

**ROLE OF PRODUCER ORGANIZATIONS IN IMPROVING MILK
PRODUCTION AND SAFETY AMONG DAIRY FARMERS IN SOUTH IMENTI,
MERU COUNTY, KENYA**

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**A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements
for the Master of Science Degree in Agribusiness Management of Egerton University**

EGERTON UNIVERSITY

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DECLARATION AND RECOMMENDATION

Declaration

I declare that this is my original work and has never been submitted to any other learning institution for an award of a degree.

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DEDICATION

I dedicate this thesis to my children Janipher, Henry, Jeconia and Barack.

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ABSTRACT

To determine the role of producer organizations (PO) in improving milk production and safety among dairy farmers the study was anchored on cross-sectional research design, relevant data was collected on identified variables between October and November 2018. Multi-stage sampling technique was employed to select the sample of 282 dairy farmers (182 PO members and 100 non-members) in South Imenti sub-county, Meru County, Kenya and the data was analyzed using SPSS and STATA. From the descriptive and independent sample t-tests results there was statistically significant difference in milk production of dairy farmers as well as difference in performance of producer organizations in South Imenti sub-county. The average annual quantity of milk (8207 litres) produced by members was twice that produced by non-members (4099 litres). Poisson regression results also indicated that producer group membership had a positive and significant influence on farm-level implementation of milk hygiene strategies. Further, Probit regression results identified institutional factors, including access to credit, distance to milk collection centres, and milk prices as the most crucial factors that positively influenced membership in producer organizations. Superior animal breeds and hours spent on dairy production activities encouraged membership and enhanced milk production. Endogenous switching regression results revealed positive and significant effects of producer organizations on actual and counterfactual scenarios for both members and non-members. Therefore, dairy farmers experiencing technical difficulties should be targeted and encouraged to participate in PO (e.g. dairy cooperatives) to develop their capacity on milk production and safeguarding milk quality and safety standards to improve the performance of dairy enterprises. Moreover, the capacity and capability of already existing producer organizations and other like-minded organizations should be strengthened to deliver training, extension, and education to technically challenged smallholder dairy farmers.

TABLE OF CONTENTS

DECLARATION AND RECOMMENDATION	ii
COPYRIGHT	iii
DEDICATION	iv
ACKNOWLEDGEMENTS	v
ABSTRACT	vi
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS AND ACRONYMS	xii
CHAPTER ONE	1
INTRODUCTION.....	1
1.1 Background Information	1
1.2 Statement of the problem	4
1.3 Objectives of the Study	4
1.3.1 General Objective	4
1.3.2 Specific Objectives	4
1.4 Research Questions	4
1.5 Justification and significance of the study	5
1.6 Scope and Limitation of the Study	5
1.7 Operational Definition of Terms	6
CHAPTER TWO	7
LITERATURE REVIEW	7
2.1 Effect of Producer Organization on Milk Yield.....	7
2.2 Role of Producer Organizations in Implementation of Milk Hygiene Strategies	9
2.3 Effect of Membership in Producer Organizations on Dairy Enterprise Performance....	11
2.4 Theoretical Framework	12
2.5 Conceptual Framework	14
CHAPTER THREE	17
METHODOLOGY.....	17
3.1 Study Area.....	17

3.2 Research Design.....	18
3.3 Target Population	18
3.4 Sampling Design and Sample Size Determination	18
3.5 Data and Data Collection	19
3.6 Analytical Framework.....	19
3.6.1: Objective 1: To compare milk yield of producer organization members and non-producer organization members	19
3.6.2: Objective 2: To determine the role of producer organizations on farm-level implementation of milk hygiene strategies.....	20
3.6.3: Objective 3: To measure the effect of producer organization membership on dairy enterprise performance	22
CHAPTER FOUR.....	28
RESULTS AND DISCUSSION	28
4. 1 Characteristics of Dairy Farmers.....	28
4.1.1 Socio-demographic Characteristics of Dairy Farmers.....	28
4.1.2 Enterprise Characteristics of Dairy Farmers	31
4.1.3 Comparison of Milk Yield.....	37
4.2 Role of Producer Organization on the Level of Farm-level Implementation of Milk Hygiene Strategies.....	44
4.2.1 Training on Milk Hygiene Strategies	44
4.2.2 Farm-level Implementation of Milk Hygiene Strategies	45
4.2.3 Influence of producer organization membership on farm-level implementation of milk hygiene strategies	49
4.3 Effect of producer organizations on dairy enterprise performance.....	52
4.3.1 Preliminary Diagnostic of ESR model	52
4.3.2 Determinants of Producer Organization Membership.....	53
4.3.3 Effect of Producer Organization Membership.....	56
4.3.4 Treatment Effects	59

CHAPTER FIVE	61
CONCLUSIONS AND RECOMMENDATIONS.....	61
5.1 Conclusion.....	61
5.2 Recommendations	61
5.3 Areas of Future Research	61
REFERENCES.....	63
APPENDICES.....	74
Appendix A: Questionnaire.....	74
Appendix B: Multicollinearity Test	86
Appendix C: ESR Diagnostics	86
Appendix D: ESR Results	88
Appendix E: Research Permit	91
Appendix F: Ethical approval	93
Appendix G: Publication Abstract	95

LIST OF TABLES

Table 3.1: Distribution of sample size	19
Table 3.2: Description of variables for Objective 2.....	22
Table 3.3: Description of variables used in ESR framework.....	27
Table 4.1: Socio-demographic characteristics of dairy farmers	30
Table 4.2: Summary statistics of farm characteristics of dairy farmers disaggregated by producer organization membership.....	32
Table 4.3: Correlation coefficients of the relationships among PO membership, access to services, and milk produced.....	39
Table 4.4: Average milk production, yields, and volumes produced by producer organization member disaggregated by name of producer organizations	40
Table 4.5: Summary results of percentages of farmers that reported receiving milk hygiene training over a three-year period.....	44
Table 4.6: Comparisons of percentages of farmers implementing milk hygiene strategies by status of membership in dairy producer organizations	47
Table 4.7: Poisson coefficient estimates of influence of dairy producer organization membership on level of farm-level implementation of milk hygiene strategies	50
Table 4.8: Probit regression results of determinants of dairy producer organization membership.....	54
Table 4.9: OLS estimates of milk production per cow	57
Table 4.10: ESR estimates of producer organization membership on farm-level performance	59

LIST OF FIGURES

Figure 2.1: Diagrammatic Representation of Conceptual Framework	16
Figure 3.1: Map of study area	17
Figure 4.1: Proportions of producer organization membership by sex of the farmers	29
Figure 4.2: Percentages of marital status of dairy farmers disaggregated by membership to dairy producer organization	29
Figure 4.3: Proportions of farmers that engaged in other farm and non-farm activities disaggregated by membership to producer organizations.....	31
Figure 4.4: Proportions of breeds of cows owned by members and non-members of producer organizations	33
Figure 4.5: Proportions of members and non-members of producer organizations owning different dairy cows	34
Figure 4.6: Distance to the nearest milk collection point by membership to producer organizations	35
Figure 4.7: Average annual prices of milk received by members and non-members of producer organizations.....	36
Figure 4.8: Percentages of farmers' access to credit during twelve months of milk production cycle	36
Figure 4.9: Average number of hours spent on dairy production activities by members and non-member of producer organizations	37
Figure 4.10: Average annual volumes (litres) of milk produced by producer organization members and non-members	38
Figure 4.11: Distribution of milk produced by members and non-members of producer organizations	39
Figure 4.12: Percentages of sampled producer group farmers that reported to have received services disaggregated by producer organization	41
Figure 4.13: Percentages of sampled farmers that owned pure breed cows disaggregated by name of producer organization	42
Figure 4.14: Governance of producer organizations	43

LIST OF ABBREVIATIONS AND ACRONYMS

ESR:	Endogenous Switching Regression
FAO:	Food and Agriculture Organization (of the United Nations)
GDP:	Gross Domestic Product
KDB:	Kenya Dairy Board
LIQUID:	Local and International Business Collaboration for Productivity and Quality Improvement in Dairy chains in Southeast Asia and East Africa
MLE:	Maximum Likelihood Estimator
MoALF:	Ministry of Agriculture, Livestock and Fisheries
OECD:	Organization for Economic Co-operation and Development
PO:	Producer Organization
PRM:	Poisson Regression Model
QBMPS:	Quality Based Milk Payment System

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Worldwide milk production has increased steadily in the last three decades. The global milk output increased from 530 million tonnes in 1988 (FAO, 2020a) to 906 million tonnes in 2020 representing more than 70% increase (FAO, 2021). According to OECD-FAO (2021) projections, worldwide milk output is expected to rise by 1.7% per annum to 1,020 million tonnes by 2030. Growth in global milk output is attributed to the increases in milk production in the Asia, Europe, the Americas, Oceania and Central America with Asia recording the highest milk output increases (FAO, 2021). The increases in milk output is further attributed to increasing dairy herd sizes, improvements in milk collection, increased per cow milk yield, continued integration of dairy production systems and improved production and operational efficiency as well as higher global demand for milk and milk products in the respective regions (FAO, 2021).

Per capita milk consumption, which is an indicator of demand, has nearly doubled in developing countries since the early 1960s (FAO, 2020b) and is projected to rise over the coming decade due growing demand for milk and milk products as result of increases in population and income. Per capita milk consumption was averagely 23.6kg and 10.6 kg respectively in developed and developing countries in 2018-2020 and is projected to rise by 1% per annum to 25.2kg in developed countries and 12.6kg in developing countries by 2030 (OECD-FAO, 2021). These statistics are a clear indication that worldwide milk production is sufficient to meet the global demand for milk and milk products. However, in some regions such Africa, milk output is expected to rise at a slower rate than milk consumption due to poverty and unfavourable climatic conditions (OECD-FAO, 2021). Hence, the dairy sector has a crucial role in sustaining the rising demand for milk and milk products.

East Africa is one of the leading regions in Africa with the fastest growing dairy sector. According to the East and Southern Africa Dairy Association report (2018), the East African region accounts for about 27.5% of the total milk output on the continent. According to the report, the region produced about 12 billion litres of milk in 2017. The report further attributes the significant contribution of the region's dairy sector to its robust economic growth. In particular, the rise in milk production is attributed to increases in milk output in Kenya, Ethiopia, Tanzania, and Rwanda. Kenya is the dominant player in the East African dairy sector. According to FAO (2019), milk output in Kenya rose from 3.4 million tonnes in

2014 to about 4.1 million tonnes in 2016, before declining to about 3.6 million tonnes in 2017. Ethiopia is second largest milk producer in the region, the milk output in Ethiopia was about 3.3 million litres and 3.1 million litres of milk in 2014 and 2017, respectively.

Dairy farming is the most dominant and leading sub-sector in the Kenyan livestock sector. The dominance of the dairy sub-sector is reflected through its contribution to the agricultural gross domestic product (GDP) and the national GDP. The sector accounts for about 14% of the agricultural GDP and about 8% of the Kenyan GDP (Odero-Waitituh, 2017). The dairy sub-sector is an important source of livelihoods for over 1 million smallholder farmers in the country. Furthermore, it is estimated that the Kenyan dairy sub-sector is the fastest growing in Sub-Saharan Africa. This is reflected in increasing annual milk production, which was about 5.2 billion litres in 2018 (Kibogy, 2019; Muchira, 2018). Milk output in Kenya is projected by KDB to rise to 12 billion litres by 2030 (Kibogy, 2019). The aforementioned statistics underpins the importance of the dairy sub-sector in the socioeconomic development of rural economies and the national economy at large.

The phenomenal performance of the dairy is buoyed up by the increasing milk consumption in Kenya. The Kenyan per capita milk consumption stood at 100 litres by 2015 and 120 litres in 2018 (Bingi & Tondel, 2015; Muchira, 2018). Rising incomes, rising population, urbanization and changing lifestyles are the main drivers of milk consumption in the country. Furthermore, it is projected that per capital milk consumption will rise to about 220 litres by 2030 (Bingi & Tondel, 2015). This provides a positive outlook for the dairy sub-sector in the country as this will make Kenya achieve the World Health Organization annual per capita milk consumption of 200 litres.

Meru County is among the highest milk producing regions in Kenya. The county has approximately 180,000 dairy cattle producing 120,000,000 litres of milk (MoALF, 2016) and according to Mugambi *et al.* (2014) output in milk can be increased by 16.3% by improving the efficiency of the dairy farms. Despite the favourable ecological condition in the region that supports agricultural production, dairy farming is mainly dominated by smallholder farmers with majority of the dairy farmers owning one to three milking cows that produce less milk than their genetic potential due to poor adoption of proper feeding strategies (Mugambi *et al.*, 2014).

According to Bingi and Tondel (2015), the supply side factors constrain the full utilization of milk processing capacity. Firstly, smallholder farmers are constrained by high milk collection costs (Bingi & Tondel, 2015). The smallholder farmers are sparse and milk

collectors have to incur significant costs that are passed on to the farmers. This increases marketing costs which is a disincentive to farmers participating in formal markets.

Secondly, smallholder farmers are constrained by high milk production costs. This prevents adoption of improved breeding and feeding technology with a potential of improving milk yield per cow thus limiting the expansion of dairy production. According to Ton *et al.* (2016), the average milk yield per cow ranges between 2-10 litres among cooperatives operating in the central region, the highest milk production region in the country. Notably, Ton *et al.* (2016) revealed that most of the cooperatives buy milk from informal peddlers which compromises milk quality. The informal market accounts for 86% of the total milk output in Kenya (Alonso *et al.*, 2018; Silali & Shimba., 2017).

Despite the increasing pressure on the dairy sector to meet the regulations by the Kenya Dairy Board (KDB) on safety of dairy produce, labelling and packaging of dairy produce, procedure for examining of dairy produce, storage and distribution of dairy produce, milk safety in dairy, design, location and construction of milk collection centers, milk bars and milk dispensers, milk processing establishments (Dairy Produce Safety Regulations, 2020), inadequate availability of quality milk is an important constraint to the dairy sector. A majority of the smallholder farmers have limited access to technical information about milk hygienic strategies. Additionally, milk is contaminated during collection. The milk collection processes in some formal milk collection systems do not strictly adhere to hygienic milk handling procedures, which negatively impacts on milk quality. Together, these bottlenecks reduce the potential of households to increase the performance of dairy enterprises and are a clear indication that the full potential of producer organizations has not been met in Kenya.

Collective action is cited as being crucial to enabling farmers to overcome bottlenecks they face. By organizing themselves into producer organizations that provide capacity building services, smallholder farmers are supported to overcome production and marketing challenges thereby improving their livelihoods. Producer organizations provide extension services that enhance dairy farmers' technical capacity in adhering to milk quality strategies (Ton *et al.*, 2016) as well as take social responsibility of creating awareness and enforcing milk quality and safety measures at farm and market levels. For instance, producer organizations conduct impromptu farm level visits to ensure that farmers adhere to milk quality strategies. They offer farmer training in milk handling and encourage adoption of clean storage equipment (Ton *et al.*, 2016). By registering serious farmers and enforcing

quality control measures, producer organizations are able to make attractive payments for quality milk.

1.2 Statement of the problem

Enhanced production of high quality and safe milk is a pathway to closing existing gaps in milk production vis-à-vis consumption. The demand for high quality milk still outstrips its supply. This is attributed to low milk production, poor milk handling practices and domination of the sub-sector by informal and unregulated milk marketing channel. Most importantly, concern for food safety and health demands an improvement in the quality of milk produced. Furthermore, the role of producer organizations in enhancing milk quality at farm-level has not been adequately exploited and a comparison of the effect of producer organizations and informal channels on dairy enterprise performance least captured. To narrow the gaps between increased demand for high quality milk and its supply, dairy farmers' access to formal markets through producer organizations needs to be improved. This study therefore sought to determine the role of producer organizations in improving milk production and quality as well as ascertaining the extent to which producer organizations have succeeded in improving dairy enterprise performance in South Imenti sub-county, Meru County.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this study was to contribute towards improved welfare of farmers in South Imenti sub-county, Meru County through improved performance of the dairy enterprises.

1.3.2 Specific Objectives

- i. To compare milk yield of producer organization members and non-producer organization members.
- ii. To determine the role of producer organizations on farm-level implementation of milk hygiene strategies.
- iii. To measure the effect of producer organization membership on dairy enterprise performance.

1.4 Research Questions

- i. What is the difference between milk yield of famers affiliated to producer organizations and non-producer organization members?
- ii. What is the role of producer organizations on farm-level implementation of milk hygiene strategies?

- iii. What is the effect of producer organization membership on dairy enterprise performance?

1.5 Justification and significance of the study

Dairy farming is one of the major agricultural activities practiced all over the world. The livestock sub- sector plays a vital role in improving the welfare of the farmers in both rural and urban areas through its contribution to poverty alleviation as well as food and nutritional security. In addition, it generates significant economic returns and employment opportunities along the dairy value chain. Increased production of safe and high-quality milk is vital for sustainability and development of the dairy sub-sector. It facilitates exploitation of opportunities in the global market and ensures that consumers demand for safe and high-quality milk and milk products is efficiently and effectively met.

This study contributes to a body of knowledge around milk production with highlights on a comparative analysis of quantity and safety as well as the ability of producer organizations to enhance dairy enterprise performance. In addition, the study provides information around producer organizations with regard to their contribution to milk production highlighting their strengths and weaknesses which subsequently would be made available to both the producer organizations and farmers for decision making. Further, the findings of this study provide relevant information for policy formulation aimed at improving performance of producer organizations and growth of the dairy industry in the: area under study, country, continent and world at large.

1.6 Scope and Limitation of the Study

This study focused on the role producer of organizations in dairy sub-sector to enhance milk production and quality as well as the performance of the dairy enterprises in South Imenti sub-county, Meru County. Dairy farmers affiliated to producer organizations and non-producer organizations members were targeted to provide data that was used in this study. Cross –sectional data was analysed to report findings and to draw conclusions on the subject matter of the study hence does not capture the dynamics that occur in production and collective action over time. Furthermore, this study focused on one milk producing sub-county in Meru County, hence does not provide a representation of the facts around milk production and producer organizations at the county and national level.

1.7 Operational Definition of Terms

Collective action:	An institution involvement in which people, social or economic agents of shared interest voluntarily engage in a common action in pursuit of the shared interest
Formal markets:	Refers to the legally registered milk marketing channels in the dairy value chain.
Informal markets:	Refers to non- registered milk marketing channels in the dairy value chain.
Milk hygiene strategies:	Refers to the sanitary strategies farmers pursued to ensure production of clean milk that is safe for human consumption
Enterprise performance:	The average annual litres of milk produced per dairy cow per year
Producer organization:	These are formal milk marketing channels and they include dairy cooperative societies and self-help groups.
Dairy value chain:	The various stages through which milk and milk products pass from farm to the final consumer.
Pure breed:	Refers exotic or imported breed, they are high yielding milk cows

CHAPTER TWO

LITERATURE REVIEW

This chapter presents relevant literature and empirical evidence on role of producer organizations in enhancing milk yield and quality and its impact on dairy enterprise performance, theoretical framework and conceptual framework.

2.1 Effect of Producer Organization on Milk Yield

Producer organizations provide production and marketing incentives to smallholder farmers, especially in the developing countries. As a result, empirical studies investigating the effect of producer organizations on milk yield are increasing. Kumar *et al.* (2018) assessed the Impact of Dairy Cooperatives on Farmers' Performance among smallholder dairy farmers in Bihar, India. Some of the indicators were milk production and yield, and price per unit of butter and milk. The study employed endogenous switching regression (ESR) framework to estimate the parameters. Results revealed there is a significant difference in the milk yield between members and non-members of dairy cooperatives. The milk yield is significantly higher for cooperative members than for non-members. This signified the positive relatedness of producer organizations membership and milk yield.

Neutzling *et al.* (2017) investigated the relatedness of milk production of integrated farms and milk marketing via private dairy companies and cooperatives in Brazil. The study also focused on the relationship between milk production and herd size, land and dairy inputs. Neutzling *et al.* (2017) found that selling via cooperatives and private companies significantly improved milk production per day per cow. Additionally, they established that land area under fodder crop, pasture area, and amount of concentrates were positively and significantly associated with dairy milk production. They argued that cooperatives strongly advised and trained farmers on feeding strategies and seasonal utilization of pastures to guarantee good milk production.

Lal and Chandel (2017) reported that herd size was positively associated with milk yield in India. In contrast, Andaleeb and Khan (2017) applying Cobb-Douglas production function, found that herd size was negatively related to milk production among dairy farmers in Pakistan, Andaleeb and Khan (2017) noted that small-sized dairy farms were more productive compared to large-sized dairy farms. In another study, conducted on sustainable conditions of agricultural cooperatives, Sultana *et al.* (2020) found that dairy cooperative societies of Sirajgonj District in Bangladesh provided technical assistance through training and extension services, assured farmers of secured market for their produce and offered a fair price thus contributing to enhanced production and increased income for the farmers.

Expanding market choices for smallholder farmers is a pathway for empowering and enabling them capture benefits of the growing demand of animal products. Consequently, membership to farmer cooperatives was identified as a modern approach of contributing to improved efficiency and scale of dairy production by providing incentives and overcoming production and market risks (Neupane *et al.*, 2022 & Olagunju *et al.*, 2021). BIRTHAL *et al.* (2017) compared the role of informal and formal dairy value chains in India with the view of disentangling their role in the performance of dairy farms. In contrast, BIRTHAL *et al.* (2017) and Neutzling *et al.* (2017), multinomial treatment effects model indicated positive but statistically insignificant effect of participation in formal value chains (cooperatives, milk processors, and multinational companies) on milk yield.

Improving milk yield is not sufficient in meeting the ever-increasing global demand for milk and other animal products. Therefore, there is increasing desire of sustaining high production of livestock products. Mahida *et al.* (2018) recognized that although the Indian dairy sub-sector has progressed commendably in terms of milk production, milk yield remained significantly low. Consequently, they conducted a study to establish the potential role of dairy cooperative societies on sustainable milk production. Using multiple linear regression, they found that membership to dairy society positively and significantly influenced the technical aspects of dairy farming, enhancing the potential of sustainable milk production. The study attributed the change to the role of dairy cooperatives in provision of technical information to farmers.

Aspirations about a product, service or technology determines individual behaviour. The implication is that besides the socioeconomic and institutional factors, individual aspirations may also play a significant role in enhancing growth of agricultural productivity. Funde *et al.* (2018), showed that farmers have multiple aspirations that support them to utilize resources more efficiently and effectively thus improving productivity. Mausch *et al.* (2018) suggested that aspirations of people have a very big effect on the choice of technology therefore an in-depth understanding of aspirations enhances researchers development of technological targets.

Studies by BIRTHAL *et al.* (2017), Neutzling *et al.* (2017) and Kumar *et al.* (2018) provided good background information on the role of cooperative in enhancing milk production and productivity. This study therefore sought to establish if the situation was replicated in South Imenti Sub- County, Meru County, Kenya.

2.2 Role of Producer Organizations in Implementation of Milk Hygiene Strategies

There are several strategies farmers can adopt at farm level to enhance milk quality. Taking a case study of Smallholder Dairy Farmers in Bihar, India, Kumar *et al.* (2018), identified 42 milk hygiene strategies. The strategies were categorized into two broad categories: control of chemical and microbiological hazards. Farmers are perceived to be rational in making decisions on the type of enterprises to venture in on the farm. Consumers are health conscious and demand healthier and safe food (Fung *et al.*, 2018). However, Cardoso *et al.* (2018) highlighted disconnects in expectations of farmers and consumers. The disconnect arose from farmers' emphasis of the economic aspect of milk production and consumer emphasis on milk quality. Consequently, milk quality is a point of concern in the dairy value chain.

In a comparative study, Resti *et al.* (2017) reported that large dairy cooperatives performed better than small cooperatives and private companies in quality assessment of milk supplies in West Java Province, Indonesia. Furthermore, the study established that large cooperatives experienced problems in collecting quality milk because of low commitment by members and shortage of quality fodder. This finding appeared to suggest that animal feed and level of engagement of farmers in cooperative activities predict milk quality.

Poor milk handling strategies results in post-harvest losses among dairy farmers. Ndungu *et al.* (2019) identified experience in dairy farming, breed type, total milk production, use of detergent to clean milk containers, feeding system and maintenance of records of production as the major causes of post-harvest losses. Moreover, Ziad *et al.* (2018) identified lack of proper training and illiteracy as important factors that determined the way in which farmers in Punjab province of Pakistan produced and handled milk. This finding underscored the importance of training in dairy production and management and the importance of education and extension in enhancing milk quality. Ziad *et al.* (2018) also attributed low milk quality to poor milk handling strategies in the informal marketing channels that were dominated by mid-chain agents. These findings revealed the importance of linking dairy farmers to the formal market channels through producer organizations.

A study by Nyokabi *et al.* (2021) revealed that there is low knowledge level and negative attitudes with respect to antibiotics treatment withdrawal periods, milk quality standards and food safety regulations among the smallholder dairy farmers, this is attributed to limited access to training on milk quality and safety standards. Majority of the farmers adopted animal health measures and hygienic measures such as hand washing and udder cleaning during milking exercise. However, use of plastic containers, the use of unsterilized

water, lack of teat dipping and unhygienic milking environment compromised milk quality and safety, a strong indication that health of consumers are at high risks during milk production, handling as well consumption.

Milk that is unhygienic can be a source of channel for the pathogens like bacteria, virus, chemical remains and parasitic carriers leading to food-borne ailments that adversely affect health and nutrition conditions of the consumers (Amenu *et al.*, 2019). According to Bava *et al.* (2017), the teat preparation procedure does not influence the lactic acid bacterial levels in the milk, which is very positive in that decreased lactic acid bacterial content lessens raw milk cheese quality. Clostridia in the milk results in late blowing and cheese defect. Clostridia are ubiquitous, originating from farm surrounding and feed fed to the dairy cow which are further contracted through faeces. Studies by Amenu *et al.* (2019) found that low quality milk as well as safety risks pose a great bottleneck within the dairy industry among low to medium income earning nations which are characterised by unstable food safety management systems which lowly comply to food safety standards.

Kumar *et al.* (2017), using multiple linear regression and ordered logit model, found that uptake of hygiene strategies was correlated with the herd size, farmer access to information, and enforcement of quality standards. Belage *et al.* (2018) used Chi-square tests to establish the association of adoption of hygiene strategies with a number of explanatory variables in Canada. Findings corroborated Kumar *et al.* (2017) result that adoption of milking hygiene strategies was associated with herd size. Additionally, in contrast to Belage *et al.* (2018) and Carloni *et al.* (2016) established that milking system as well as geographical area influenced the adoption of hygiene strategies. Sannino *et al.* (2018) evaluated the potential effect of automatic milking system on the quality of buffalo milk in Campania, Italy.

Producer organizations offers a package of advisory and veterinary services to members. This increases access to services that are not easy to access in the market. Results from least square analysis obtained by DeLong *et al.* (2017) indicated that farmers' access to extension and veterinary information improved milk quality in south-eastern United States. Additionally, parlour milking and farmers' perceptions about mastitis were important determinants of milk quality. Ritter *et al.* (2019) identified veterinary communication as critical in adoption of herd health recommendations that are important to high-quality milk production. Producer organizations increases the interaction of dairy farmers with veterinary officer through regular farm visits. Ndambi *et al.* (2019) indicated that dairy farmers in Kenya can clearly benefit from a QBMPS. However, a cost-benefit analysis indicated that a

QBMPS may not be financially viable due to the high cost incurred in the short term (Ndambi *et al.*, 2018).

This study was built on the study by Ziad *et al.* (2018) to determine the influence of producer organizations in enhancing farm-level implementation of milk hygiene strategies by dairy farmers.

2.3 Effect of Membership in Producer Organizations on Dairy Enterprise Performance

There is mounting empirical evidence that membership in producer organizations contributes to performance of the dairy enterprises in developing countries. The producer organizations are, therefore, an important aspect in the analysis of the economic impact of smallholder farmers' participation in the dairy enterprises. In fact, the economic importance of producer organizations appears to be acknowledged owing to the fragmented nature of dairy value chain in the developing countries. Consequently, development programs are increasingly focusing on increasing dairy farmers' access to information and markets. The aim of such programs is to create market linkages along the dairy value chain for increased input and output markets participation.

Ngeno (2018), applying endogenous switching regression, found that membership in dairy hub increased dairying net return of Kenyan smallholder farmers. The pathway towards increased net returns conditional on participation in dairy hubs was that members were able to decode new information offered by dairy hubs, translating into improved dairy or milk productivity. In another study conducted in India, Kumar *et al.* (2018) established significant difference in net returns between members and non-member of dairy cooperative societies. Members received significantly higher net returns from dairying compared to non-group members. Kumar *et al.* (2019) used nationally representative survey data of 14,276 dairy farmers to compare the effect of traditional and modern milk outlets on net returns from dairying in India. Net returns is used as a measure of dairy farm performance. Applying a multinomial endogenous switching regression, Kumar *et al.* (2019) found that all market outlets, traditional and modern, had positive treatment effects, implying higher net returns. Furthermore, the study established that selling via more than one milk-marketing outlet significantly increased farmers' net returns.

Aku *et al.* (2018) showed that besides group membership, differences in outcomes of vegetable market participation were also affected by socioeconomic factors. Applying PSM in estimation of the effect of market access on farmer's incomes, Aku *et al.* (2018) established that farm size was positively associated with smallholder vegetable farmers' incomes in Tanzania. This underlined the importance of access to productive resources in

enhancing farm incomes. Additionally, the study found that distance to the market as well as transportation cost were negatively associated with farmers' incomes. This result appeared to emphasize the necessity of institutional interventions in encouraging production and profitability of farming.

Ma and Abdulai (2017) using treatment effects model reported that farmers who marketed milk through dairy hubs generated significantly higher revenues and household incomes compared to non-participating farmers. They established that membership to agricultural cooperatives positively impacted on Chinese smallholder farmers' gross incomes, farm profits, and returns on investment. Mandi *et al.* (2022) using propensity score matching techniques revealed that socio-economic condition of dairy cooperative members differed significantly from non-members. Participation in the cooperative enhanced yield, improved household milk consumption and net dairy income. Cooperative members had a higher percentage of milk sale than their counterpart non-member milk producers indicating their intensity of market participation.

There are several factors that influences the performance of producer organizations. Pant *et al.* (2022) using structural equation modelling revealed that social capital and self-efficacy play a significant role as a partial mediator in influencing the performance of farmer producer organizations. In another study conducted by Singh (2023) on the impact of governance on performance of producer organisations, findings identified rules, members commitment to producer organisations, composition and roles of directors as well as democratic and transparent functioning of the board as the key management and governance factors that contribute to the greater performance of dairy enterprises.

Despite the studies by Bayan (2018), Liu *et al.* (2018) and Mandi *et al.* (2022) being instrumental to the understanding of the potential effects of producer organizations, they relied on PSM which may have suffered from unconfoundedness problem. This study employed endogenous switching regression. Endogenous switching regression adjusts for possible confounders by allowing measurement of heterogeneous treatment effects.

2.4 Theoretical Framework

This section provides a review of the theory that was used in this study to institute theoretical as well as methodological framework necessary for presenting the role of producer organizations in enhancing dairy enterprise performance. This study was based on the theory of collective action.

The theory of collective action was first published by Mancur Olson, an American economist in 1965. In his book, "The Logic of Collective Action, Olson argued that

organizations exist mainly to further the common interest of groups of individuals. He further acknowledged that all of the members of an organization have purely personal interests which are totally different from the common interest of the group members. Collective action is driven by the desire to take advantage of the existing opportunities or to overcome challenges to the pursuit of shared interest. The theory postulates that people can collectively exclude individuals who do not contribute to a common course (Raihani & Aitken, 2011). Collective action is also achieved by reducing the expected benefits of those who are unwilling to contribute (Delton *et al.*, 2012).

Collective action is facilitated by constant communication processes which culminate in a common understanding among different stakeholders (Klandermans *et al.*, 2002). Bengtsson and Kock (2000) observed that communication and agreement with stakeholders is necessary in competitive relationships in which the stakeholders are oriented towards a shared and common decision. Involvement in the communication process differs with the type of collective action. Processing collective action tend to exclude members who are less resource endowed, less educated, non-innovative, younger and unspecialized whereas bargaining producer organizations are more inclusive as they involve all stakeholders in the decision-making process irrespective of their social and economic status.

The Kenyan dairy value chain faces multiple challenges that hamper maximization of its full potential. Despite recording significant production increases, the demand for fresh milk still outstripped supply. Most importantly, the increased concern about food safety and health and the penetration of Kenyan milk and milk products into the international markets demands an improvement in milk quality. To this end, focus on improving milk production and milk quality is important to maximizing the competitiveness and marketability of the Kenyan fresh milk and other milk products domestically and international. Improvement in marketability and competitiveness is also important in strengthening agribusiness across the dairy value chain.

Action towards improved milk production and milk quality identifies smallholder dairy farmers as important in contributing to the competitiveness and marketability of dairy products. This is because smallholder farmers control a significant proportion of milk produced in the country. Therefore, there is need to bring together smallholder farmers and other stakeholders in working towards improving milk production and enhancing milk quality. Actions designed to improve production and quality do not only benefit farmers, but also processors and consumers. Given the fragmented nature of the Kenyan dairy value chain, the actions are actualized through collective action.

There are several examples of collective action in agriculture (Devitt *et al.*, 2013; Le Cren *et al.*, 2009). The organization of dairy cooperative across the world are formed through collective action as an initiation of individual farmers, milk processors, non-governmental organizations, or governments. The shared or common interest pursued by cooperative increases the bargaining power of milk producers, provides incentives for production and marketing of quality milk, and encourages value addition (Gołębiowski & Drejerska, 2017; Kurakin & Visser, 2017; Le Cren *et al.*, 2009; Mu *et al.*, 2014; Wassie *et al.*, 2019). Nettle *et al.* (2010) showed the role of collective action, milk cooperatives in particular, in provision of advisory services and capacity building. These are some examples of application of collective action in dairy value chains that were important in supporting this study.

2.5 Conceptual Framework

This section presents of the interrelationships between different variables that are used in the study. The conceptual framework provides the basis of the research problem and helps the reader to comprehend what the study seeks to accomplish.

The dairy value chain is diverse, that is, it involves several players. The players represent entities that may have common or divergent interest in the dairy value chain. The entities comprise of milk producers, milk buyers, milk processors, government and non-government agents, regulatory agencies, input dealers, fresh milk and processed milk sellers, and consumers (Gołębiowski & Drejerska, 2017). The movement of milk from the producer to the final consumer involves processes such as input acquisition, milk production and marketing, storage, value addition, and eventual selling. Not all produced milk goes through the entire sequence of activities. The existence of informal market channels implies that some milk is sold locally. However, the emergence of producer organizations does not only support marketing through formal markets, but also supports farmers in terms of advisory services, training, and adherence to industry's milk safety standards. Therefore, it is anticipated that producer organizations breaks the challenges that farmers face in accessing the market.

Producer organizations are a form of collective action that provides incentives to farmers to increase the performance of their dairy enterprises. Assuming that dairy farmers are rational economic agents, they register as producer organization members in anticipation that their membership will result in improved dairy performance. Additionally, dairy farmers anticipate that they would gain from their access to services provided by producer organizations. In doing so, producer organizations reduce the expected gains of non-members while enhancing gains to members (Devitt *et al.*, 2013). At the same time, producer organizations facilitate communication with other stakeholders in the dairy value chain with a

common interest of improving milk production and milk quality. Therefore, it is expected that producer organizations will not only enable members to increase milk production, but also contribute to improved milk quality. In turn, improved milk production and quality translated into improved performance of the dairy enterprises.

This study also anticipates that milk production and milk quality strategies are also affected by socio-economic and farm level characteristics. Furthermore, it is anticipated that access to credit, dairy production and management training, extension, veterinary, and artificial insemination services also influences milk production and milk quality.

Increased milk production and application of milk quality strategies are important pathways for enhancing the performance of the dairy enterprises. Farmers gain from performance of the dairy enterprises through increased milk production and improved farm-level implementation of milk hygiene strategies. Production of high-quality milk minimizes losses due to spoilage as a result of poor milk handling strategies thereby improving competitiveness and marketability of members of dairy cooperatives. The conceptual framework of the interrelationships between different variables that are used in the study are illustrated in Figure 2.1.

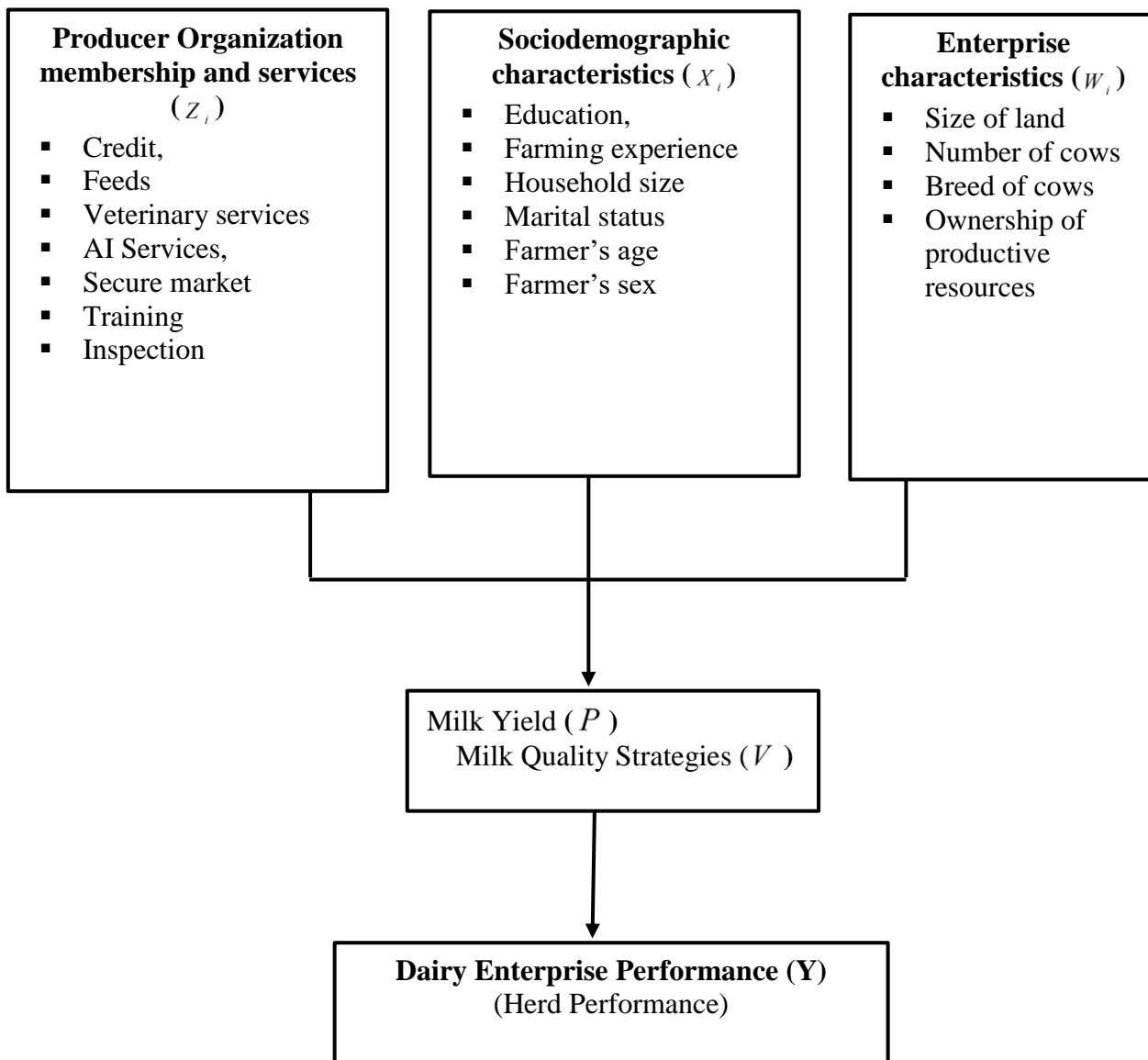


Figure 2.1: Diagrammatic Representation of Conceptual Framework

CHAPTER THREE

METHODOLOGY

3.1 Study Area

This study was conducted in South Imenti sub-county, Meru County because it is among the highest milk producing regions in Kenya (Rademaker *et al.*, 2016) and has a relatively high degree of collective action activities. Moreover, it experiences a high demand for milk from both local traders and the nearby urban population. South Imenti sub-county is divided into six administrative wards. These are Abogeta East, Abogeta West, Igoji West, Igoji East, Nkuene and Mitunguu. Meru County borders five counties; Nyeri, Laikipia, Isiolo, Tharaka Nithi and Kitui. It is a high agricultural potential area with vast agricultural land and favourable climatic condition that makes agriculture the county's mainstay economic activity. Agriculture in the region is mainly dominated by smallholder farmers, accounting for about 98.6% of the production systems (County Government of Meru, 2014). About 90% of the county's population directly and indirectly depends on agriculture as a source of livelihood. Livestock rearing and dairy production are emerging sub-sectors with a positive growth outlook. Animal husbandry support programs have been up-scaled since the inception of devolution to promote livestock and dairy production (County Government of Meru, 2014). The map of the study area is presented in Figure 3.1.

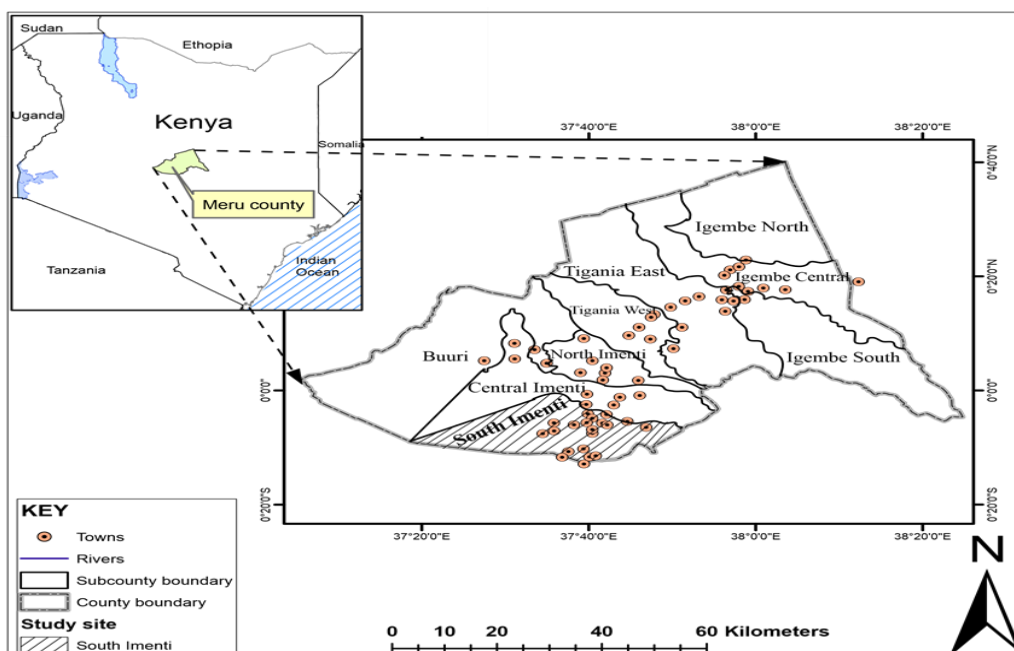


Figure 3.1: Map of study area

Source: Virtual Kenya and Google Earth Pro. (2021)

3.2 Research Design

This study was anchored on cross-sectional research design. Cross-sectional research designs consist of observations on a variable(s) across various units such as households, firms or countries taken at a given point in time. Cross sectional research design was appropriate for this study because relevant data was collected on identified variables at one point in time. A structured questionnaire (Appendix A) was administered to the targeted respondents to provide data for descriptive analysis as well as investigation of associations between variables of interest.

3.3 Target Population

The targeted population were dairy farmers in South Imenti sub-county, Meru County and the key informants targeted were dairy farmers affiliated to dairy producer organizations and non-members of dairy producer organizations.

3.4 Sampling Design and Sample Size Determination

This study adopted multi-stage sampling procedure employed by the LIQUID (Local and International business collaboration for productivity and Quality Improvement in Dairy chains in Southeast Asia and East Africa) Project. In the first stage, Meru County was purposively selected because it was among the highest milk production zones in Kenya (Rademaker *et al.*, 2016) and had active dairy marketing activities and farmer organizations. In the second stage, South Imenti sub-county was purposively selected because it had both individual and collective milk marketing systems. In the third stage, stratified random sampling was used with two strata: producer organization members and non-producer organization members. From the list of producer organizations obtained from South Imenti sub-county three producer organizations were randomly selected. Finally, systematic random sampling was used to select producer organization members. For the selection of non-members, collection routes of traders were identified. Different routes were followed by the enumerators every morning. The first enumerator identified households at the start of the collection route. After identification of the first household, the next households were identified by skipping four to five households. The remaining enumerators identified households at least five kilometers from where the previous enumerator had stopped. This process was repeated until the targeted number of respondents was reached. A total of 282 dairy farmers were sampled (182-producer organization members and 100-non-producer organization members) by the LIQUID Project (Mwambi *et al.*, 2020). The sample was distributed as illustrated in Table 3.1 below.

Table 3.1: Distribution of sample size

PO name	PO members sampled	Non-PO members sampled	Total sample size
Abogeta PO	58	36	94
Kionyo PO	60	34	94
Uruku PO	64	30	94
Total sample size	182	100	282

3.5 Data and Data Collection

Data for this study is based on data collected by the LIQUID project in Kenya between October and December 2018. The LIQUID project was supported by Wageningen University, Netherlands in collaboration with Egerton University and other local partners. The overall objective of LIQUID is to contribute to an improved food and nutrition security in South East Asia and East Africa by addressing safety issues, quality losses and economic inefficiencies in Kenya and Tanzania. During the process of data collection, cross-sectional data from dairy farmers was collected in a survey that was conducted in South Imenti sub county, Meru County. A structured questionnaire was administered by well-trained enumerators to the dairy farmers in the study area under the supervision of the Lead Doctoral researcher and the two co-students undertaking Masters. The survey instrument captured general farmer characteristics, dairy production and marketing, milk hygiene, producer group membership, gender roles, and social capital.

3.6 Analytical Framework**3.6.1: Objective 1: To compare milk yield of producer organization members and non-producer organization members**

The interest of the first objective was to compare milk yield of producer organization members and non-producer organization members. The variable of interest was milk yield. This objective was achieved using descriptive statistics and test statistics. Independent samples T tests were applied to determine whether the milk yield between the two groups of farmers were statistically different. The study also compared performances of members of three producer groups; Abogeta, Kionyo and Uruku. In addition, sociodemographic, economic and enterprise characteristics of dairy farmers were described using measures of central tendency (mean and median) and dispersion (standard deviation), as well as measures of distribution or proportions (frequencies and percentages). Results from these analyses were tabulated and also visualized using bar plots and histograms.

Furthermore, the study was interested in establishing potential correlation between the level of access to various services offered by the producer organizations and milk yield. Farmers rated their agreement with regard to access to services on a 7-point Likert scale, where 1= completely disagree when farmers say they did not have access and 7=completely agree if farmers had full access. The services included credit, feeds, advisory, artificial insemination, veterinary and secure market. Lastly, the Pearson Correlation was performed to establish the direction and strength of the relationship between the level access to various services offered by the producer organizations and milk yield.

3.6.2: Objective 2: To determine the role of producer organizations on farm-level implementation of milk hygiene strategies

Variable Construction. Farmers were asked to rate their perceptions of the level of farm-level implementation of milk hygiene strategies as a percentage. Farmers with zero response on the 0-100 scale were considered not to have implemented a given milk hygiene strategy. Farmers rated 26 milk hygiene strategies that were found to be significant in influencing milk safety (Table 9). The strategies were identified after reviewing publication and manuals on hygiene and safety of milk and milk products (Dairy Industry (Dairy Produce Safety) Regulations, 2020; FAO/WHO, 2011; KEBS, 2015; Pandey & Voskuil, 2011) The strategies were grouped into six broad categories: Personal and animal health (6 strategies), Personal hygiene (2 strategies), Udder hygiene (6 strategies), Equipment hygiene (6 strategies), Post-milking milk handling and storage (4 strategies), Workspace Hygiene (2 strategies). New variables were constructed from the scale, with farmers with 0 level of implementation being considered not to have implemented the strategy, while those with greater than 0 taking the value 1 implying that at least they implemented the strategy. The second variable was constructed as summation of the 26 strategies with binary responses of 1 or 0 for each. The resultant variable was a count variable with maximum value of 26 if farmer implemented all the milk hygiene strategies. The new count variable measured level of farm-level implementation of milk hygiene strategies.

Descriptive Statistics. Descriptive statistics involved cross-tabulation of variables of interest, including milk hygiene strategies, training in milk hygiene, and inspection for compliance with milk hygiene strategies. Frequency distributions and percentages were tabulated and also visualized using bar plots. Two inferential statistics were employed: Independent sample t-test and chi-square test of independence. Independent samples t-test tested the significance of differences in distribution of the total count of milk hygiene

strategies, while chi-square test of independence was used to test whether or not there existed significant differences in the distribution of farmers' responses with respect to training, providers of training, use of each milk strategy, and inspection for adherence to milk hygiene standards.

Econometric Model. The second objective involved determining the influence of producer organizations on farm-level implementation of milk hygiene strategies. As earlier stated, a new variable was constructed from existing data as a count of all strategies implemented by each farmer. The Poisson regression model (PRM) was adopted in determination of the role of producer organizations on farm-level implementation of milk hygiene strategies by dairy farmers. The model was appropriate because the outcome variable is count data and has non-negative integers (Lukman *et al.*, 2021). The PRM was estimated using maximum likelihood estimator (MLE) and its probability structural form is specified as follows:

$$f(y_i) = \frac{\exp(-\mu_i)\mu_i^{y_i}}{y_i!}, y_i = 0, 1, 2, \dots \quad (3.1)$$

where

y_i = non-negative integer outcome variable, number of milk hygiene strategies implemented by farmer

$\mu_i > 0$.

The model assumes that the mean and variance of the count variable are the same. Thus, following Myers *et al.* (2012), a function, g , which relates the mean of the outcome variable to a set of predictor variables can be written as:

$$g(\mu_i) = \eta_i = \beta_0 + \beta_1 X_1 + \dots + \beta_p X_p + \varepsilon_i = X'\beta, \quad (3.2)$$

where

$g(\cdot)$ = the monotone differential link function

β = the parameters of coefficients to be estimated

$X_1 - X_p$ = the predictor variables

ε = the stochastic error term.

The function in equation 3.2 is a link function such that $g(\mu_i) = \ln(\mu_i) = \exp(X'\beta)$, which is a log function that ensures the fitted variables for the outcome variables are positive (Lukman *et al.*, 2021). In this study, membership to producer organizations, sociodemographic and

institutional variables were expected to influence the outcome variable – number of farm-level milk hygiene strategies implemented by farmers. Table 3.2 presents description of variables that were used in Poisson regression model.

Table 3.2: Description of variables for Objective 2

Variable	Description	Measurement	Expected sign
Dependent Variable			
MHS	Milk Hygiene Strategies	Count	
Independent Variables			
PO	Membership to Producer Organization	Binary	+
GND	Gender of farmer	Binary	±
MRTS	Marital status	Binary	±
FMSZ	Total size of the farm	Continuous	+
COWN	Cow ownership	Categorical	±
PRICE	Price per litre of milk	Continuous	+
HOURS	Hours spent on dairy production	Continuous	+
TRN	Formal training on MHS	Binary	+
DIST	Kilometres to the nearest town	Continuous	-

3.6.3: Objective 3: To measure the effect of producer organization membership on dairy enterprise performance

The third objective involved estimation of the effect of membership in producer organization on dairy enterprise performance. The variables of interest for this objective were membership in producer organization and performance of dairy enterprise. Milk production per cow was computed as an indicator to measure the performance of dairy enterprise. Milk production per cow is a weighted average of litres of milk output per cow per year. The Milk production per cow was computed using the following formula:

$$MPC = \sum_{j=1}^J \frac{M_j}{C_j} \quad (3.3)$$

where M_j is the summation of milk produced by j dairy cows in a year and C_j denote the total number of milking cows.

Econometric Analysis. The effect of producer organization membership on dairy enterprise performance was estimated using endogenous switching regression (ESR) model, where average treatment effects were calculated as differences between actual and counterfactual scenarios for both members and non-members. ESR accounted for self-selection and endogeneity resulting from pre-membership and membership heterogeneity (Alene & Manyong, 2017; Asfaw *et al.*, 2012; Di Falco *et al.*, 2011; Wossen *et al.*, 2017). Estimation of ESR involved two steps. In the first step, a probit regression was estimated to capture farmers' choice of belonging to producer organization.

$$PO_i^* = X_i\beta + \varepsilon_i \quad \text{with } PO_i^* \begin{cases} 1 & \text{if } PO_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (3.4)$$

Where

PO_i^* = dummy variable that is equal to 1 if the household is a producer organization member and 0 if otherwise

X_i = vector of independent variables,

β = parameters to be estimated and

ε_i = stochastic error term.

The parameters in β consist of factors that influence the decision to participate. Equation 3.4 is the selection equation, that is, the probability of membership to a producer organization by the i^{th} household.

Membership to producer organization was likely to be endogenous, that is, it might have been statistically related with at least one of the variables within the model or the error term, ε_i . Therefore, to account for endogeneity, membership to producer organization variable was specified as a function of explanatory variables and a set of instrumental variables (Abdulai & Haffman, 2014; Adegbo *et al.*, 2019; Khonje *et al.*, 2015; Ma & Abdulai, 2017; Mojo *et al.*, 2017; Sibiko & Qaim, 2020) as follows:

$$PO_i = X_i\alpha_1 + Z_i\alpha_2 + \zeta_i \quad (3.5)$$

Where

PO_i = the potential endogenous variable (producer organization membership),

X_i = the vector of explanatory variables,

Z_i = the vector of instrumental variable that was correlated with the given endogenous variable but uncorrelated with the error term, ε_i in equation 3.4,

α =the parameters to be estimated and

ζ_i = the stochastic error term.

The ESR also estimated the outcome equations that were conditional on household decision to participate in producer organizations. Following Khonje *et al.* (2015), the outcome equations for members and non-members of producer organizations were specified as follows:

$$\text{Regime 1 (PO members) : } Y_{1i} = \beta_0 + \beta_1 X_{1i} + \beta_2 PO_i^* + R_{1i} + \mu_{1i} \quad \text{if } P = 1 \quad (3.6)$$

$$\text{Regime 2 (Non - PO members) : } Y_{0i} = \beta_0 + \beta_1 X_{0i} + \beta_2 PO_i^* + R_{0i} + \mu_{0i} \quad \text{if } P = 0 \quad (3.7)$$

Where,

Y_{1i} = the outcome variable (dairy enterprise performance) for members of producer organizations for the i^{th} households

Y_{0i} = the outcome variables (dairy enterprise performance) for non-members of producer organizations for the i^{th} households

X_i = the vector of exogenous variables that determine dairy enterprise performance,

PO_i^* = the corrected endogenous variable,

R_i =the vector of the residual terms from the regression of the potential endogenous variable

μ_i = the stochastic error term of the endogenous switching regression,

β_0 = the intercept term,

β_1 = the coefficients of exogenous to be estimated and

β_2 = the coefficients of endogenous variables to be estimated.

For unbiased OLS estimates of equations 3.6 and 3.7, ε and μ must be independent. Additionally, a consistent estimation of equations 3.6 and 3.7 required inclusion of selection bias correction terms, $\sigma_i \lambda_1 + \omega_i$ and $\sigma_0 \lambda_0 + \omega_0$, resulting in the following specifications.

$$\text{Regime 1 (PO members) : } Y_{1i} = \beta_0 + \beta_1 X_{1i} + \beta_2 PO_i^* + R_{1i} + \sigma_i \lambda_1 + \omega_{1i} \quad \text{if } P = 1 \quad (3.8)$$

$$\text{Regime 2 (PO members) : } Y_{0i} = \beta_0 + \beta_1 X_{0i} + \beta_2 PO_i^* + R_{0i} + \sigma_i \lambda_0 + \omega_{0i} \quad \text{if } P = 0 \quad (3.9)$$

σ_j is the covariance between ε and μ , ω is the error terms, and λ the inverse mills ratio.

Following Khonje *et al.* (2015), the conditional expectation of error term of regime 1 equation is given as:

$$E[\varepsilon_{1i} | P_i = 1] = \sigma_{\varepsilon 1} \frac{\phi(X_i \beta)}{1 - \Phi(X_i \beta)} = \sigma_{\varepsilon 1} \lambda_{1i} \quad (3.10)$$

while for regime 2 equation is given as

$$E[\varepsilon_{0i} | P_i = 0] = \sigma_{\varepsilon 0} \frac{\phi(X_i \beta)}{\Phi(X_i \beta)} = \sigma_{\varepsilon 0} \lambda_{0i} \quad (3.11)$$

where $\sigma_{\varepsilon 1}$ and $\sigma_{\varepsilon 0}$ represent the covariance between the error terms and ϕ and Φ denote the standard normal probability density and cumulative density functions, respectively.

Furthermore, ESR model was used to compare the expected dairy enterprise performance of dairy farmers affiliated to producer organizations and non-producer organization members as well as to investigate the expected dairy enterprise performance if members were non-members and if non-members participated in producer organizations as follows:

$$E(Y_{1i} | PO_i = 1) = X_{1i} \gamma_1 + \sigma_{\varepsilon 1} \lambda_{1i} \quad (3.12)$$

$$E(Y_{0i} | PO_i = 0) = X_{0i} \gamma_0 + \sigma_{\varepsilon 0} \lambda_{0i} \quad (3.13)$$

$$E(Y_{0i} | PO_i = 1) = X_{1i} \gamma_0 + \sigma_{\varepsilon 0} \lambda_{1i} \quad (3.14)$$

$$E(Y_{1i} | PO_i = 0) = X_{0i} \gamma_1 + \sigma_{\varepsilon 1} \lambda_{0i} \quad (3.15)$$

The actual expectations observed in the sample for producer organization members and non-members are represented by (3.12) and (3.13). (3.14) and (3.15) represent the counterfactual outcomes. Turning to the treatment effects of farmer participation in producer organizations, it was anticipated that producer organizations would have positive effect on performance of dairy enterprises (Ji *et al.*, 2019; Kumar *et al.*, 2018). This involved estimation of the average treatment effects of the treated (ATT) and the average treatment effect of the untreated (ATU).

Following Khonje *et al.* (2015), the ATT and ATU are given in equation 3.16 and 3.17 respectively:

$$ATT = E(Y_{1i} | PO_i = 1) - E(Y_{0i} | PO_i = 1) = X_{1i} \gamma_1 + \sigma_{\varepsilon 1} \lambda_{1i} - X_{1i} \gamma_0 + \sigma_{\varepsilon 0} \lambda_{1i} \quad (3.16)$$

$$ATU = E(Y_{0i} | PO_i = 0) - E(Y_{1i} | PO_i = 0) = X_{0i} \gamma_0 + \sigma_{\varepsilon 0} \lambda_{0i} - X_{0i} \gamma_1 + \sigma_{\varepsilon 1} \lambda_{0i} \quad (3.17)$$

Testing validity of the instrumental variables. Distance to the nearest milk collection point was employed as an instrumental variable. Distance to the milk collection point was likely to strongly influence group participation. The nearer the milk collection point, the higher the anticipated chance of marketing through producer organization to reduce transaction costs and vice versa. However, distance to milk collection point was likely to

have no significant effect on dairy enterprise performance. Wooldridge's score test and over-identification test were used to test exogeneity and instrument validity assumptions respectively (Abdulai & Haffman, 2014; Adegbo *et al.*, 2019; Khonje *et al.*, 2015; Ma & Abdulai, 2017; Mojo *et al.*, 2017; Sibiko & Qaim, 2020).

Model Specification. The Probit model and ESR model are specified in equation 3.18 and 3.19 respectively:

$$PO = \beta_0 + \beta_1 Age + \beta_2 Educ + \beta_3 Sex + \beta_4 Hhsz + \beta_5 Fmsz + \beta_6 Crt + \beta_7 Marstat + \beta_8 Breed + \beta_9 Own + \beta_{10} Hours + \beta_{11} Pprice + \beta_{12} Dist + \varepsilon_p \quad (3.18)$$

$$DEP = \beta_0 + \beta_1 PO + \beta_2 Age + \beta_3 Educ + \beta_4 Sex + \beta_5 Hhsz + \beta_6 Fmsz + \beta_7 Crt + \beta_8 Marstat + \beta_9 Breed + \beta_{10} Own + \beta_{11} Hours + \beta_{12} Price + \beta_{13} Dist + \beta_{14} R_p + \varepsilon_i \quad (3.19)$$

The model estimated two regimes separately for equation 3.19, that is, regime 1 for producer organization members and regime 2 for non-members using the same variables specified in equation 3.19. The study expected household demographic factors (household size and age, gender, education level and marital status), farm characteristics (hours spent on dairy production, farm size, and cow ownership and breeds) and institutional factors (milk prices and credit) to affect the decision to participate in producer organization and dairy enterprise performance. The description of variables that were used in ESR and their expected relationships are presented in Table 3.3.

Table 3.3:Description of variables used in ESR framework

Variable	Description	Measurement	Expected sign
Dependent			
PO	Membership in PO (1=Yes, 0=No)	Binary	
DEP	Milk per cow per year in litres	Continuous	
Independent			
Age	Age of farmer	Continuous	±
Educ	Number of years of formal schooling	Continuous	+
Sex	Sex of household head (1=Female, 0=Male)	Binary	±
Hhsz	Number of persons in household	Continuous	±
Exp	Dairy farming experience in years	Continuous	+
Marstat	Marital status (1=Married, 0=Not married)	Binary	±
Fmsz	Total landholding in acres	Continuous	+
Breed	Type of cow breed (1=Pure, 0 otherwise)	Binary	+
Own	Cow ownership (1=Joint, 2=Male, 3=Female)	Categorical	±
Hours	Hours spent on dairy production	Continuous	+
Crt	Access to credit (1=Yes, 0 otherwise)	Binary	+
Price	Price per litre of milk	Continuous	+
Instrument			
Dist	Kilometres to milk collection point	Continuous	+

CHAPTER FOUR

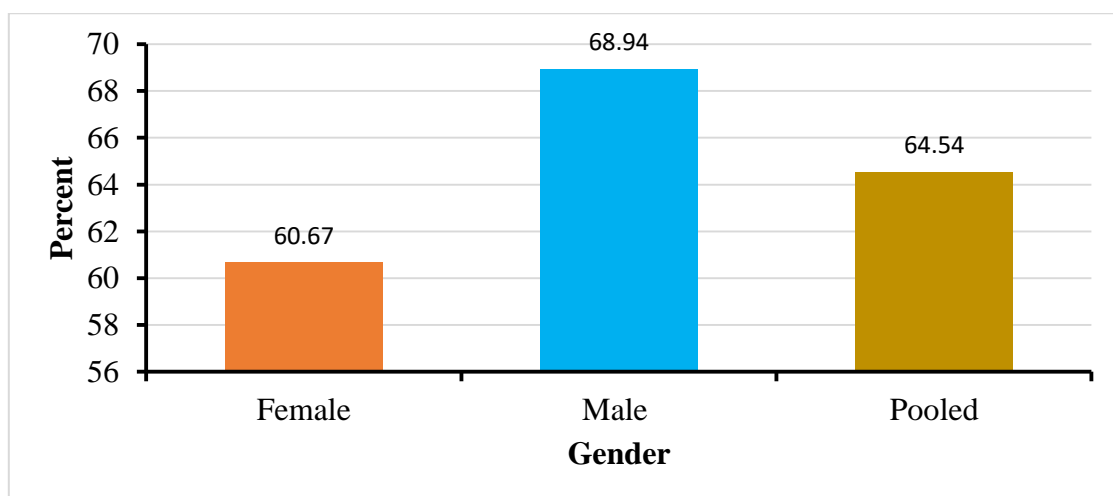
RESULTS AND DISCUSSION

This chapter presents the findings of this study and it is divided into three main sections. The first section presents sociodemographic and enterprise characteristics of dairy farmers and comparison of milk yield. The second section provides findings on role of producer organizations on farm-level implementation of milk hygiene strategies and the last section presents results on determinants of producer organization membership and the effect of producer organization membership on dairy enterprise performance

4.1 Characteristics of Dairy Farmers

4.1.1 Socio-demographic Characteristics of Dairy Farmers

Figure 4.1 shows combined and sex disaggregated status of membership in producer organizations. About 65 percent, 182 out of 282 of the sampled farmers were members of dairy producer organizations. Disaggregated results show that a higher proportion of male farmers (69 percent) than women (61 percent) were members of dairy producer organizations. Nonetheless, the difference in proportions of male and female members of producer organizations was statistically not significant ($\chi^2=2.100$, $p=0.147$). This finding suggests that there were no sex disparities in participation in formal collective action. Thus, producer organizations are special and inclusive conduits for encouraging and strengthening commercialization of dairy farming. This finding contrasts results reported by Katothya (2017) which indicated that although women in Bungoma, Kiambu, and Nandi counties dominated milk production node, they had little visibility at milk transportation and marketing nodes of the value chain which are the primary purposes of producer organizations in the study area.



($\chi^2 = 2.10$, $P = 0.147$)

Figure 4.1: Proportions of producer organization membership by sex of the farmers

A majority (87 percent) of sampled farmers were married. Around 86 percent of producer organization members were married compared to 89 percent of non-members (Figure 4.2). The lower percentage of married producer group members vis-à-vis married non-members could imply that married farmers have to always reach a consensus about dairy production and marketing decisions. Consequently, variations in spouses’ perspectives on division of authority over production and marketing may have reduced chances of married farmers registering as producer organization members. This finding is in concurrence with Anderson *et al.* (2017) explanation that lack of intra-household accord over household and agricultural decisions may be problematic in enabling positive shifts towards market orientation or innovations. Thus, marital status could be a critical predictor of farmers’ participation in producer organizations and economic outcomes associated with participation in dairy output market.

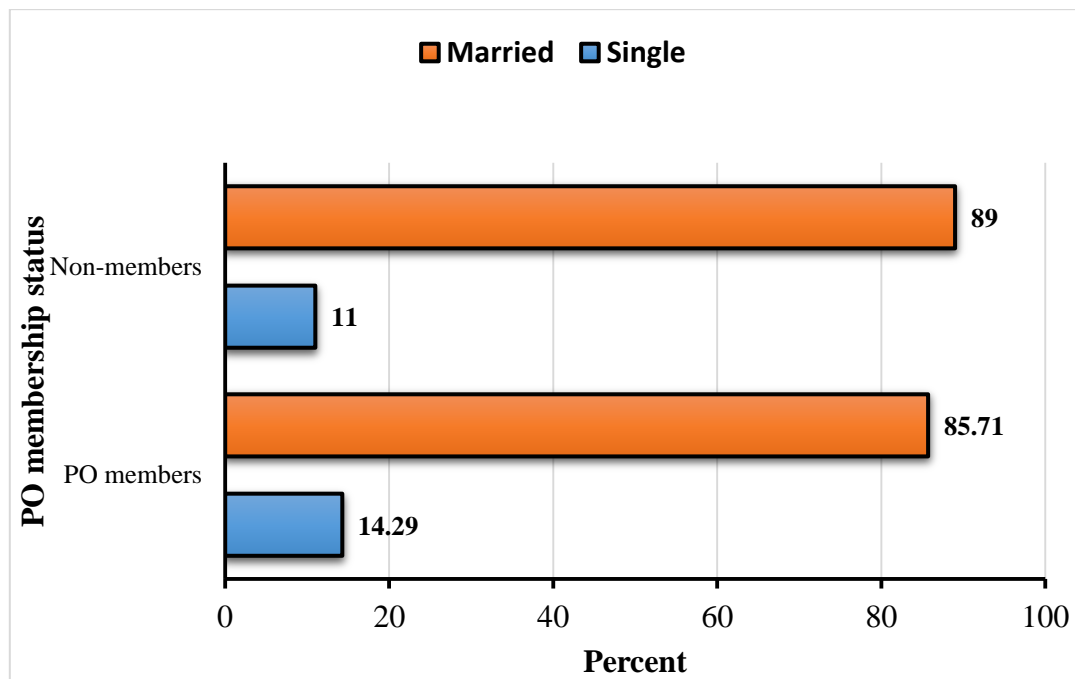


Figure 4.2: Percentages of marital status of dairy farmers disaggregated by membership to dairy producer organization

$$\chi^2 = 0.611, p = 0.434$$

In Table 4.1, the average age of dairy farmers was 50 years, with producer group members being relatively older (51 years) than non-members (49 years). On average, sampled farmers had 19 years of dairy farming experience, with producer organization members and non-members having 19 and 18 years respectively. However, age and farming

experience of dairy farmers did not significantly differ depending on membership status. Additionally, producer organization members tended to be marginally more educated (9.87) than non-members (9.03) ($t = 1.94, p < 0.1$). Furthermore, both member and non-member households tended to have an average of 4 people. These results imply that demographic profiles of farmers may not be critical in explaining their decision to participate in collective action. Instead, other factors beyond demographics could explain participation in collective action.

Table 4.1: Socio-demographic characteristics of dairy farmers

	Pooled (N=282)		Member (n=182)		Non-member (n=100)		<i>t</i>
	Mean	SD.	Mean	SD	Mean	SD	
	Age of farmer	50.49	14.18	51.39	14.04	48.85	
Farming experience	18.73	14.20	19.16	14.13	17.96	14.36	0.68 1.94
Education years	9.57	3.51	9.87	3.46	9.03	3.56	*
Household size	4.05	1.66	4.08	1.80	3.99	1.38	0.45

Furthermore, the surveyed dairy farmers were asked to state other farm and non-farm enterprises that they engaged in in the last twelve months. The results presented in Figure 4.3 show that almost all farmers practiced mixed farming: that is, nearly 99 percent of both members and non-members of producer organizations practiced crop farming. This finding suggests that dairy and crop production are complementary enterprises, with dairy farming depending on crop production for feed and crops on dairy enterprise for manure. Besides, almost equal proportions of producer organization members (48 percent) and non-members (49 percent) engaged in other livestock enterprises, including poultry and pig farming. However, the proportions of farmers that engaged in other farm enterprises did not differ depending on producer organizations membership status.

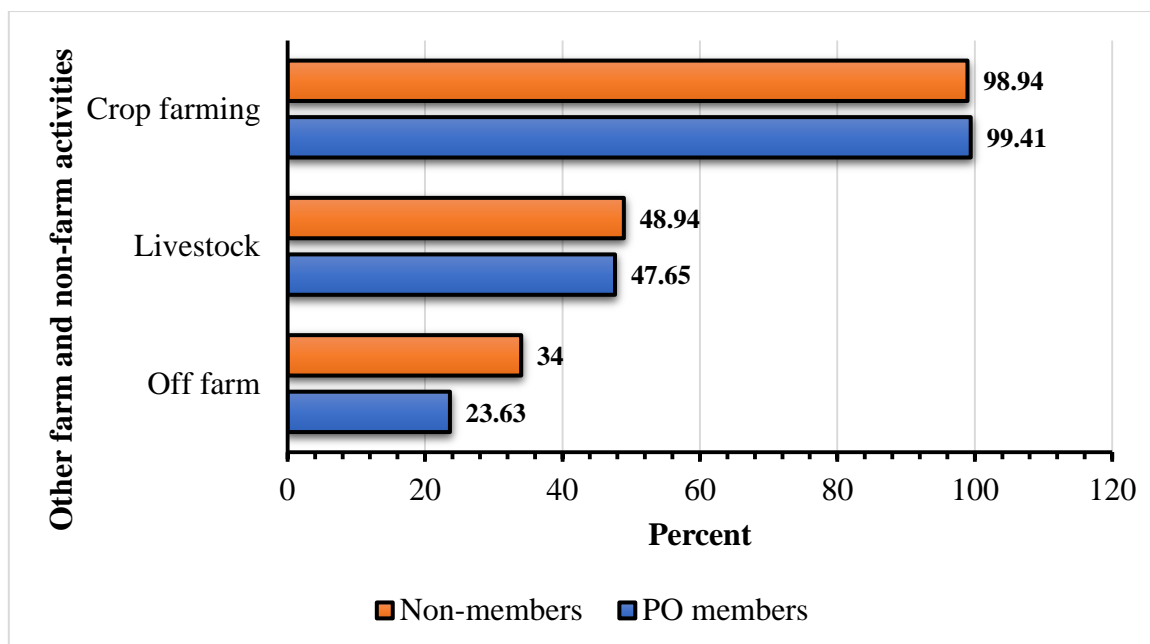


Figure 4.3: Proportions of farmers that engaged in other farm and non-farm activities disaggregated by membership to producer organizations

Additionally, smallholder farmers engage in off-farm activities in order to diversify livelihood sources and build resilience to uncertainties and risks of poor performance of dairy enterprises (Buechler, 2016; Kemboi *et al*, 2020; Korir & Njehia, 2011; Lenaiyasa *et al.*, 2020). For this reason, more (34%) non-producer organization members than members (24%) participated in off-farm activities such as businesses and formal and informal employment. The number of non-producer organization members that engaged in off-farm enterprises was marginally significantly more than members ($\chi^2 = 03.50$, $p < 0.1$). Farmers engaged in diverse farm and non-farm income generating activities possibly to reduce risks associated with market and non-market shocks that may impede the contribution of dairy enterprise to overall farm performance and household economic welfare.

4.1.2 Enterprise Characteristics of Dairy Farmers

The average landholding and utilization, as well as total number of cows owned by farmers disaggregated by producer organization memberships, are presented in Table 4.2. It is crucial to note that the mean is significantly influenced by outliers and, therefore, inappropriate when individual data points differs from sample average (Rosenthal, 2011). Thus, the median presented in Table 4.2 were interpreted because of the large variability of the data points: the standard deviations were larger than the mean.

First, the median land size (2 acres) accessed by members of producer groups was not significantly larger than that accessed by non-members (1.13 acres). Similarly, the median

land areas owned with title for members (1.50) and non-members (0.25) were not significantly different. Furthermore, median land area under fodder production did not significantly differ depending on farmers' membership to producer organizations. Nonetheless, the median number (2) of dairy cows kept by members of producer organizations was significantly higher ($t = 2.80, p < 0.01$) than that of non-members (1 cow). These results indicate that land area accessed and farmed may not be crucial in underlining farmers' decision to participate in collective action. Instead, the number of cows matters for they determine milk volumes and level of market participation. In other words, milk volumes may be a critical driver of farmers' decision to join producer associations with the aim of exploiting opportunities associated with collective actions. This finding contrasts results reported by Jitmun *et al.* (2020) who showed that Thai producer organization members tended to own smaller number of animals compared to farmers in other forms of collective actions.

Table 4.2: Summary statistics of farm characteristics of dairy farmers disaggregated by producer organization membership

	PO Membership Status						
	Pooled ($N=282$)		Member ($n=182$)		Non-member ($n=100$)		t
	Mean	SD	Mean	SD	Mean	SD	
Total land accessed	2.74 (2.00)	6.25	2.67 (2.00)	2.40	2.88 (1.13)	10.02	0.27
Owned with title	2.09 (1.00)	6.36	2.04 (1.50)	2.60	2.18 (0.25)	10.12	0.18
Land under fodder	0.62 (0.38)	1.09	0.65 (0.50)	0.78	0.56 (0.25)	1.52	0.67
No. of cows	2.11 (2.00)	2.19	2.37 (2.00)	2.54	1.62 (1)	1.18	2.8***

Note: Median provided in parentheses

Notwithstanding the results presented in Table 4.2, it was crucial to profile types of breeds kept by farmers in order to validate empirical argument by Jitmun *et al.* (2020) that not only the number of cows matter in farmers' decision to participate in the collective action. Instead, Jitmun *et al.* (2020) asserted breed is an important factor for participation in collective action and markets. Figure 4.4 provides types of dairy cows kept by farmers disaggregated by producer membership status. While significantly higher proportion (54%)

of members of producer organizations owned pure breed dairy cows ($\chi^2 = 4.95, p < 0.05$), the proportion (63%) of non-member that owned cross-breed animals was marginally higher than percentage (51%) of producer organization members ($\chi^2 = 3.70, p < 0.1$). However, only 2 percent and 3 percent of members and non-members owned local breeds respectively. With more than half of members of producer organizations owning pure and cross breed dairy cows, there were indications that they were market-oriented. Possibly farmers' intentions were to exploit market opportunities arising from high milk output such as access to superior formal buyers (cooperatives and processors) who emphasize voluminous milk supplies. In other words, producer organization facilitate milk collection, allowing farmers to supply maximum milk volumes that is guaranteed by type of breed kept.

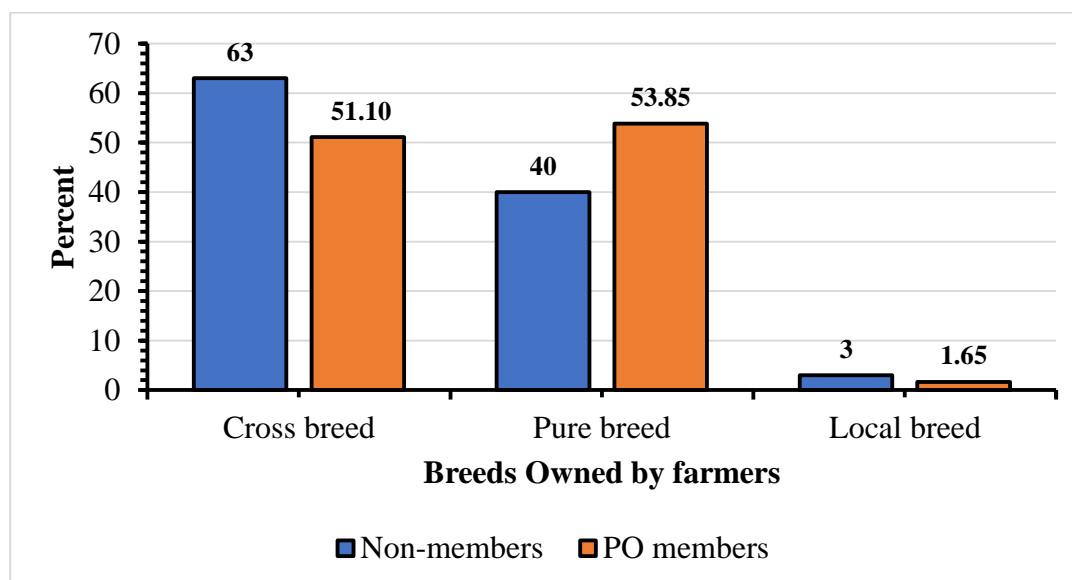


Figure 4.4: Proportions of breeds of cows owned by members and non-members of producer organizations

Furthermore, ownership of productive resources also plays a vital role in determining farmers' participation in producer organization. In other words, control over resources amplifies voices of groups of people within households. Thus, farmers were also asked to indicate who, within households, owned most of the dairy cows. Figure 4.5 show that male heads owned most of the cows for both producer organization members (41 percent) and non-members (55 percent). The proportions of farmers that reported that cows were jointly owned by male head and spouse were 26 percent for non-members and 35 percent for members. Almost 14 percent of producer organization members and 13% of non-members indicated that cows were owned by female spouses. Only 9 percent and 6 percent of members and non-members indicated that female heads owned dairy cows respectively. Nevertheless,

membership to producer organization and ownership of dairy cows were not significantly associated ($\chi^2 = 5.32, p = 0.150$). This result suggests that type of livestock ownership and its subsequent influence on farm-level decision-making does not matter in determining status of producer organization membership.

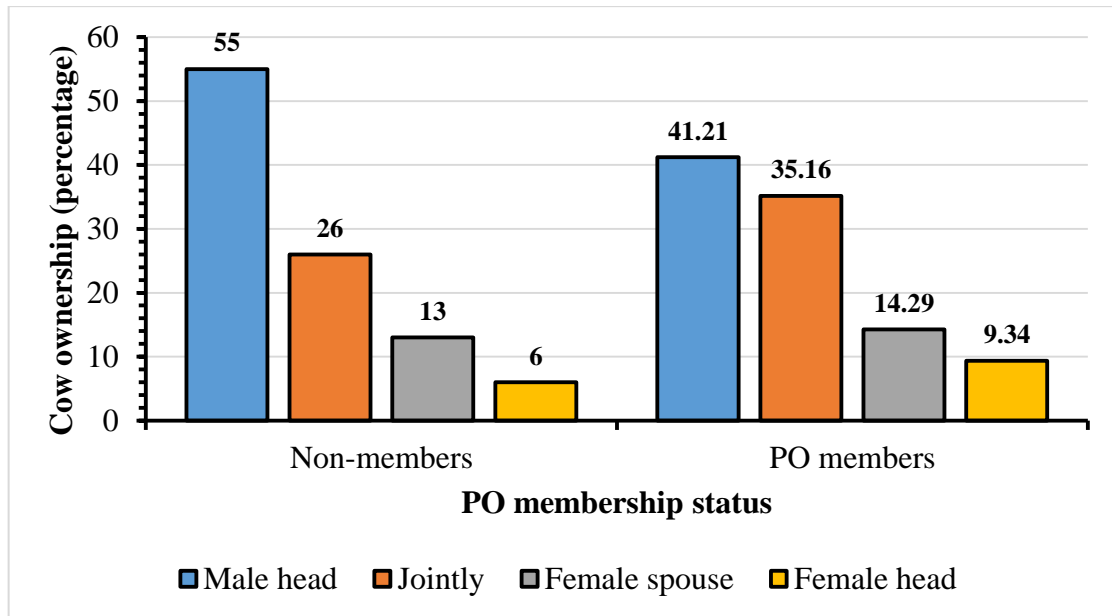


Figure 4.5: Proportions of members and non-members of producer organizations owning different dairy cows

The result displayed in Figure 7 show that sex inequalities in terms of ownership of productive dairy farming resources still persists and transcends producer group membership, with women ownership of cows being lower than men. Similar findings were reported by Katothya (2017) who indicated that ownership and control of dairy cattle in Kenya is still skewed towards men.

Decision making on which market to sell milk was mainly dominated by male head for both producer organization members (32%) and non-members (40%). The proportion of female spouse that reported they make decision on where to sell the milk were 24% for producer organization members and 33% for non-members. About 34% of producer organization members and 20% of non-members indicated that they make decision on which market to sell the milk jointly while only 10% and 7% female heads of producer group members and non-members respectively made decisions on which market to sell milk. Decision making on which market to sell the milk significantly influenced dairy farmers participation in producer organization. Additionally, Tavenner and Crane (2018) found that men ownership and control over production and decision-making of dairy production and

marketing has largely remained intact in western Kenya. Thus, Kenyan still lags behind in bridging gender gaps in dairy production and marketing.

The distances to the nearest milk buyer collection point for member and non-members of producer organizations are displayed in Figure 4.6. On average, sampled farmers reported 0.4 kilometres to the nearest milk buyer collection points from their farms. While milk buyer collection points were 0.25 kilometres from farms of non-members, producer organization members had to travel almost twice the distance (0.48 kilometres) to reach the nearest milk buyer collection centres. In other words, nearest milk buyer collection points were significantly far from farms of members than non-members ($t=2.857, p< 0.01$).

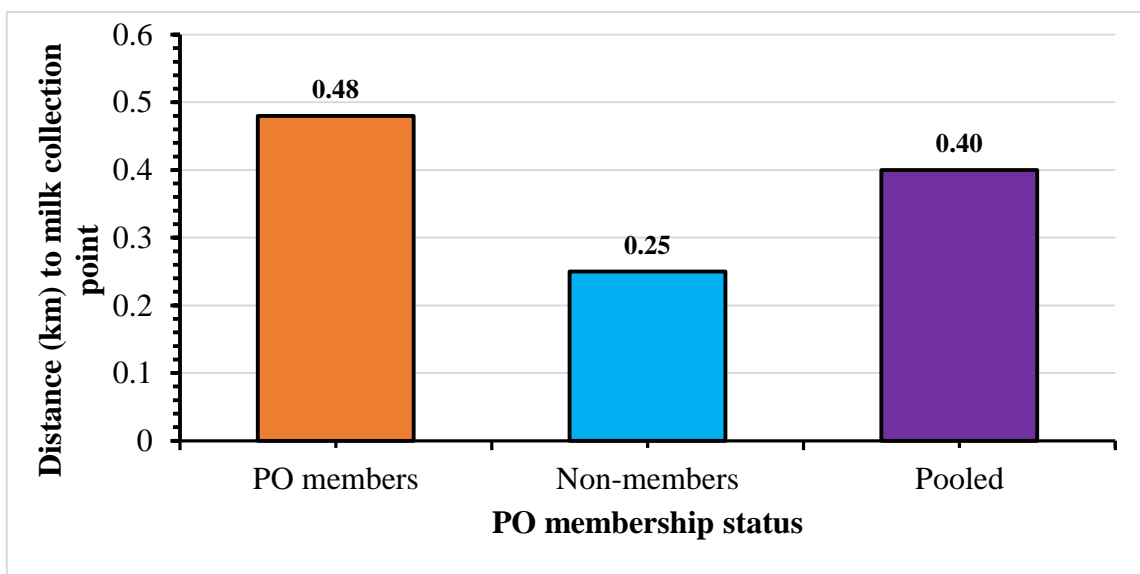


Figure 4.6: Distance to the nearest milk collection point by membership to producer organizations

Figure 4.7 shows the average annual price of a litre of milk sold by farmers. The unit prices of milk for members and non-members were significantly different ($t=2.17, p< 0.05$). Members of producer received about 34.91 Kenyan shillings per litre of milk sold compared to 35.26 received by non-members. This result suggests that producer organizations members

received lower prices for milk they supplied compared to non-members.

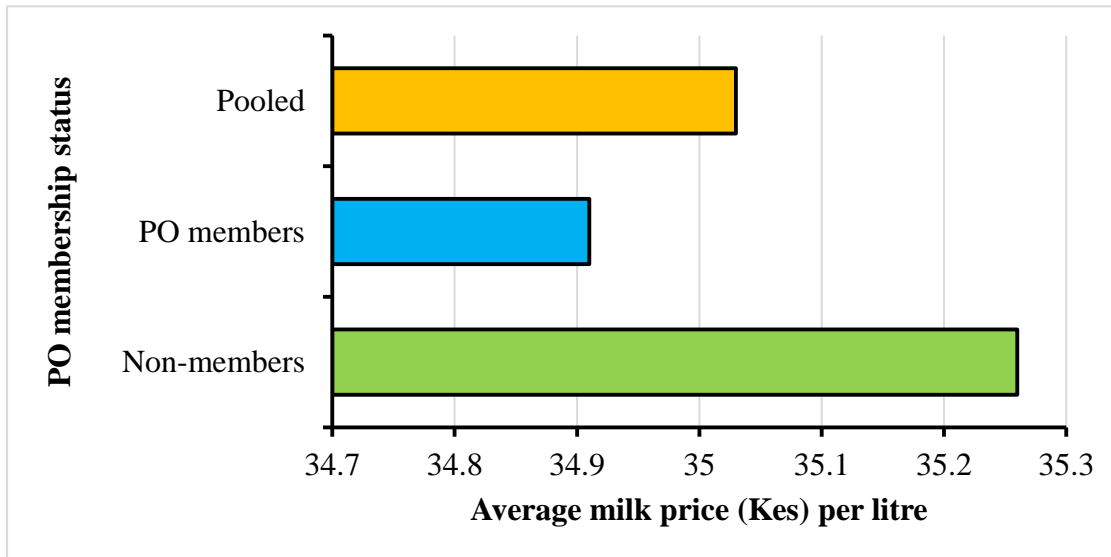


Figure 4.7: Average annual prices of milk received by members and non-members of producer organizations

Furthermore, farmers were asked to state their access to credit within one year of dairy production. The results are presented in Figure 4.8. There was a significant association between producer organization membership and access to credit ($\chi^2 = 10.837$, $p < 0.01$). Significantly higher percentage of producer organization members (32%) accessed loan in the last twelve months of dairy production cycle than non-members (14%). This is one of possible incentive for registration as producer organization members for farmers in the study area.

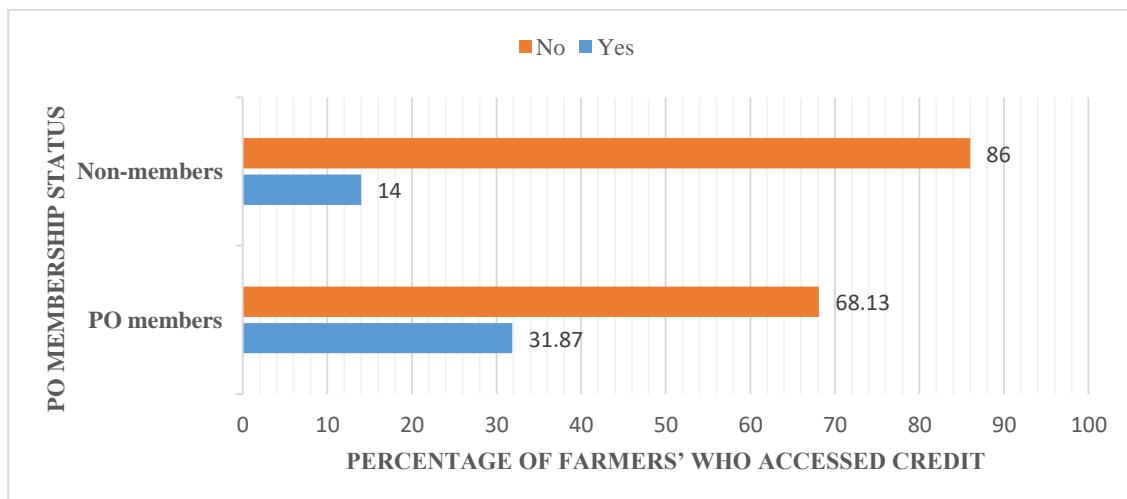


Figure 4.8: Percentages of farmers' access to credit during twelve months of milk production cycle

Dairy farming was an important farm enterprise in the study area. Besides, as displayed by Figure 4.9, farmers also engage in other complementary farm and off-farm activities. These activities may have an implication on resource allocation or investment in dairy farming which, in turn, influence performance of the enterprise. Therefore, it was crucial to document amount time allotted to dairy farming by farmers. The results of these analysis are presented in Figure 4.9. The results reveal that producer organization members spent significantly ($t=5.60$, $p< 0.01$) more hours (6.37) on dairy production activities than non-members (4.71 hours). This result suggests that dairy production was an important farm enterprise or economic activity to members than to non-members.

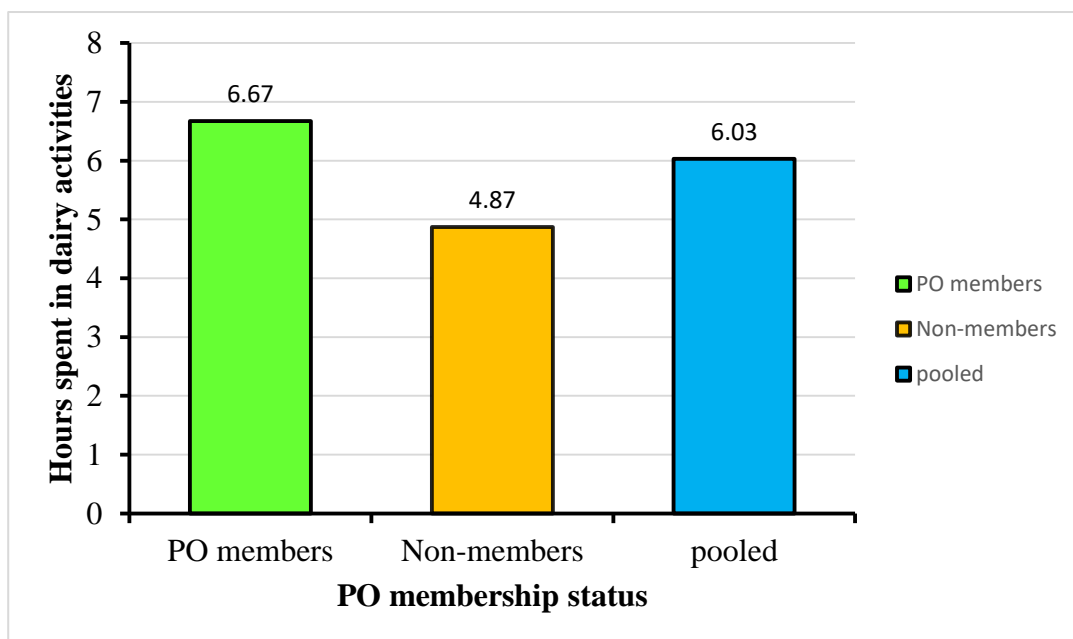


Figure 4.9: Average number of hours spent on dairy production activities by members and non-member of producer organizations

4.1.3 Comparison of Milk Yield

Between Comparison. The interest of the first objective was to compare milk yield of members of producer organization with that of non-members. Therefore, the variable of interest was average annual quantity of milk produced by the two groups of farmers. The average annual quantity of milk produced by farmers was 6750 litres. The results displayed in Figure 4.10 show that producer organization members significantly produced higher milk volumes in twelve months than non-members ($t = 2.99$, $p< 0.01$). The average annual quantity of milk (8207 litres) produced by members was twice that produced by non-members (4099 litres). This finding is tandem with Michalek *et al.* (2018) who indicated that participation in producer organization increased milk production and productivity in Ethiopia,

India, and Slovakia, respectively. The significant difference in annual quantity of milk produced by members and non-member could be attributed to significantly higher percentages of members owning pure breed cows (Figure 4.10), which were high milk yielders than cross-breed owned by a majority of non-members.

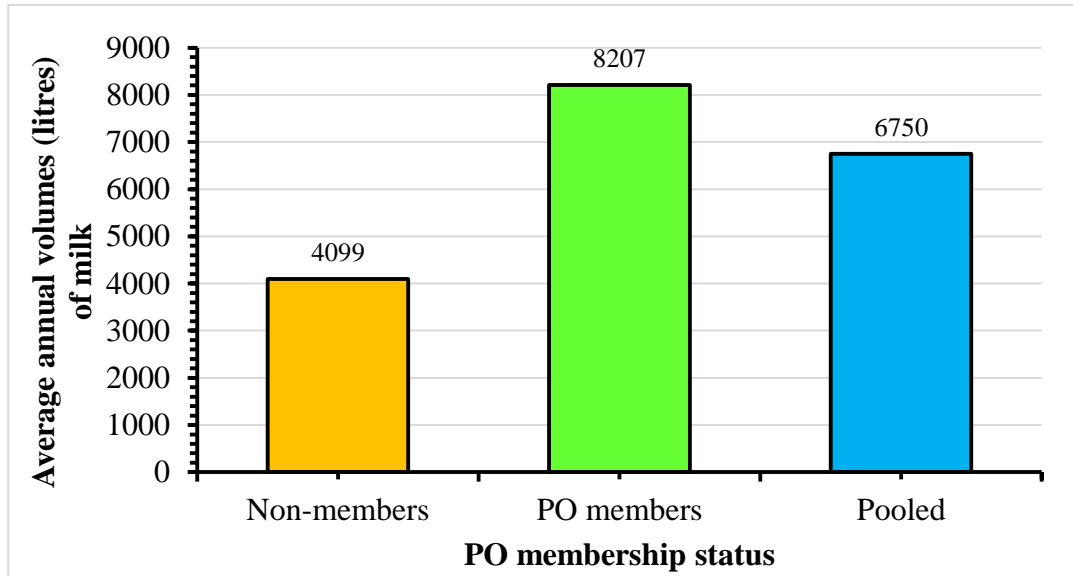


Figure 4.10: Average annual volumes (litres) of milk produced by producer organization members and non-members

However, displaying the average milk production is necessary but not sufficient in providing information on the distribution of milk production of members of producer organization relative to milk output of non-members. This weakness is overcome by histogram which is a powerful graphical method for communicating the distribution of numeric data. Figure 4.11 displays a histogram plot of the relative distribution of milk production of members to non-members. The plot has longer tails to the right, meaning that a huge chunk of data points ranged between 1250 litres and 10,000 litres. While most non-members milk production ranged from between 1250 to 10,000 litres per year, that of members ranged from 1250 litres and 15,000 litres. The longer distribution of milk production towards the right shows that members recorded significantly higher milk volumes than non-members. The longer tails to right means that the distribution of annual milk produced is greater than the median, while the median is greater than mode. This is a positive skew that reveals that there were positive deviance farmers who were outstanding in terms of milk produced. However, there were more outstanding milk producers among producer organization members than there were among non-members. These results reveal that producer group members tended to outperform non-members in terms of milk production.

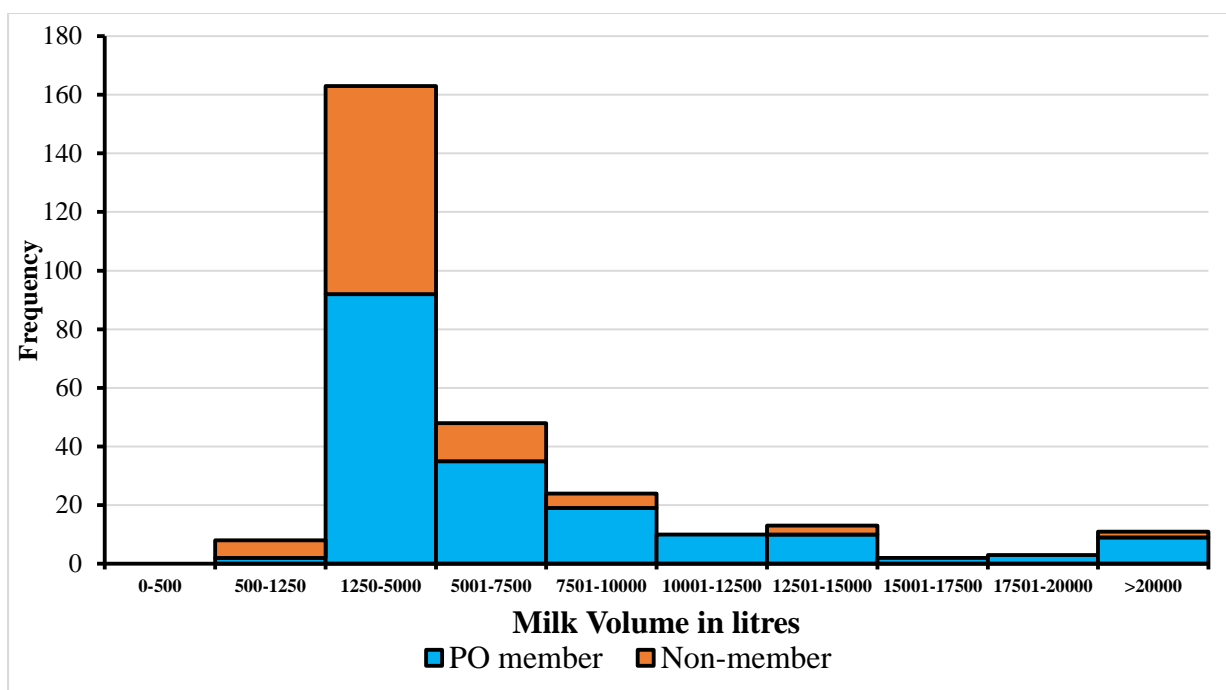


Figure 4.11: Distribution of milk produced by members and non-members of producer organizations

Nevertheless, producer organizations effectively contribute towards improved performance of dairy enterprise via provision of several services, including credit, feeds, advisory, artificial insemination, veterinary and marketing. Therefore, it was expected that membership to producer organizations would be correlated not only with the services accessed by farmers but also with total milk production. Therefore, pairwise Pearson correlation coefficients were calculated to establish the direction and strength of the associations between services received by PO members and performance of the dairy enterprises in terms of annual milk produced. The results in Table 4.3 show the relationships between membership and access to services ($r = 1.90$), between membership and milk production ($r = 0.18$), and between services and milk production ($r = 0.16$) were positive and strongly significant. These results mean that producer organizations facilitated dairy farmers in accessing input and other services, leading to higher milk volumes.

Table 4.3: Correlation coefficients of the relationships among PO membership, access to services, and milk produced

	PO membership	Services	Milk produced
PO membership	1		
Services	0.90***	1	
Milk production	0.18***	0.16***	1

Note: *** denotes significance level at 1%

Within Comparison. In addition to between comparisons, it was crucial to compare the performance of milk producers among the three producer organizations. This was founded on recognition that producer organizations may face unique governance, organizational or institutional challenges related to provision of services crucial to production. This sub-section compares milk production of the three producer organization members. The results were presented in Table 4.4. Besides the mean, median is also reported in parentheses because of extreme values in the survey data; that is, the data is highly dispersed, having a number of farmers producing small and large quantities of milk. Milk volumes produced, which is a summation of annual milk produced by member of each producer organization, is also reported. In this case, volumes of milk can be useful in predicting possible collection capacity and level of off-take at producer organization.

The average and median milk production was highest among members of Uruku dairy producer organization. The quantity of milk produced by Uruku members ($\bar{X} = 11,815$, $\tilde{X} = 6528$) was significantly higher than that produced by Abogeta ($\bar{X} = 7,659$, $\tilde{X} = 3833$) and Kionyo ($\bar{X} = 4,888$, $\tilde{X} = 3,885$) ($F = 4.36$, $p < 0.05$). Furthermore, milk yields were significantly higher for farmers in Uruku producer organization than for Abogeta and Kionyo ($F = 16.63$, $p < 0.001$). The average milk per cow per year were 2,712, 2741, and 4123 among farmers in Abogeta, Kionyo, and Uruku respectively. Furthermore, total volumes of milk produced by Uruku member (756,133 litres) was higher than those produced by Abogeta (444,218 litres) and Kionyo (264,745 litres). These results reveal that members of Uruku producer organization were the highest milk producers in the area of study. In addition, Uruku appears to have a higher operational capacity compared to the other two producer organizations.

Table 4.4: Average milk production, yields, and volumes produced by producer organization member disaggregated by name of producer organizations

PO Name	Freq.	Mean	p-value	Yield	p-value	Volume
Abogeta	58	7,658.93 (3,832.50)	0.014	2712.02 (2537.50)	0.000	444,218
Kionyo	60	4,888.83 (3,885)		2740.69 (2555.00)		264,745
Uruku	64	11,814.58 (6527.50)		4123.25 (4032.50)		756,133

Note: Median provided in parentheses

As earlier noted, institutional factors may precipitate differences in farm-level performance of dairy enterprises. For this reason, further analyses were conducted to unravel possible causes of significant differences in milk production among sampled producer organization members. It is important to note that the analysis is context specific and based on the survey data and, therefore, cannot be generalized beyond the description and representation of the data.

In Figure 4.12, the observed percentages of members of Uruku (97%), Abogeta (83%) and Kionyo (93%) that received extension services from their respective producer organizations were significantly different ($\chi^2=8.0654, p < 0.05$). Furthermore, there were significant differences in proportions of farmers in Uruku (97%), Kionyo (63%) and Abogeta (66%) that received artificial insemination ($\chi^2=23.9394, p < 0.001$). On the other hand, 61% of Uruku members, 57% of Kionyo members and 66% of Abogeta members received credit from their producer organizations. Nearly 72% of Uruku members, 63% Abogeta members and 60% of Kionyo members reported that they received veterinary services from producer organizations. In addition, 83%, 88%, and 92% of Abogeta, Kionyo, and Uruku members received feed from their respective producer organizations, respectively. However, there were no significant differences in percentages of farmers that received credit, feed and veterinary services.

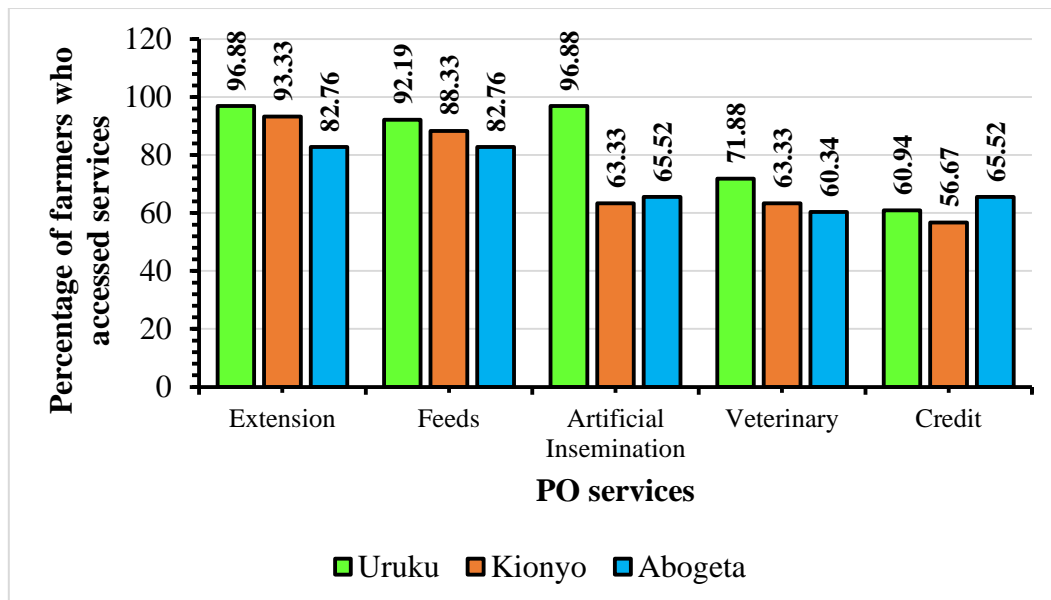


Figure 4.12: Percentages of sampled producer group farmers that reported to have received services disaggregated by producer organization

The results presented in Figure 4.13 provides possible reasons of the differences in milk production among members of three producer organizations. Extension services received by Uruku members possibly enabled them to gain dairy-specific knowledge that was crucial in narrowing productivity gaps. A higher number of Uruku members that received extension contacts or information may have enhanced their technical abilities and capacity that enabled them to initiate farm-level changes in dairy enterprises, including improved breeds, feed and fodder production, and management strategies and infrastructure, which resulted in higher milk production compared to farmers in the other two producer organizations. This finding corroborates finding by Kolekar and Meena (2013) and Nicholas and Angubua (2019) in studies that were conducted in Pakistan and Uganda respectively.

Furthermore, farmers in Uruku received artificial insemination and breeding services more than those in Kionyo and Abogeta. This could have had positive influence on-farm production efficiency because of rearing improved cows with high productivity and reproductive traits. Uruku farmers possibly were more motivated in investing in improvement in the quality of their dairy animals which translated into increased productivity. This argument is supported by results displayed in Figure 4.13 which show that 70% of Uruku members owned pure breed cows which was significantly higher than 53% and 36% of farmers in Abogeta and Kionyo that owned the same types of breeds. Higher ownership of pure breeds accompanied by improvements in quality of the dairy herd courtesy of access to reproductive services – artificial insemination – from Uruku producer organization possibly explains higher milk production and yields reported in Figure 4.13.

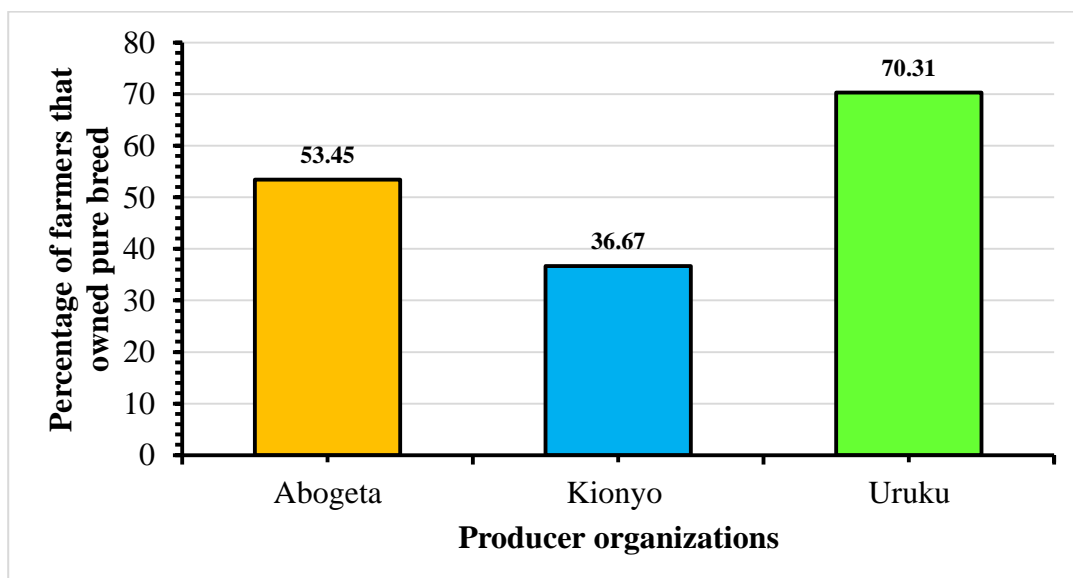


Figure 4.13: Percentages of sampled farmers that owned pure breed cows disaggregated by name of producer organization

Furthermore, significant milk production differences among producer organization members provided in Figure 1.14 could be explained by governance differences of the three organizations. Regardless of whether membership to producer organizations is random or not, dairy producers have varying priorities which were often difficult to fulfil or manage. For this reason, producer organizations should invest considerably in governance in order to engage and maintain functioning of the collective formations and performance (Jussila *et al.*, 2012). Producer organizations that put in place structures that gives members power to participate in decision-making processes, election management team, directly or indirectly, and ensure transparency and accountability of professional managers improve their performances (Jussila *et al.*, 2012). In other words, effective functioning requires grassroots ownership of the producer organizations through general meetings, members' expression of ideas and suspicion of misappropriations, and voting in important decisions. As shown in Figure 16, Uruku had strong governance structures in these four domains as compared to Abogeta and Kinyo. These results could also be explanation of higher performance of Uruku producer organization in terms of milk production by members compared to those that belonged to Kinyo and Abogeta.

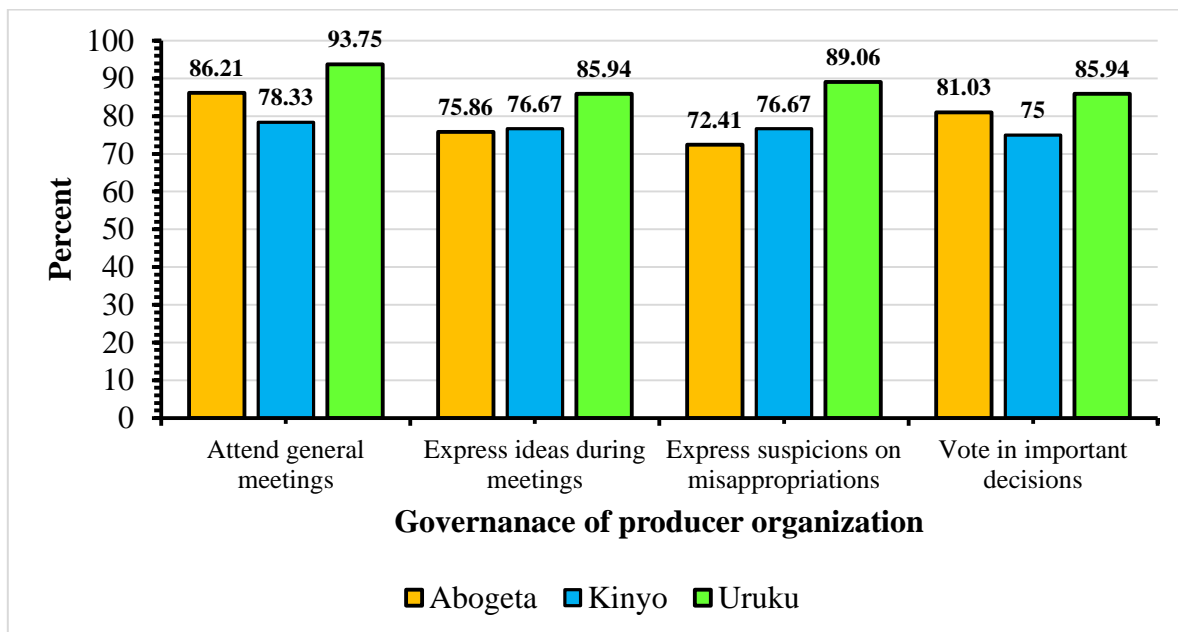


Figure 4.14: Governance of producer organizations

4.2 Role of Producer Organization on the Level of Farm-level Implementation of Milk Hygiene Strategies

4.2.1 Training on Milk Hygiene Strategies

Results on whether respondents had received training on are presented in Table 4.5. Group membership was significantly ($p < 0.01$) associated with receiving formal training on milk hygiene strategies by farmers. About 80% of producer organization members received the training compared to 37% of non-members conforming the Sangadah *et al.* (2021) assertion that milk cooperatives develop training program that address dairy production capacity building in multiple areas, including hygienic milking, storage and maintenance of milking environment, milk safety and quality. The percentage of farmers that received training from producer organizations was significantly ($p < 0.1$) higher for members (81%) than non-members (68%). However, the relatively higher percentage of non-members that received training from producer organizations in the last three years could have either resigned as dairy cooperative members by time of survey or paid for training. In contrast, significantly more non-members (30%) than members (11%) received milk hygiene training from government extension officers. The fewer members trained by government extension officers could have represented a proportion those who did not receive training on milk hygiene from their respective producer organizations. Other sources of trainings were NGOs, input dealers, milk processors and the media, and members and non-members that received training from these sources were not significantly different.

Table 4.5: Summary results of percentages of farmers that reported receiving milk hygiene training over a three-year period

Description	Pooled (<i>N</i> =282)	Non-Members (<i>n</i> =100)	Members (<i>n</i> =182)	<i>p</i> -value
Milk hygiene training (%)	64.54	37.00	79.67	0.000***
Source of training (%)				
Producer organization	78.02	67.57	80.69	0.085*
Government extension officer	14.84	29.73	11.03	0.004***
NGO	8.79	2.70	10.34	0.143
Input dealer	2.20	5.41	1.38	0.136
Milk processor	15.93	13.51	16.55	0.652
Media	4.40	2.70	4.83	0.574
On-farm hygiene inspection (%)	21.99	9.00	29.12	0.000***

*Note: *, ***, represent significance levels at 10% and 1% respectively*

Nonetheless, despite 81% of producer organization members receiving training in milk hygiene strategies from their respective cooperatives, a paltry 29% indicated that their farms were inspected by producer organization staff for compliance with milk hygiene strategies. This result suggests possible capacity challenges that impede producer organization. For instance, the producer organizations may be lacking the financial capacity to conduct regular on-farm inspections for compliance with milk hygiene strategies. Second, the societies may lack human resource capacity to inspect and enforce milk hygiene strategies. However, these assertions were not tested and they were beyond the scope of the current study.

4.2.2 Farm-level Implementation of Milk Hygiene Strategies

Farm-level milk hygiene strategies were broadly classified into six categories, namely personal hygiene, animal and personal health, udder hygiene, workspace hygiene, equipment hygiene, and milk handling and storage hygiene practices. Farm-level results of implementation of milk hygiene strategies results are presented in Table 4.6. There were six personal and animal health strategies reported by farmers: milkers not milking when sick, only milking healthy cows, and milking cows with mastitis last and discarding the milk. Others were examining foremilk from each teat and discarding abnormal milk, checking for mastitis prior to milking, and milk from cows on antibiotics not consumed until withdrawal is over (Younan, 2013). There were significant differences between percentages of members and non-members that ensured milkers do not milk cows when sick and those that examined milk from each teat and discarded any abnormal milk. The percentage of farmers that ensured that sick milkers did not milk was higher among members (77.13%) than non-members (63.70%). Besides, there was a marginal significant difference ($p < 0.1$) between members (84.10%) and non-members (79.52%) who ensured milked cows are free from diseases. Nonetheless, no significant differences were reported in the level of farm-level implementation of the other animal and personal health hygiene measures between members and non-members.

Furthermore, two personal hygiene practices were reported by farmers; milkers washing hands with soap before initiating milking and drying hands with clean dry towel or cloth. While no significant differences were reported for drying hands with clean dry towel or cloth, there was a marginal significant difference ($p < 0.1$) between members (84.10%) and non-members (79.52%) who ensured milkers washing hands with soap before initiating milking. Thirdly, udder hygiene strategy implemented by farmers was teats dipped/sprayed

with antiseptic solution after milking. In general, the implementation of udder hygiene practices was statistically significant higher among members compared to non-members.

Table 4.6: Comparisons of percentages of farmers implementing milk hygiene strategies by status of membership in dairy producer organizations

Practice	Pooled (N=282)	Non-Members (n=100)	Members (n=182)	p-value
Personal and animal health				
Milkers do not milk when sick	72.37	63.70	77.13	0.000***
Milked cows free of diseases	90.32	87.78	91.74	0.097*
Cows with mastitis milk last and milk discarded	91.70	90.99	92.09	0.798
Milk from cows on antibiotics not consumed	97.54	97.73	97.44	0.798
Mastitis checking prior to milking	77.65	76.49	78.28	0.649
Foremilk from each teat was examined and abnormal milk discarded	74.58	71.53	76.26	0.268
Personal hygiene				
Wash hands with soap before initiating milking	82.48	79.52	84.10	0.087*
Clean dry towel/cloth used to dry hand after washing	86.70	86.13	87.02	0.768
Udder hygiene				
Cow udder and teats washed before milking	95.40	96.11	95.01	0.403
Teats/udder wiped with clean towel after washing	87.73	87.77	87.70	0.981
Use one towel per cow	77.06	77.10	78.70	0.278
Fast but gentle milking of cows without interruptions	94.17	94.58	93.95	0.641
Stripping to get last drop out of the udder after milking	94.28	93.56	94.68	0.504

Teats dipped/sprayed with antiseptic solution after milking	42.20	33.19	47.15	0.006***
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Table 4.6: Continuation

Equipment hygiene				
Cloth/strainer cleaned after use	92.83	88.42	95.25	0.004***
Cloth/strainer disinfected after use	64.58	55.69	69.46	0.008***
Equipment made from approved material	79.88	65.51	87.77	0.000***
Equipment cleaned immediately after use	94.75	93.72	95.31	0.294
Milk vessels/equipment sterilized after cleaning	82.79	80.08	84.28	0.257
Vessels/equipment put upside down to dry	91.13	88.38	92.65	0.069*
Post-milking milk handling and storage				
Immediate filtering of milk after milking	93.91	89.55	96.31	0.003***
Milk is stored in clean sealed containers	92.39	92.57	92.29	0.883
Milk transported to buyer with 2 hours of milking	92.46	90.46	93.57	0.156
Cooling up to 10 degrees when stored for > 2 hours	68.33	44.14	81..63	0.000***
Workspace Hygiene				
Concrete floor of milking parlour	72.89	55.08	82.68	0.000***
Thorough cleaning of milking area	65.70	45.52	76.80	0.000***

Note: *, ***, represent significance levels at 10% and 1% respectively

There were significant differences in implementation of three milking equipment hygiene practices. The practices that significantly differed were cleaning and disinfecting cloth or strainer after use and using milking equipment made from approved material, with significantly more producer organization members than non-members reporting that they implemented at farm-level. There was a marginal significant difference ($p < 0.1$) between members (92.65%) and non-members (88.38%) who reported milking equipment are put upside down to dry after cleaning and sterilization. However, there were no significant differences in cleaning and sterilization of milking equipment immediately after use. While levels of farm-level implementation of two storage hygiene practices – milk storage in clean sealed containers and transportation within two hours after milking – among members and non-members were not significantly different, there was significantly higher perceived levels of storage hygiene practices in terms of immediate filtering of milk after milking cooling milk up to 10 degrees when stored for more than 2 hours among members than non-members. Nonetheless, workspace hygiene practices – concrete floor of milking parlour and thorough cleaning of milking area – were implemented highly by members than non-members.

4.2.3 Influence of producer organization membership on farm-level implementation of milk hygiene strategies

The influence of producer organization membership on farm-level implementation of milk hygiene strategies was estimated using poisson regression model (PRM). PRM suffers from high instability in cases when predictor variables included in the model are correlated. Correlated regressors widens confidence intervals, affects variance and covariance of significant coefficient estimates, enlarges the coefficient of determination, and causes t -ratios to be insignificant (Lukman *et al.*, 2021). These negatively influences the performance of maximum likelihood estimator as well as the Poisson regression. Therefore, PRM was tested for the presence of multicollinearity. The results presented in Appendix B show that the model did not suffer from multicollinearity and, therefore, it was stable.

A total count of milk hygiene strategies out of the maximum possible twenty-six was constructed to determine how producer organizations influenced the level of farm-level implementation of the milk hygiene strategies. The role of producer organization membership on the level of farm-level implementation of the 26 strategies controlling for socioeconomic and institutional variables are presented in Table 4.7. The model fitness statistics (Wald $\chi^2 = 121.19$, $p < 0.01$) were statistically significant, indicating that Poisson model fit the data well. There were four variables statistically significantly associated with level of farm-

level implementation of milk hygiene strategies; producer organization membership ($\beta = 0.072, p < 0.01$), total farm size ($\beta = 0.001, p < 0.01$), hours spent on dairy farming activities daily ($\beta = 0.006, p < 0.01$), and distance to nearest town ($\beta = 0.001, p < 0.1$). Besides, Table 4.7 also presents the incidence-rate ratios (IRR) which are transformations of estimated coefficients. The IRR are interpreted for ease of understanding of the model output given the type of distribution that Poisson model relies.

Table 4.7: Poisson coefficient estimates of influence of dairy producer organization membership on level of farm-level implementation of milk hygiene strategies

Variable	Coef.	IRR	p-value
PO membership (1=Yes, 0 otherwise)	0.072 (0.012)	1.074 (0.013)	0.000***
Sex of farmer	-0.008 (0.010)	0.992 (0.010)	0.438
Marital status	0.012 (0.017)	1.012 (0.017)	0.477
Log of milk per cow	0.014 (0.009)	1.014 (0.009)	0.123
Cow ownership	0.003 (0.011)	1.003 (0.011)	0.779
Total farm size	0.001 (0.000)	1.001 (0.000)	0.000***
Price per unit of milk	0.001 (0.004)	1.001 (0.004)	0.836
Hours spent on dairy farming activities	0.006 (0.002)	1.007 (0.002)	0.001***
Training in milk hygiene strategies	0.010 (0.012)	1.010 (0.012)	0.382
Distance to nearest town	-0.001 (0.001)	0.999 (0.001)	0.062*
Constant	2.954 (0.135)	19.192 (2.584)	0.000

Note: Standard errors provided in parenthesis.

*, ***, represent significance levels at 10% and 1% respectively

The variable of interest – producer group membership – had a positive and significant influence on level of farm-level implementation of milk hygiene strategies. The results showed that producer organization members had 1.07 times the number of milk hygiene strategies implementation at farm-level. This result was expected since more producer organizations members accessed training on milk hygiene strategies and reported their farms inspected for compliance with the strategies (Table 4.7). Furthermore, the significant influence of producer organizations on implementation of milk hygiene strategies could be attributed to the institutional structures that cooperatives deploy to ensure adherence to milk quality. Producer organizations offer access to reliable formal markets, thereby compelling milk suppliers to adhere to quality standards. As also demonstrated in Table 4.7, members of producer organizations were trained by multiple organizations and agents, possibly because of the mobilization and facilitative role of dairy cooperatives. This result reaffirms arguments by Lemma *et al.* (2018) who asserted that registration of dairy producers with milk cooperative in Kenya ensures compliance with dairy industry regulations for dairy products, as well as food safety standards.

Secondly, total farm size owned by dairy farmers had a positive and significant relationship with level of implementation of farm-level milk hygiene strategies. One more acre of farm size increased the number of milk hygiene strategies implemented by farmers by one holding other factors fixed. Land sizes possibly allowed farmers to allocate more land to dairy infrastructure which in turn provide proper workspace conditions for cattle. Investment in food production and feeding infrastructure as argued by GlobeCore (2021) reduces the need for antibiotics which improves milk quality. Younan (2013) also posited that feeding cows on hay reduces the risk of mastitis thereby ensuring udder health and milk quality.

The hours spent on dairy production activities was associated in a positive and significant way to the level of implementation of milk hygiene strategies at the farm-level. Allocation of one extra hour on dairy production activities resulted in 1.01 more implementation of farm-level milk hygiene strategies holding other factors constant. Farmers who allocated more time on dairy production activities were possible able to ensure that milking equipment were clean before and after milking. Furthermore, they ensured that the milking workspace was always clean. They were also able to identify and ensure that sick animals and those on treatment were milked last and their milk discarded. In addition, spending more hours on dairy activities could have enabled farmers to supervise implementation of milk hygiene strategies. In this case, more hours was spent on possibly to

enhance milk quality in order to access formal and guaranteed markets for improved return on investment.

In contrast to farm size and hours spent on dairy activities, distance to nearest town had a negative significant influence on the extent of farm-level implementation of milk hygiene strategies. An extra kilometre from the farm to the nearest town reduced implementation of milk hygiene strategies by 1 strategy *ceteris paribus*. Possibly longer distance to nearest town formed a major bottleneck to farmers' access to information about consumer demand for quality milk and market regulation. For instance, longer distance to market may have denied farmers opportunities to interact with other value chain stakeholders for valuable sharing of knowledge on current trends or developments in milk hygiene regulations and important strategies to improve milk quality (De Vries *et al.*, 2020). In addition, farmers further away from town were unable to access credit for investment in milk hygiene infrastructure. Furthermore, as espoused by De Vries *et al.* (2020), Duncan *et al.* (2013) and Migose *et al.* (2018) longer distance could have been associated with poor milk prices and low access to high quality inputs and equipment, thereby discouraging farm-level intensification of milk hygiene strategies.

4.3 Effect of producer organizations on dairy enterprise performance

4.3.1 Preliminary Diagnostic of ESR model

The endogenous switching regression model has to satisfy a number of assumptions for it to be appropriate in estimating treatment effects. First, the Wooldridge's score and regression-based test were used to test the exogeneity of membership to producer organization. The results are presented in Appendix C. The results show that the Wooldridge's score test ($\chi^2 = 4.905$ $p = 0.027$) and regression-based test score ($\chi^2 = 4.702$, $p = 0.031$) were significant at 5% level. Thus, the null hypothesis of exogeneity of dairy producer group membership is rejected. Instead, it is concluded that membership to dairy producer organizations was rightly considered and treated as endogenous. Therefore, accounting for the endogeneity makes the results of the second stage of endogenous switching regression model consistent.

Second, distances to milk buyer collection point, all-weather road and producer organization office were used as instruments. Distances to milk buyer collection point and all-weather road were also interacted and included as an additional instrument. Therefore, it was crucial to determine the validity of these instruments. The results presented in Appendix C show statistically significant robust F -statistic ($F=9.234$, $p < 0.01$), indicating that the

instruments used were valid. Furthermore, over-identification test statistics (Appendix C) were not significant, meaning that variables used as instruments were valid and regression model correctly specified. Nonetheless, only distance to milk buyer collection point was used as an instrument in the ESR model because of possibility of same buyer being the producer organization in regime 1 equation.

4.3.2 Determinants of Producer Organization Membership

Fitting treatment effects models using endogenous switching regression involves establishing reasons for occurrence of two states; those individuals involved in a programs and those not involved. This is done in the first stage. In this study, the first stage involved modelling membership in producer organization under assumption that dairy farmers in the study area chose between being members and non-members. This was achieved using probit model. Literature provides that choice between membership and non-membership in producer organization is shaped is socio-demographic variables such as sex, education, household headship and other human capital factors (Matchaya & Perotin, 2013), economic characteristics such as farm size, income, asset ownership, physical infrastructure such as distance to marketplace and roads, farmer perception, and institutional factors. Thus, this subsection present probit results of determinants of membership in dairy producer organizations. Table 4.8 presents results of the determinants of dairy farmers' decision to register or not to register as producer organization members.

Table 4.8: Probit regression results of determinants of dairy producer organization membership

Variable	Coeff.	Std. Error	p-value
Socio-demographic characteristics			
Age of household head	0.012	0.009	0.205
Education level of HH head in years	0.002	0.025	0.922
Sex of household head	-0.312	0.209	0.136
Farming experience	-0.011	0.009	0.223
Marital status	-0.093	0.120	0.442
Household size	-0.022	0.051	0.663
Farm characteristics			
Farm size	-0.007	0.011	0.557
Breed (1=pure, 0 otherwise)	0.290	0.176	0.099*
Cow ownership (base = Joint)			
Male	-0.316	0.214	0.140
Female	0.179	0.273	0.512
No. of hours spent on dairy production daily	0.159	0.039	0.000***
Institutional characteristics			
Price per litre of milk in KES	-0.155	0.074	0.036**
Access to credit	0.667	0.210	0.001***
Distance to milk buyer collection point	0.400	0.136	0.003***
Constant	4.552	2.646	0.085

Note: *, **, *** represent significance levels at 10%, 5% and 1% respectively

There were five independent variables that significantly influenced the probability of farmers registering as members of dairy producer organizations; two farm characteristics (breed and number of hours spent on dairy production daily) and institutional factors – price per litre of milk, access to credit, and distance to milk buyer collection point. First, ownership of pure breed cows was positive and significantly associated with the probability of farmers registering as members of producer organizations. In other terms, farmers who owned pure breed had 29 percent higher chances of being producer organization members than those that owned local or cross-breed animals. Pure breed animals are high milk producers compared to cross-breed and local breed animals. Therefore, producer group members could have been informed by the need for assured market or buyer of high milk volumes. In this case,

producer organizations provide market guarantees because of their formal engagements with milk processors. Besides, pure breed keepers incur relatively higher cost per cow on feed, labour, breeding, and veterinary service (Marshall *et al.*, 2020), efficiency of management strategies notwithstanding, and could have been the reason for membership. Farmers were possibly incentivized by access to feed and breeding and veterinary services that were often provided by producer organizations. This finding corroborates results reported by Mwambi *et al.* (2020) in Nyandarua and Meru counties of Kenya.

Furthermore, number of hours spent on dairy production daily and membership in producer organizations were positively and significantly related. One additional hour spent on dairy production activities such as feeding, grazing, watering, and health management among others was associated with 15.88% higher probability of participation in producer organizations. This finding suggests that dairy production was possibly the primary source of livelihood or, in other words, the main occupation. Besides, although labour provision in dairy farming depends on production system, lack of mechanization of most production and management activities possibly explained high investment of time in dairy farming and membership to producer organization as an avenue for accruing benefits of the investment. In this case, dairy enterprise is an employment opportunity whose contribution to farmers' livelihoods depends on how they invest in the enterprise and connect with other farmers and other value chain actors through collective action.

Third, although price offered by main buyer significantly influenced membership to producer organizations, the association was unexpectedly negative. Increase in milk price was associated with 15.50 percent less chance of farmers being producer group members. This finding suggests that producer organizations possibly offered less attractive prices than what milk traders offered to non-members or members that had multiple buyers. Farmers' membership may have not been founded on price rather on the need to reduce the impact of price fluctuations on farm operations or livelihoods. This contradicts theoretical claims of price incentives or price effects of membership to cooperatives as reviewed by Carletti *et al.* (2019) who also attributed membership in some dairy cooperatives in Argentina to farmers' attraction to stable prices or price risk safety nets rather than price incentives.

The fourth finding from results presented in Table 4.8 is the positive and significant relationship between membership to producer organizations and access to credit services. Farmers who had access to credit had 66.7% higher probability of being members than those who had no access. Credit acquired possibly enabled farmers to invest in breeds and innovations, as well as dairy infrastructure and management strategies thus, in turn, enabled

them to meet membership requirements such as hygiene, minimum milk supply, and quality standards. In this case, membership could have acted as safeguard of market access that guaranteed farmers returns on cost of credit. Additionally, credit received may have been used to expand dairy enterprises, resulting in production at scale and producer organization membership acting as pathway for accessing formal market because of the resultant economies of scale. This finding is in line with results reported by Afolabi and Ganiyu (2021), Andhani (2017) and Gashaw and Kabret (2018), who reported positive influence of credit on cooperative membership among farmers in Kenya, Ethiopia, and Nigeria respectively.

The distance from farm to the milk buyer's collection point had a significant positive influence on membership in producer organizations. Each additional kilometre to the nearest milk purchaser's collection point increased the likelihood of membership in the producer organization by 0.4 times. Longer distances between milk buyers' collection points may have increased transport costs, making them unaffordable to smallholder farmers. This would have allowed farmers to choose to become members to lower transaction costs through collective action. These results were similar to that of Lin *et al.* (Year 2019) who noted that cooperative societies can integrate vertically to provide transportation services or to save on transaction costs that prevent small farmers from accessing markets. Earlier results also found a positive association between distance to milk collection centres and membership to dairy cooperatives (Moturi *et al.*, 2015). Second, milk handling during transportation is an important cause of milk quality deterioration. Therefore, membership could have been a viable option to reduce transportation-related milk quality issues for farmers targeting formal markets. Tadesse *et al.* (2016) also argued that farmers closer to milk collection centres were less likely to be cooperative society members due to lower transportation charges and low risks of milk spoilage.

4.3.3 Effect of Producer Organization Membership

The second stage of the endogenous switching regression model involved separate estimation of dairy enterprise performance for members and non-members, conditional on membership decision in the first stage. The OLS regression results presented in Table 4.9 show coefficient estimates of milk production per cow for members and non-members of dairy producer organizations. Two variables were significantly associated with milk production per cow for both members and non-members: animal breed and number of hours spent on dairy production. On the other hand, while sex of household head significantly

affected milk production among non-members, female ownership of dairy cows had significant influence of members' milk production per cow.

Table 4.9: OLS estimates of milk production per cow

Variable	Members			Non-members		
	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value
	-					
Age of household head	0.003	0.004	0.435	0.002	0.008	0.783
Education level of HH head	0.012	0.012	0.321	0.008	0.022	0.701
	-			-		
Sex of household	0.047	0.102	0.646	0.497	0.181	0.006***
	-			-		
Farming experience	0.003	0.004	0.514	0.011	0.008	0.158
Household size	0.002	0.022	0.942	0.058	0.047	0.216
	-			-		
Marital status	0.039	0.054	0.468	0.019	0.109	0.862
Cow ownership (base = Joint)						
	-			-		
Male	0.028	0.102	0.782	0.296	0.187	0.113
Female	0.219	0.124	0.077*	0.014	0.240	0.953
	-			-		
Farm size	0.001	0.017	0.963	0.014	0.009	0.134
			0.000**			
Breed (1=pure, 0 otherwise)	0.318	0.083	*	0.468	0.155	0.002***
No. of hours spent on dairy prod.	0.051	0.017	0.003**	0.124	0.037	0.001***
Access to credit	0.044	0.091	0.634	0.168	0.195	0.388
				-		
Price per litre of milk in KES	0.008	0.032	0.810	0.041	0.063	0.512
Constant	7.157	1.130	0.000	9.305	2.250	0.000

Note: *, *** represent significance levels at 10% and 1% respectively

Sex of the household head had a negative and significant influence on milk production per cow for non-members but no significant effect on members' production.

Holding other factors fixed, female-headed households produced 50% less milk per cow than male-headed households. Compared to male-headed non-member households, female-headed non-member household could have lacked opportunities and resources to improve milk production efficiency. Female household heads may also have not had full autonomy over allocation of resources to dairy production as compared to male-heads. Exclusion of women participation in decision-making limits adoption and application of animal husbandry strategies for improved milk production. Compared to men, female farmers' participation in dairy value chain is mainly concentrated at production with limited participation in profitable market opportunities. Therefore, limited access to profitable activities in dairy value chain could have been a major disincentive for milk production among female-headed household than male-headed households.

The dairy animal breed had the expected positive and significant effect on milk production per cow for both non-members and members of producer organizations. Members and non-members that owned pure breed dairy cows produced 31.8% and 46.8% more milk per cow than farmers who owned local or cross breed animals, respectively. Pure breed animals have superior productive qualities that enhance milk production. In particular, the breeding efficiency and genetic potential of pure breed cows is expressed via a combination of economically beneficial qualities, including optimal feeding and milk yields (Mymrin & Loretts, 2019). These were traits that possibly explained higher effect of pure breeds on milk production per cow regardless of whether farmers were producer organizations members or non-members.

The number of hours spent on dairy production was also statistically and significantly associated with milk production per cow regardless of producer organization membership status. One more hour spent on livestock production activities per day increased milk production per cow by 5% and 12% for members and non-member respectively. Time allocation to dairy production activities may imply that the enterprise is critical to farmers and their households in social and economic terms such as contribution to incomes and food security. Therefore, farmers would have invested more time in dairy management and husbandry strategies in order to maximize milk production. Households invested more time in dairy technology in order to enhance milk production and dairy share of household incomes.

Female ownership of dairy cow had a positive and marginal association with milk production per cow among producer group membership. Female ownership of dairy cows increased milk production per cow by 21.9% more than joint ownership (male and female).

As argued by Lenjiso (2019), female manage cows and also process milk and milk products for both sale and household consumption. Therefore, full ownership of dairy cows meant that they had control over management and income generated from dairy production. As such, female farmers would have invested more in dairy enterprise to maximize returns through increased milk production in order to strengthen their position in formal milk markets granted by producer organizations and to ensure household food and nutrition security.

4.3.4 Treatment Effects

The third objective also focused on treatment effects of participation in producer organizations on dairy enterprise performance. Milk production per cow was used as the proxy for dairy enterprise performance. The treatment effects were also generated with the ESR model. Nonetheless, it was crucial to check the appropriateness of ESR in estimating treatment effect. The Wald χ^2 test statistic presented in Appendix C was significant indicating that ESR fit the data well and was appropriate to measure treatment effects compared to performing independent samples *t*-test or linear regression and other alternative models. Second, the correlation coefficient (ρ) was statistically significant indicating sample selection and justify ESR model. Third, the likelihood ratio test was also statistically significant showing the independence of the outcome regression equations.

The second column in the second row of Table 4.10 is the observed milk production per cow for members of producer organization, while the third column on the same row is the counterfactual scenario for producer group members. On the other hand, the second and third columns of the third-row present counterfactual scenario and observed milk production per cow for non-members of producer organization. The last column of Table 4.10 presents the average treatment effects (ATE) which is the differences between observed and counterfactual scenarios. The last row presents base and transitional heterogeneous effects.

Table 4.10: ESR estimates of producer organization membership on farm-level performance

Type and treatment effect	Membership	Non-membership	ATE
Member household (ATT)	2,787.83	2,273.05	514.79
Non-member households (ATU)	10,468.71	2,170.16	8,298.55
Heterogeneous effects	-7,680.88	102.89	-7783.76

The actual milk production per cow for members was 2,788 litres compared to 2,170 litres by non-members. This result suggests that producer organization members produced

618 litres of milk per cow (28.5%) more than non-members. However, this interpretation may disguise the true effect of producer organization on dairy performance. A focus on the ATE reveals that producer organization members would have produced 22.6% (515 litres) less milk per cow had they not been members. On the other hand, non-members would have produced 8,299 more litres of milk per cow had they been members of producer organization. Though, since the transitional heterogenous effect is negative, it implies that effect of producer organization membership on dairy enterprise performance is significantly smaller for members of producer organizations relative to non-members. At the same time, members of producer organizations would still have had higher milk production per cow than non-members had they not even been members. This result reveals heterogeneity that makes producer organization members best performers in dairy production than non-members irrespective of challenges associated with milk production. Nonetheless, members were better off as members than being non-members.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

Chapter Five provides conclusions of the study, policy recommendations as well as areas of future research.

5.1 Conclusion

- i. There is statistically significant difference in milk production of dairy farmers as well as difference in performance of producer organizations in South Imenti sub-county.
- ii. Membership to producer organization significantly influenced the level of farm level implementation of milk hygiene strategies.
- iii. Membership to producer organizations positively affect dairy enterprise performance particularly for the technically challenged smallholder dairy farmers by increasing their technical abilities.

5.2 Recommendations

The following are recommendations to dairy producer organizations, farmers and policy makers/government

- i. Farmers should take advantage of organizational innovations such as mobilization of farmers to increase their access to producer organization services such as training of farmers on milk hygiene strategies to overcome milk safety and quality challenges and meet increasing consumer demand for high quality milk and milk products.
- ii. The government should develop policies that support formation of producer organizations and strengthen the capacity and capability of existing producer organizations to deliver services aimed at enhancing milk quality as this is central to closing productivity gaps at farm level as well as improving performance of producer organizations and growth of the dairy industry in the area under study and in the country at large.
- iii. Producer organizations should target farmers that are technically disadvantaged through sensitization trainings to enhance awareness and knowledge of the role of producer organizations in performance of dairy enterprises and marketing of dairy products.

5.3 Areas of Future Research

This study was limited to determination of the role of producer organizations on farm-level implementation of milk hygiene strategies. However, there is need to collect farm-level samples and conduct laboratory tests to establish if farm-level implementation of milk hygiene strategies correlates with microbial quality of raw milk. In addition, a similar

research building on panel data can be conducted to capture the dynamics that occur in production and collective action over time.

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APPENDICES

Appendix A: Questionnaire

Wageningen University

Project title: Local and International business collaboration for productivity and Quality Improvement in Dairy chains in Southeast Asia and East Africa (LIQUID)

Consent

My name is _____. In this community we are conducting a study on farmers' participation in producer organizations, drivers of adoption of milk hygiene practices and gender roles in dairy. I would like to request for your participation. Your participation is voluntary. Any information you provide will be treated strictly confidential, used anonymously, and will not be used for any other purpose other than this study.

Verbal consent _____ (Yes / No)

IDENTIFICATION

Name of the respondent: _____

County: _____

Sub-County: _____

Phone number of the respondent: _____

A. GENERAL FARMER CHARACTERISTICS

1. Did you sell cow milk in the year Sept 2017 to Sept 2018? (0=No, 1=Yes) _____
2. How many years of formal schooling did you receive (starting from standard 1) _____
3. What is the size of your household _____
4. What is your marital status? _____ (1=Married, 2=Single, 3=Divorced, 4=Widowed)

If no, end of the questionnaire

B. DAIRY PRODUCTION

5. What breed of cows did you own _____ 1=Pure breed 2=Cross breed, 3=Local breed
6. How many milking cows did you own in total in the year Sept 2017 to Sept 2018 _____
7. Who owns most of the cows? _____ (1=Male head, 2= Female spouse, 3=Female head, 4=Jointly)
8. Fill in the table below on farm owned in the year Sept 2017 to Sept 2018

Total size of your farm (owned, rented, borrowed and leased)	Size of your farm owned with a title deed	Size of your farm allocated to fodder	Percentage of the farm owned by					
			Acres	Acres	Acres	Male head	Female spouse	Female head

9. What is the total amount of milk produced in your farm in the year Sept 2017 to Sept 2018? _____ litres

10. To what extent do you agree with the following statements about milk production in your farm? (production and environmental uncertainty)

Rate on a scale of 1 to 7 where 1 is completely disagree and 7 is completely agree

Statement	Completely disagree Neutral Completely agree						
	1	2	3	4	5	6	7

a. It is difficult to tell the amount of milk my dairy farm will produce in the next 2 years							
b. My dairy farm has suffered loss as a result of extreme weather in the past 2 years							

11. How many full time employees did you hire in your dairy farm?

12. How many casual labourers did you hire in your dairy farm?

C. DAIRY MARKETING

13. What kind of transport did you own in the year Sept 2017 to Sept 2018 _____ (1= car, 2= motorcycle, 3= bicycle, 4= cart, 5= tractor, 6= truck , 7=none, 8=other, specify)

14. From the total milk produced in the year Sept 2017 to Sept 2018, what percentage did the household sell? _____%

15. Who did you sell the milk to? _____ (1=PO, 2=Trader, 3=Neighbour, 4=Processor, 5=Others, specify)

16. At what price did you sell the milk per litre Ksh _____

17. Of the total percent sold, what percentage was sold to the PO? _____

18. Of the total percent sold, what percentage was sold to the trader? _____

19. Fill in the table below regarding information on your buyer(s) of milk

Buyer type	Kilometres to the point of sale of the buyer	Reason (s) for selling to this buyer (indicate all the reasons)	The average price received from the buyer in KES/ litre in the year Sept 2017 to Sept 2018 during:		When do you receive payment from this buyer?
	Km	Code A	Wet	Dry	Code B

			season	season	
1=PO					
2=Trader					
<p>Code A (Reason): 1=pays better prices, 2=only one available, 3=nearest, 4=offers credit, 5=is reliable, 6=pays in lump sum, 7=accepts small quantities, 8=pays timely, 8=other, specify</p> <p>Code B (Time of payment): 1=Beforehand, 2=On the same day of sale, 3=1-15 days after sale, 4=16-30 days after sale, 5=1 to 2 months after sale, 6=more than 2 months after sale</p>					

20. To what extent do you agree with the following statements about your buyer(s) of milk? Rate on a scale of 1 to 7 where 1 is completely disagree and 7 is completely agree

1=Completely disagree; 2= Mostly disagree; 3=Slightly disagree; 4=Neutral; 5=Slightly Agree; 6=Mostly Agree; 7=Completely Agree

Statement	Buyer type	
	1=PO	2=Trader
Behavioural uncertainty in the buyer		
a. I expect the buyer to change facts on quality or quantity of milk delivered to their benefit		
b. I know beforehand about the quality requirements of this buyer		
c. I know beforehand the price I will receive from this buyer		
d. I'm certain that this buyer will commit to the price we agreed on		

D. DAIRY FARM HYGIENE

23. Have you received formal training on milk hygiene practices in the past three years? _____ (0=No, 1=Yes)

if no to 21 proceed to question23

24. If yes to 21, who offered the formal training? Use codes below _____

Codes for source of training: 1=Producer organization, 2=Government officials/extension officers, 3=NGOs,
4=Input dealers, 5=Private processor, 6=Others, specify

25. Did you receive inspection on your farm on milk hygiene practices in the period of Sept. 2017- Sept. 2018? _____ (0=No, 1=Yes)

if no to 23 proceed to question25

26. Who inspected your farm on milk hygiene practices? Use codes below _____

Codes for source of training: 1=Producer organization, 2=Government officials/extension officers, 3=NGOs,
4=Input dealers, 5=Private processor, 6=Others, specify

27. To what extent do you implement the following milk hygiene practices on your farm? Rate your answer on a percentage scale where 0% never practiced and 100% always practiced

Practice	Level of implementation of practice (in percentage)
a. The milker does not milk when suffering from diseases such as cough, cold, diarrhoea or typhoid	

b. The milker washes his/her hands with soap up to the elbow before initiating milking	
c. After washing the hands, the milker dries his/her hands with a cloth/towel	
d. The udder and teat of the cow are washed before milking	
e. A clean dry towel is used to wipe the udder dry after washing	
f. The milker uses only one towel per cow	
g. The milker checks for mastitis prior to milking	
h. The foremilk (initially drawn small quantity of milk) is examined from each teat and abnormal milk discarded	
i. The cows are milked fast but gentle, without any interruptions	
j. When milking is complete, the cow is “stripped” to get the last drops out of the udder	
k. After milking, the teats are dipped or sprayed with an antiseptic solution	
l. Milk is filtered immediately after milking	
m. The cloth/strainer is cleaned after use	
n. The cloth/strainer is disinfected after use	
o. After milking, milk is stored in clean sealed containers	
p. Milk is transported to the buyer within two hours of milking	
q. Where the milk is stored for more than two hours, cooling to 10 degrees or below is undertaken	
r. The milking vessels and equipment are made from approved material e.g steel, aluminium or mazzican	
s. The milking vessels and equipment are cleaned immediately after use	
t. The milking vessels and equipment are sterilized with boiling water or dairy sanitizing solution after cleaning	
u. The milking vessels and equipment are put upside down on a drying rack, in the sun, after cleaning	
v. The floor of the milking area is made of concrete	

w. The milking area is cleaned thoroughly after every milking	
x. The cows being milked are free from diseases such as tuberculosis, brucellosis, mastitis and rift valley	
y. The cows suffering from mastitis are milked last and their milk discarded	
z. If the cow is on antibiotics, the milk from such cows is not consumed until the withdrawal period is over	

26. Do you use a milking machine _____ (0=No, 1=Yes)

If no proceed to question 27

ONLY for farmers using milking machines

Milking machines	Level of implementation of practice (in percentage)
aa. Milking machines are cleaned immediately after use	
bb. While cleaning milking machines, hot water is circulated with detergent through the system	
cc. The rubber parts of the milking machines are examined after every cleaning, those rubber parts that are wearing out are replaced as soon as possible	

27. Are you a member of a non-dairy PO? _____ (1=Yes, 0=No)

28. If yes to 28, what type of group or association do you belong to? _____ (1=agricultural, 2=non-agricultural)

29. Are you a member of a dairy PO? _____ (1=Yes, 0=No)

FOR DAIRY PO MEMBERS ONLY

If the farmer is not a member of a dairy PO proceed to question 34

30. Fill in the table below regarding membership in **dairy** producer organization (PO)

What is the name of the PO?	What is the type of the PO?	Which year did you join the PO?
Code A	Code B	
Code A (PO name): 1=Bamboo, 2=Muki, 3=Tulaga, 4=Igoji, 5=Oruko, 6=Kionyo muungano Code B (PO type): 1=Cooperative, 2=self-help group, 3=other, specify		

31. To what extent do you agree with the following statements about your PO?

Statement	Completely disagree Neutral Completely agree						
	1	2	3	4	5	6	7
Access to services from the PO in the year Sept 2017 to Sept 2018							
a. I obtained access to credit from the PO							
b. I obtained access to feeds from the PO							
c. I got technical assistance and advisory services from the PO							
d. I obtained access to artificial insemination services from the PO							
e. I got veterinary services from the PO							
f. I got a secure market for milk from the PO							

Trust in PO members	1	2	3	4	5	6	7
g. Most members who are in this PO can be trusted							
h. In this PO one has to be alert or a member is likely to take advantage of you							
i. Most people in this PO are willing to help if you need it							
j. In this PO people generally do not trust each other in matters of lending and borrowing money							
Trust in PO leadership	1	2	3	4	5	6	7
k. I trust in the behaviour of the leader of the PO							
l. I trust in the management ability of the leader of the PO							
m. There is corruption in the PO							
Loyalty in Pos	1	2	3	4	5	6	7
n. I will sell to my PO even if another buyer offers a better price for my product							
o. I will continue in the future as a member of this PO							
p. I regularly sell all my products to the PO							
q. I will sell my products to another buyer if I get a higher price than offered by my PO							
Participation in PO governance	1	2	3	4	5	6	7
a. I regularly attend annual general meetings							
b. I participate in voting in every important decision that affects my business							
c. I always express my ideas during annual general meetings							
d. I usually speak to express my suspicion on misappropriation of the PO fund by the							

leaders							
---------	--	--	--	--	--	--	--

32. Are you a member of the board? _____ (0=No, 1=Yes)

33. What are the reasons for not joining a dairy PO? Use the following codes, name all _____

Codes for reasons for not joining a PO

1=other buyers offer higher price

2=poor PO services

3=membership fee is high

4=long distance to the milk collection point

5=poor PO leadership

6=other (specify)

E. OTHER FARMER CHARACTERISTICS

34. What is your age? _____

35. How many years of experience do you have in dairy farming? _____

36. Were you involved in other farm activities apart from dairy in the year Sept 2017 to Sept 2018?

37. What type of farm activities were you involved in? _____ (1=crop farming, 2=other livestock farming)

38. On average, how many hours per day did you spend in these other farm activities?

39. Were you involved in off-farm activities?

40. What type of off-farm activities were you involved in? _____ (1=formal employment, 2=self-employment, 3=Retailing business, 4=none, 5=other, specify)

41. On average, how many hours per day did you spend in these off-farm activities? _____

42. Fill in details below on distances from your homestead.

What is the distance from your homestead to:	Distance in kilometres
a. the nearest town	
b. the nearest all weather road	

c. the nearest milk collection point of the dairy PO	
d. the nearest office of a PO	

43. To what extent do you agree with the following statements? (farmers aspirations)

Statement	Completely disagree Neutral						
	1	2	3	4	5	6	7
a. I have plans to become a leader in the community in the next five years							
b. I have plans to continue dairy farming in the next five years							

FOR ENUMERATOR: OBSERVE THE FOLLOWING

44. What is the geographical terrain of the farmers village? (0=highland, 1=lowland) _____

45. What is the sex of the farmer? (0=Male, 1=Female) _____

46. Record the GPS coordinates of the farmer's homestead _____

47. Name of the enumerator

Thanks for your cooperation!

Appendix B: Multicollinearity Test

Variable	VIF	1/VIF
PO membership	1.43	0.700507
Cow ownership	1.40	0.714100
Sex of household head	1.38	0.725604
Training_hygiene	1.33	0.752778
Hours spent on dairy activities	1.29	0.777644
Milk per cow	1.16	0.861249
Distance to the nearest town	1.13	0.883774
Milk price	1.07	0.930573
Marital status	1.05	0.950593
Total farm size	1.04	0.962173
Mean VIF	1.23	

Appendix C: ESR Diagnostics

Endogeneity Test

Tests of endogeneity

Ho: variables are exogenous

Robust score chi2(1) = 4.90515 (p = 0.0268)

Robust regression F(1,266) = 4.7017 (p = 0.0310)

estat firststage

First-stage regression summary statistics

Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	Robust F(5,263)	Prob > F
Mem_dairypo	0.2514	0.2030	0.1040	9.23435	0.0000

Test of overidentifying restrictions:

Score chi2(4) = 6.47847 (p = 0.1662)

Appendix D: ESR Results

Endogenous switching regression model

Number of obs = 281

Wald chi2(13) = 33.00

Log likelihood = -355.25325

Prob > chi2 = 0.0017

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
Ln milk_Per_Cow_1						
Age	-.0033373	.0042791	-0.78	0.435	-.0117242	.0050496
Education	.0120885	.0121854	0.99	0.321	-.0117946	.0359715
Sex	-.046929	.1022368	-0.46	0.646	-.2473095	.1534515
Experience	.0026927	.0041223	0.65	0.514	-.0053869	.0107723
Household size	.0015856	.0217441	0.07	0.942	-.041032	.0442032
Marital_status	-.0393917	.0542595	-0.73	0.468	-.1457383	.0669549
_Ijoint_2	-.02807	.101623	-0.28	0.782	-.2272474	.1711073
_Ijoint_3	.2189628	.123623	1.77	0.077	-.0233338	.4612595
Total_Farm	-.0007831	.0170482	-0.05	0.963	-.0341971	.0326308
Pure_breed	.318221	.0829353	3.84	0.000	.1556707	.4807713
Hh access to loan	.0435046	.0912852	0.48	0.634	-.1354112	.2224204
Price	.0319133	.0319133	0.24	0.810	-.0548634	.0702344
Hours_dairy	.0505756	.0172855	2.93	0.003	.0166967	.0844545
_Cons	7.156798	1.1296	6.34	0.000	4.942823	9.370773
ln milk_per_cow_0						
Age	.0023194	.0084298	0.28	0.783	-.0142026	.0188414
Education	.0083932	.021854	0.38	0.701	-.0344398	.0512261
Sex	-.4972447	.1810605	-2.75	0.006	-.8521168	-.1423726
Experience	-.0114776	.0081362	-1.41	0.158	-.0274244	.0044691
Hhsize	.0579848	.0468697	1.24	0.216	-.0338781	.1498478
Marital_status	.0190252	.1093186	0.17	0.862	-.1952353	.2332857
_Ijoint_2	-.296138	.186703	-1.59	0.113	-.662069	.0697931
_Ijoint_3	.0141052	.2397317	0.06	0.953	-.4557603	.4839707
Total_farm	-.0135508	.0090416	-1.50	0.134	-.0312721	.0041704
Pure_breed	.4681627	.154693	3.03	0.002	.1649699	.7713555
Hhaccess_loan	.1682598	.1947189	0.86	0.388	-.2133821	.5499018
Price	-.0410791	.0625932	-0.66	0.512	-.1637596	.0816014

Hours_dairy	.1240255	.0373778	3.32	0.001	.0507664	.1972845
Cons	9.304575	2.249641	4.14	0.000	4.895359	13.71379
Mem_dairypo						
Age	.0119461	.0094237	1.27	0.205	-.0065241	.0304163
Education	.002433	.0249081	0.10	0.922	-.046386	.0512519
Sex	-.3118015	.208945	-1.49	0.136	-.7213261	.0977232
Experience	-.0108003	.0088539	-1.22	0.223	-.0281536	.0065531
Hhsize	-.022186	.0508691	-0.44	0.663	-.1218877	.0775156
_Ijoint_2	-.3159701	.2139547	-1.48	0.140	-.7353135	.1033734
Total_farm	-.006588	.0112289	-0.59	0.557	-.0285964	.0154203
Pure_breed	.289533	.1756602	1.65	0.099	-.0547546	.6338207
Price	-.1547148	.0737324	-2.10	0.036	-.2992275	-.010202
Hours_dairy	.1588117	.0393076	4.04	0.000	.0817703	.2358531
Marital_status	-.0926481	.1203803	-0.77	0.442	-.3285892	.1432929
_Ijoint_3	.1788948	.2726588	0.66	0.512	-.3555066	.7132962
Hhaccess_loan	.6666395	.2095735	3.18	0.001	.2558831	1.077396
Km_buyercoll	.4003326	.1360515	2.94	0.003	.1336766	.6669887
_Cons	4.552175	2.645539	1.72	0.085	-.6329873	9.737336
/lns1	-.6822328	.0532893	-12.80	0.000	-.7866779	-.5777878
/lns2	-.1398617	.0984206	-1.42	0.155	-.3327626	.0530392
/r1	.0633303	.3040182	0.21	0.835	-.5325344	.6591951
/r2	2.462686	.4815711	5.11	0.000	1.518825	3.406548
sigma_1	.5054871	.026937			.455355	.5611384
sigma_2	.8694785	.0855746			.7169404	1.054471
rho_1	.0632458	.3028021			-.487316	.5778275
rho_2	.9855846	.013784			.9084926	.9978038
LR test of indep. eqns. : chi2(1) = 13.63 Prob > chi2 = 0.0002						

Two-sample t test with equal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
xx	181	7.93302	.0187965	.2528815	7.89593	7.970109
Xy	100	7.728876	.020311	.2031102	7.688575	7.769178
Combined	281	7.860371	.0152422	.2555059	7.830367	7.890375
Diff		.2041432	.029458		.146155	.2621314

diff = mean(xx) - mean(xy)

t = 6.9300

Ho: diff = 0

degrees of freedom = 279

Ha: diff < 0

Ha: diff != 0

Ha: diff > 0

Pr(T < t) = 1.0000

Pr(|T| > |t|) = 0.0000

Pr(T > t) = 0.0000

Two-sample t test with equal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
yy	100	7.682555	.0330385	.3303849	7.616999	7.74811
yx	181	9.256146	.0314249	.4227794	9.194137	9.318154
combined	281	8.696149	.0507291	.8503743	8.59629	8.796008
diff		-1.573591	.048904		-1.669859	-1.477324

diff = mean(yy) - mean(yx)

t = -32.1771

Ho: diff = 0

degrees of freedom = 279

Ha: diff < 0

Ha: diff != 0



Ha: diff > 0

Pr(T < t) = 0.0000

Pr(|T| > |t|) = 0.0000

Pr(T > t) = 1.0000

Appendix E: Research Permit

 REPUBLIC OF KENYA	 NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
Ref No: 944935	Date of Issue: 08/March/2023
RESEARCH LICENSE	
	
This is to Certify that Ms., Magdaline Adhiambo Owiti of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Meru on the topic: ROLE OF PRODUCER ORGANIZATIONS IN IMPROVING MILK PRODUCTION AND SAFETY AMONG DAIRY FARMERS IN SOUTH IMENTI SUB-COUNTY, MERU COUNTY for the period ending : 08/March/2024.	
License No: NACOSTI/P/23/24174	
944935 Applicant Identification Number	 Director General NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
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See overleaf for conditions	

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013 (Rev. 2014)
Legal Notice No. 108: The Science, Technology and Innovation (Research Licensing) Regulations, 2014

The National Commission for Science, Technology and Innovation, hereafter referred to as the Commission, was established under the Science, Technology and Innovation Act 2013 (Revised 2014) herein after referred to as the Act. The objective of the Commission shall be to regulate and assure quality in the science, technology and innovation sector and advise the Government in matters related thereto.

CONDITIONS OF THE RESEARCH LICENSE

1. The License is granted subject to provisions of the Constitution of Kenya, the Science, Technology and Innovation Act, and other relevant laws, policies and regulations. Accordingly, the licensee shall adhere to such procedures, standards, code of ethics and guidelines as may be prescribed by regulations made under the Act, or prescribed by provisions of International treaties of which Kenya is a signatory to
2. The research and its related activities as well as outcomes shall be beneficial to the country and shall not in any way;
 - i. Endanger national security
 - ii. Adversely affect the lives of Kenyans
 - iii. Be in contravention of Kenya's international obligations including Biological Weapons Convention (BWC), Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), Chemical, Biological, Radiological and Nuclear (CBRN).
 - iv. Result in exploitation of intellectual property rights of communities in Kenya
 - v. Adversely affect the environment
 - vi. Adversely affect the rights of communities
 - vii. Endanger public safety and national cohesion
 - viii. Plagiarize someone else's work
3. The License is valid for the proposed research, location and specified period.
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14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.

National Commission for Science, Technology and
Innovation(NACOSTI),
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E-mail: dg@nacosti.go.ke
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Appendix F: Ethical approval

EGERTON

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UNIVERSITY

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EGERTON

**EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS
REVIEW COMMITTEE**

EU/RE/DIR/009

Approval No. *EUISERC/APP/221/2023*

23rd February, 2023

Magdaline Adhiambo Owiti,
P.O.Box 35-40101,
Ahero
Telephone: 0705849105
E-mail: magdaowiti@gmail.com

Dear Magdaline,

**RE: ETHICAL APPROVAL: ROLE OF PRODUCER ORGANIZATIONS IN
IMPROVING MILK PRODUCTION AND SAFETY AMONG DAIRY FARMERS IN
SOUTH IMENTI, MERU COUNTY, KENYA**

This is to inform you that *Egerton University Institutional Scientific and Ethics Review Committee* has reviewed and approved your above research proposal. Your application approval number is *EUISERC/APP/221/2023*. The approval period is *23rd February, 2023 –24th February, 2024*.

This approval is subject to compliance with the following requirements;

- i. Only approved documents including (informed consents, study instruments, MTA) will be used.
- ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by *Egerton University Institutional Scientific and Ethics Review Committee*.
- iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to *Egerton University Institutional Scientific and Ethics Review Committee* within 72 hours of notification
- iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be

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reported to *Egerton University Institutional Scientific and Ethics Review Committee* within 72 hours.

- v. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.
- vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
- vii. Submission of an executive summary report within 90 days upon completion of the study to *Egerton University Institutional Scientific and Ethics Review Committee*.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) <https://oris.nacosti.go.ke> and also obtain other clearances needed.

Yours sincerely,



Prof. Raphael M. Ngure

**CHAIRMAN, EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS
REVIEW CTIEE**

RMN/BK/




Appendix G: Publication Abstract



Journal of Agribusiness and Rural
Development

**VOLUME 73 (2024): ISSUE 3 (SEPTEMBER
2024)**

The Role of Producer Organizations in Promoting Farm-Level Implementation of Milk Hygiene Strategies Among Dairy Farmers in Kenya

Magdaline Adhiambo Owiti , Patience Mlongo Mshenga  and Kenneth Waluse Sibiko  | Sep 30, 2024

Abstract

Food safety remains a critical concern globally, particularly in the dairy industry of developing countries, where quality standards are often insufficient. This is attributed to low milk production, poor milk handling practices and domination of the sub-sector by informal and unregulated milk marketing channels. An improvement in the quality of the milk produced is necessary to alleviate concerns about food safety and health. This study employed a multi-stage sampling technique to select a sample of 282 dairy farmers in Meru County, Kenya. Relevant data was collected on identified variables using a structured questionnaire, and a Poisson Regression Model was used to determine the role of producer organizations in promoting farm-level implementation of milk hygiene strategies. The results indicate that producer organization membership has a positive and significant influence on the extent of farm-level implementation of milk hygiene strategies. The findings of this study provide relevant information for policy formulation aimed at improving the performance of producer organizations and the growth of the dairy industry. Therefore, dairy farmers experiencing technical difficulties should be identified and incentivized to actively participate in producer organizations, so as to increase their access to relevant extension services such as training in milk hygiene strategies, which would enhance their implementation of milk hygiene strategies at the farm-level.

Keywords

Producer organizations, milk hygiene strategies, dairy, milk quality, safety standards, Africa