting increased input use. Finally, the development of market information systems could help farmers make informed production and marketing decisions by improving price transparency.

Despite these contributions, the study has several limitations. First, the use of cross-sectional data limits the ability to establish causal relationships between variables and does not capture seasonal variations in milk production and pricing. Second, key variables such as milk yield and production costs were based on farmer recall, which may introduce measurement error. Third, the model explains only a small proportion of the variation in milk price, suggesting the presence of omitted variables such as buyer characteristics, contractual arrangements, and institutional factors that were not captured in the analysis. These limitations should be considered when interpreting the findings and highlight the need for future research using longitudinal data and more comprehensive modeling approaches.

V CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

This study contributes empirical evidence on how milk price and selected production factors are jointly associated with milk supply among smallholder dairy farmers in Matayos Sub-County, Busia County. The findings show that while production inputs such as feed, grazing, and animal-related costs influence milk yield, their effect on milk price is limited. Instead, milk pricing is largely shaped by market access, cooperative participation, and value chain dynamics. A key contribution of this study is the identification of a weak linkage between production investment and market returns, indicating that increased expenditure on inputs does not necessarily translate into higher prices or improved income for farmers. This highlights structural inefficiencies within the dairy value chain, particularly in informal market systems where pricing is not cost-based. The study further demonstrates that cooperative participation can improve access to better and more stable prices, although associated costs may constrain farm-level investment in productivity. Overall, the findings emphasize that improving milk supply requires a dual focus on both farm-level efficiency and market system development.

5.2 Recommendations

Based on the findings, improving milk supply among smallholder dairy farmers in Matayos Sub-County requires coordinated interventions that address both production efficiency and market constraints. Strengthening dairy cooperatives should be prioritized to enhance farmers' access to reliable and higher-value markets. This includes improving cooperative governance, ensuring transparency in pricing systems, and enhancing milk aggregation and marketing structures so that farmers can benefit more consistently from collective action. In addition, there is a need for targeted investment in dairy infrastructure, particularly milk collection centers, cooling facilities, and rural transport networks. Such investments would reduce post-harvest losses, improve milk quality, and enable farmers to access formal market channels where prices are generally more stable and favorable.

At the farm level, extension services should shift focus from encouraging increased expenditure on inputs to promoting efficient resource utilization. Emphasis should be placed on improving feed quality, proper ration formulation, and overall herd management practices, as these have a more direct impact on productivity than simply increasing input use. Furthermore, the development of accessible and reliable market information systems is essential. Providing farmers with timely information on prevailing milk prices and market conditions would enhance their bargaining power, reduce dependence on intermediaries, and support more informed production and marketing decisions.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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