Asian Research Journal of Agriculture

13(4): 24-34, 2020; Article no.ARJA.64214
ISSN: 2456-561X

Effect of Mineral Mix and Concentrate Feeds on Milk Revenue of Smallholder Dairy Farmers in Kapseret Sub County, Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. Author JKB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SWM and IMN managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARJA/2020/v13i430110
Editor(s):
(1) Dr. M. Yuvaraj, Adhiparasakthi Agricultural College, India.
Reviewers:
(1) Manoj Sharma, CSK Himachal Pradesh Agriculture University Palampur, India.
(2) A. Serma Saravana Pandian, Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/64214

Original Research Article

Received 15 September 2020
Accepted 28 December 2020
Published 11 January 2021

ABSTRACT

Dairy farming contributes about eight percent of National Gross Domestic Product with an annual milk production of 3.43 billion litres in Kenya. It supports the livelihood of approximately four million Kenyans through food provision, income generation and employment. However, milk production per individual animal in Kenya, averaging six to seven (6-7) litres/cow/day, is low compared to the world's best at 10,133 litres/cow/year (28 litres/cow/day) mainly due to factors including poor feeding. This means that Kenya produces an average of 20 litres of milk less per cow per day compared to the world's best. The objective of this study was to determine the effect of mineral mix and concentrate feeds on milk revenue of smallholder dairy farmers in Kapseret sub County. The study was conducted between the months of January-March, 2020. Primary data was collected using closed and open ended questionnaires. Spearman's Rank correlation was used to show the strength of the relationship between the variables. Multiple regression model was employed to assess the effect of supplementation on milk revenue. Results were presented in tables, and

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descriptive statistics such as percentages and frequencies. The results indicated a positive and statistically significant relationship between the variables (concentrate feeds and mineral mix) and milk revenue at (r=0.41, p=0.001) and (r=0.30, p=0.001), respectively. The relationship between mineral mix and concentrate feeds was positive and statistically significant (r=0.92, p=0.001). Subsequent feeding of homemade or commercial concentrates and mineral mix to dairy animals influenced milk revenue. The study concluded that mineral mix and concentrate feeds increased milk revenue of smallholder dairy farmers in Kapseret sub County. The study recommended the use of mineral mix and commercial concentrates or quality homemade concentrates in order to increase milk produce which affects farmers' milk revenue.

Keywords: Concentrates; feeds; milk revenue; mineral mix; smallholder farmers; supplementation.

1. INTRODUCTION

The world's dairy sector is fast growing and is projected that milk production will increase by 177 million tonnes by 2025 [1]. However, world's exports of dairy products are forecast to reduce by four percent in 2020, which would likely mark the sharpest year-on-year decline in three decades. This is as a result of likely declines in imports mainly by countries including China, Algeria and United Arab Emirates attributable to the Covid-19 pandemic which has resulted to economic slowdowns across the world [2]. Dairy cattle production in East Africa has increased recently subject to high demand for fresh milk to meet the needs for the ever increasing population and the demand for value-added milk products [3].

The average daily milk production in most dairy farms in Kenya is estimated to be averagely six to seven litres per cow per day, however, this is approximately 70% lower than the level of production of cows in the developed countries [4]. This level of production in Kenya is low compared to world's average best of 10,133 litres per cow per year (28 litres per cow per day) [5]. With improved management and better feeds and feeding practices, the production potential could be much higher than the milk currently produced per cow per day in Kenya [6]. Milk production stands at 5.2 billion litres and is projected that milk production will be at 7.9 billion litres by 2022 despite high expectation of a shortfall. There is need, therefore, to find mitigations of solving the expected shortage [7].

Components involved in dairy feeds for better production include dried and green forages, concentrates, minerals, vitamins and by-products [8]. In Kenya, low quality and quantity of feeds is one of the constraining factors of milk production among smallholder farmers despite the fact that they make up almost 80% of the dairy producers and produce 56% of the total milk [9]. Most smallholder farmers in Kenya do not have information on feed conservation technologies [10]. Smallholder farmers in Kenya on average owning one to four acres of land and one to five heads of cattle are largely reliant on forage and only use small quantities of concentrate to feed their cattle [9]. Most households in Kenya fed their cows with nappier grass supplemented by commercial concentrates [11]. In Kenya, dairy animal feeds account for between 60 to 80 percent of the production costs, depending on the intensity and method of production used by the farmer [12]. In Central Kenya, dairy farmers either purchase commercially produced concentrates or use homemade concentrates made using purchased ingredients [13]. However, animal feeds access and cost is one of the main problem facing cattle rearing in all agro ecological zones in Kenya [14].

Adequate trace minerals supplementation and its absorption are required for various metabolic functions including reproduction and growth, which affect farm productivity in the long run [15]. Milk producers in most of the developing countries often do not feed adequate quantities of mineral mixture to their dairy cows due to non-availability, lack of knowledge on the benefits of feeding mineral mixtures [16]. The average proportions of concentrates from maize germ/ban and mineral supplements in total diets in Kenya are higher on zero-grazing farms and semi zero grazing farms than on free grazing farms [13]. The objective of the study, therefore, was to determine the effect of feed supplementation on milk revenue of smallholder farmers in Kapseret sub County.

2. METHODOLOGY

The study employed correlation research design. Correlation design enables an observation of two variables or more at the point in time and is useful for describing the relationship between the two or more variables [17]. The research design

was appropriate since the study aimed at analysing the relationship between variables. The assessment of the magnitude of the relationship was based on the coefficient of determination, p-values and effect size of the coefficient.

2.1 Location of the Study

The study took place at Kapseret sub County, located in Uasin Gishu County. The study was carried out between the months of January-March, 2020. Kapseret sub County is located in Uasin Gishu County. The County covers an area of 3,345.2 square kilometres and lies between longitude 34^0 50´ East and 35^0 37´ West and latitude 0^0 03´ South and 0^0 55´ North. The county borders Trans-Nzoia County to the North, Elgeiyo Marakwet and Baringo Counties to the East, Kericho County to the South, Nandi County to the South West and Kakamega County to the West.

Uasin Gishu County had a population of approximately 1,163,186 people with a population density of 390/km^2 [18]. The County experiences high and reliable rainfall evenly distributed throughout the year. The average rainfall ranges between 624.9 mm to 1,560.4 mm per year with two distinct peaks in April and August. The temperatures range between seven degrees Celsius and twenty nine degrees Celsius. Vegetation ranges from open grassland, with scattered acacia trees, to natural highland forests and bush land. The county has three agro ecological zones namely lower highland, upper highland and upper midland zones. The area is a highland plateau with an altitude of 1,500-2,700 metres above sea level with four major soil types; red loam, red clay, brown clay and brown loam soils. Generally these conditions are favourable for livestock keeping, crop and fish farming.

Uasin Gishu County is divided to Kapsaret, Turbo, Moiben, Ainabkoi, Wareng and Kesses sub-counties. Kapseret sub County has five wards; Ngeria, Megun, Langas, Simat and Kipkenyo. The sub-counties act as extension units where activities for livestock and crop production are planned and implemented [19].

2.2 Population, Sample Size and Sampling Procedure

The target population in this study was 4,226 smallholder dairy farmers in Kapseret sub County. The sample size was drawn from smallholder dairy farmers in the following wards; Ngeria, Megun, Simat, Kipkenyo and Langas. The following formula by [20] was used to calculate the sample size for the study,

$$n = \frac{X^2 Np(1-p)}{d^2(N-1) + X^2 p(1-p)}$$

$$n = \frac{1.96^2 X 4226 X 0.8 X 0.2}{0.05^2(4226-1) + 1.96^2 X 0.8 X 0.2} = 232$$

Where,
N= Total population,
n= Sample size,
X^2= Table value of Chi-Square with one degree freedom and at 95% confidence interval, giving 1.96,
p = the proportion in the target population estimated to have characteristics being measured and
d = the degree of accuracy expressed as a proportion (0.05).

Cluster sampling was used to select households proportionate to the population size in Kapseret sub County (Table 1). The sub County was grouped into five clusters that included; Ngeria, Megun, Langas, Simat and Kipkenyo wards. Random sampling was then carried out to select individual smallholder farmers from each of the five clusters.

Table 1. Sample size of farmers

Ward (Cluster)	Number of farmers	Sample size
Ngeria	1015	56
Kipkenyo	1005	55
Megun	1011	55
Simat	733	41
Langas	462	25
Total	4226	232

2.3 Data Collection and Analysis

Primary data was collected using a structured questionnaire. The data was cleaned and coded before being analysed. Quantitative data was analysed using Statistical Package for Social Sciences (SPSS) version 25 for both descriptive and inferential statistics. In order to effectively analyse the primary quantitative data, descriptive statistics including percentages and frequencies were generated. Spearman's Rank correlation showed the strength of the relationship between variables in the study. Values close to +1 indicated a high-degree of positive correlation and values close to -1 indicated a high degree

negative correlation. Values close to zero indicated poor correlation of either kind.

2.4 Models

2.4.1 Multiple regression models

Multiple regression analysis showed the relationship between dependent and multiple independent variables.

2.4.2 Model specification

The regression model was:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

Where,

Y = Milk revenue
β_0 = Constant Term
β_1, β_2 and β_3 = Regression coefficients
X_1= Free grazing only
X_2= Concentrate feed
X_3= Mineral mix
ε = Error term

3. RESULTS AND DISCUSSION

3.1 Response Rate

This research mainly used questionnaires as the research tool for a total sample size of 232 farmers in Kapseret sub County. Out of the 232 farmers, a total of 220 questionnaires were returned and fit for the analysis, representing a return rate of 94.8%. Approximately 80% to 90% questionnaire return rate is appropriate for a descriptive research [21].

3.2 Gender Distribution

The study sought to establish the gender composition of the smallholder dairy farmers in Kapseret sub County. The results were analysed and tabulated in Table 3. The number of male gender smallholder dairy farmers in Kapseret sub County was higher than that of the females. This was an indication that male headed household were common in the area of study. This was in contrast with the findings by [22] that male and female-headed households had almost equal chance of participating in smallholder farming.

3.3 Education Background of Smallholder Dairy Farmers in Kapseret Sub County

The study sought to establish what levels of education were involved among smallholder dairy farmers in Kapseret sub County. The respondents were requested to indicate the highest level of education they attained. From the findings, 96.4% of the respondents had attained at least basic education. A high number of the smallholder farmers had attained the primary level as indicated by 48.2% of the respondents. Only 3.6% of the respondents did not school at all as indicated in Table 3. The results were consistent with findings by [23] that most of the smallholder household heads were fairly educated which enabled them to fairly adopt dairy cattle milk production technologies.

3.4 Dairy Farming Importance

The study went further to determine the importance of dairy farming to the livelihoods of smallholder dairy farmers in Kapseret sub County compared to other sources of livelihood earnings. Using a linkert type question, farmers were asked to indicate the importance of dairy farming to their household income. The results were analysed and are tabulated in Table 3. Majority of the respondents (98.2%) indicated that dairy farming played a key role in supporting their livelihoods in terms of household income. Eighty percent of the respondents indicated dairy farming practise as very important whereas 18.2% indicated the practise as important. Only 1.8% of the respondents underrated its importance. This meant that a high percentage of the smallholder dairy farmers in Kapseret sub County mainly depended on dairy farming as their main source of income for sustaining their livelihoods.

Table 2. Response rate

Respondents	Sample	Returned	Percent (%)
Ngeria	56	52	92.8
Megun	55	52	94.5
Kipkenyo	55	52	94.5
Simat	41	39	95.1
Langas	25	25	100.0
Total	232	220	94.8%

3.5 Milk Distribution by Farmers

The study sought to understand how smallholder dairy farmers in Kapseret sub County distributed milk produced in their farms. The computed descriptive statistics were as tabulated in Table 3. The results showed that the amount of milk sold by farmers was very high (MN=7.31 and SD=4.570) compared to the amount of milk used by farmers for their home consumption (MN=2.313 and SD=1.113). This meant that dairy farming played a significant role in determining the earnings for improving livelihoods of the smallholder farmers in Kapseret sub County. This was consistent with findings by [24] that farmers carried out dairy farming for commercial purposes which were a clear step towards improving productivity and marketing. Farmers sold 79% of the milk, while 16% of the milk was for home consumption and 5% of the milk was given out.

It was also established that the relationship between milk volume and prices was negative and statistically significant (p=-.108 & r=0.01). This was similar to findings by [25] that the prices of milk did not significantly influence the quantity of milk produced. The study established a positive and statistically significant relationship (p=0.98 & r=0.01) between amount of milk produced and the amount of milk sold. This indicated that more milk was sold (supplied) in instances of increased production. This indicated consistency with the normal supply curve.

Table 3. Summary of the dairy farming importance, gender, education level and milk distribution descriptive statistics of smallholder dairy farmers in Kapseret sub County

	Frequency (f)	Percent (%)
Dairy farming importance among smallholder dairy farmers in Kapseret sub County		
Very Important	176	80.0
Important	40	18.2
Not Important	4	1.8
Distribution of gender of smallholder dairy farmers in Kapseret sub County		
Male	152	69.1
Female	68	30.9
Education level of the respondents		
Tertiary	45	20.5
Secondary	61	27.7
Primary	106	48.2
None	8	3.6
Descriptive statistics on milk distribution by smallholder dairy farmers in Kapseret sub county		
	Mean	**Std. deviation**
Amount of milk produced	9.67	5.179
Amount of milk sold	7.31	4.570
Amount of milk consumed	2.313	1.1131

N= 220

Table 4. Spearman's rank correlation for milk distribution by smallholder dairy farmers in Kapseret sub County

		Milk volume	Milk prices	Milk produced	Milk sold
Milk volume	Correlation coefficient	1			
	Sig.				
Milk prices	Correlation coefficient	-.108*	1		
	Sig.	.01			
Milk produced	Correlation coefficient				
	Sig.				
Milk sold	Correlation coefficient			.98*	1
	Sig.			.01	

**. Correlation is significant at the 0.05 level (2-tailed); N= 220*

3.6 Feed Supplementation Effect on Milk Revenue

The study sought to establish the common feed types and the feed supplementation methods of dairy cows by smallholder farmers. The results were analysed and presented in Table 5. Feed supplementation was a common practise by smallholder dairy farmers in Kapseret sub County as indicated by 65.5% of the respondents. It was further established that 88.1% of the respondents provided both concentrate feeds and mineral mix for their dairy cows whereas 6.3% of the respondents provided mineral mix only. Concentrate feeds only were provided to dairy cows by 5.6% of the respondents. The study further established that 59.9% of the respondents offered commercial dairy meal to their dairy cows while 12.7% of the respondents provided homemade concentrates. However, 27.4% of the respondents provided both commercial and homemade concentrates to their dairy cows. This was in agreement with [13] findings in Central Kenya that dairy farmers either purchased commercially produced concentrates or used homemade concentrates to feed their dairy cows.

In regard to the frequency of feed supplementation, 64.1% of the respondents provided concentrates for their dairy cows once per day while 34.5% of the respondents provided concentrates for their dairy cows twice a day. Only 0.9% of the respondents provided the concentrates once in a week. The results from the use of mineral mix were not much different from those of concentrates use as 61.5% of the respondents provided mineral mix for their dairy cows once per day while 35.7% of the respondents provided minerals for dairy cows twice a day. Only 2.8% of the respondents provided the mineral mix once in a week. It was, therefore, noted that daily feed supplementation was the most common practise. This was in agreement with [26] findings that cows were fed twice every day after each milking.

The study sought to establish the effect of cow supplementation on milk revenue of smallholder dairy farmers. The computed descriptive statistics on the importance of free grazing only, free grazing with concentrates, and mineral mix use towards increased milk revenue of smallholder farmers in Kapseret sub County were as illustrated in Table 6.

The findings deduced the importance of feed supplementation in dairy farming. Majority of the respondents indicated that they preferred supplementing their dairy cows with concentrates which was clearly reflected by 67.9% of the respondents who considered concentrate feeding as a very important practice. Additionally, 10.1% of the respondents indicated it as important, making a total of 78% of the respondents who preferred the use of feed supplements in attaining increased milk revenue. This was consistent with findings by [27] that supplementation of feeds to dairy cattle led to increased milk production among smallholder dairy farmers in Kenya. The current results were also highly related to the findings by [28] that feeding dairy meal to a cow before calving period was associated with milk production increase by approximately 1.4 kg/day during the first 60 days of lactation. According to the findings by [29], the mean milk production for cows increased by 0.8% per cow per day with every kg increase in maize silage fed to cows.

Majority of the farmers also showed the benefits of mineral mix with 65.6% of the respondents indicating that it had a very important contribution towards increased milk revenue. Moreover, 11% of the respondents considered mineral mix as important adding up to 76.6% of the respondents who agreed on the significance of mineral mix in attaining increased milk revenue. This was consistent with findings by [30] that daily mineral mix use was positively correlated to daily milk production in Nyeri County, where every 100 grams of mineral feeds was associated with 0.82 kg higher milk production per day. Further, this was consistent with findings by [15] that adequate trace minerals supplementation was required for various metabolic functions including reproduction and growth, which affected dairy animals' productivity in the long run.

In support to the need for feed supplementation, 45.9% of the respondents indicated that free grazing only was not of importance in determining increased milk revenue. However, 35.9% of the respondents indicated that free grazing only was very important in determining increased milk revenue while 18.2% of the respondents showed that free grazing alone was important. This was further supported by 22% and 23.4% respondents who indicated that concentrates and mineral mix were not important in determining increased milk revenue, respectively. This supported the findings by [28] that smallholder dairy farmers literally lacked the knowledge and resources on how to adequately

provide better feeds for their cow(s), which ultimately limited the dairy cow productivity. Further, [31] in his study reported that the productivity of traditional dairy crossbred cows remained low on many farms at approximately 5 to10 kg/cow/day because of farmers' lack of knowledge resources like feeding, that favoured increased productivity in smallholder farming.

The positive and statistically significant relationship (r=.41, p=.001) between concentrate feeding and milk revenue was indicative that feed concentrates offered to cows affected milk revenue of the smallholder dairy farmers in Kapseret sub County. This was in agreement with findings by [32] where a highly statistically significant relationship (r=.66, p=.000) between the amount of concentrate fed and milk yield was established. This further meant that feeding animals with concentrates, either homemade or commercial concentrates resulted to increased milk revenue.

The study also established a positive and statistically significant relationship (r=.30, p=.001) between the mineral mix use and milk revenue of smallholder dairy farmers in Kapseret sub County. It also meant that mineral mixes were very important in determining the level of milk revenue. This was in line with findings by [33] that established a positive and statistically significant relationship (r=.78, p=.009) between milk yield and supplement feeds in dairy animals in Kenya. The results indicated a statistically significant and positive correlation between mineral mix and concentrates use (r=.92, p=.001). The concentrates included dairy meal and homemade concentrates from maize talks while the minerals included commercial salts rich in calcium, phosphorus among other components that improved production.

Table 5. Descriptive statistics on feed supplementation by smallholder farmers in Kapseret sub County

Feed supplementation	Frequency (f)	Percent (%)
Grazing and feed supplementation		
Free grazing alone	69	34.5
Free grazing with feed supplementation	151	65.5
Common supplements used by the smallholder farmers		
Concentrates	8	5.6
Mineral mix	9	6.3
Both	134	88.1
Common concentrates used by the smallholder farmers		
Commercial	85	59.9
Homemade	18	12.7
Both	39	27.4
Rate of concentrates provision to the dairy cows		
Twice a day	49	34.5
Once a day	91	64.1
Once a week	2	1.4
Rate of mineral mix provision to the dairy cows		
Twice in a day	51	35.7
Once in a day	88	61.5
Once in a week	4	2.8

Table 6. Descriptive statistics on feed supplements effect on milk revenue of smallholder farmers in Kapseret sub County

Statement		VI	I	NI	Totals
Importance of free grazing only in increased milk revenue	F	79.0	40.0	101	220
	%	35.9	18.2	45.9	100
Importance of concentrate feeding in increased milk revenue	F	150	22.0	48.0	220
	%	67.9	10.1	22.0	100
Importance of mineral mix in increased milk revenue	F	145	24.0	51.0	220
	%	65.6	11.0	23.4	100

VI- Very Important, I- Important, NI- Not Important

3.7 Regression Model Summary

The multiple linear model significance was evaluated using ANOVA. Regression results indicated that the linear association between milk revenue and feed supplementation has an F value of F=7.532 which is significant with p value p=0.000. This implied that the overall model was significant in forecasting the effect of milk revenue and feed supplements at 5% level of significance. The R^2 value of 0.105 meant that approximately 10.5% of the resultant changes in milk revenue among smallholder farmers in Kapseret sub County was explained by feed supplementation.

The regression coefficients results for the model revealed that the beta coefficient of the resulting regression model were β_0= 12.664, β_1= 3.658, β_2= 7.806 and β_3= 2.040, respectively. Using the value of the coefficients from the regression coefficient, the accepted regression equation took the form: *Milk Revenue* = $12.664+3.658X_1+7.806X_2+2.040X_3$, where X_1 was the concentrate feeds, X_2 the mineral mix and X_3 free grazing. The study showed that all the independent variables had a positive relationship with the dependent variable. The results stipulated that a unit change in concentrate feeds led to 3.658 changes in milk revenue while with a unit change of mineral mix changed the milk revenue by 7.806. The findings further stipulated that for every unit change in free grazing there was a 2.041 increase in milk revenue.

The findings suggested that concentrates and mineral mix had a positive and significant influence on milk revenue of smallholder farmers with *P* value of .01 and .009, respectively at 5% level of significance. This implied that an increase in the concentrate feeds and mineral mix had a major impact on milk revenue. Free grazing alone was found to have a positive insignificant effect on milk revenue of smallholder dairy farmers. However, the contribution of concentrate feeds in increased milk revenue was low compared to that of mineral mix. This could be explained by the low nutritional value of common homemade concentrates especially from maize stalks. Commercial dairy meals are mostly out of reach as they are not affordable by most of the smallholder farmers in the study area.

Table 7. Spearman's rank correlation between feed supplements and milk revenue of smallholder dairy farmers in Kapseret sub County

		Revenue	Free Grazing	Concentrates	Mineral Mix
Revenue	Correlation coefficient	1			
	Sig.				
Free Grazing	Correlation coefficient	.28**	1		
	Sig.	.001			
Concentrates	Correlation coefficient	.41**		1	
	Sig.	.001			
Mineral Mix	Correlation coefficient	.30**		.92**	1
	Sig.	.001		.001	

***. Correlation is significant at the 0.01 level (2-tailed)*

Table 3. Significance of the regression of milk revenue on concentrate feeds, mineral mix and free grazing

Model		Unstandardized coefficients		Standardized coefficients	T			Sig.
		B	Std. Error	Beta		R Square	F	
1	(Constant)	12.664	1020.828		5.400	0.105	7.532	.000[a]
	concentrate feed	3.658	836.377	0.046	0.273			.01
	mineral mix	7.806	822.581	0.120	0.711			.009
	free grazing	2.040	315.162	0.013	0.091			.52

(Values where P= .05 were statistically significant) a Predictors: (Constant), Free grazing, mineral mix, concentrate feed b Dependent Variable: Revenue

4. CONCLUSION

The study concluded that dairy animal feed supplements were very essential in determining milk revenue of smallholder dairy farmers. Commercial dairy meal, homemade concentrates and mineral mix were vital in achieving increased milk revenue for smallholder dairy farmers in Kapseret sub County and thus better incomes. Therefore, more emphasis should be given to feed supplementation as it was found to have a significant effect on milk revenue.

5. RECOMMENDATIONS

The study recommended the use of commercial concentrates, homemade concentrates and mineral mix in order to increase production for improved milk revenues. However, high nutritional value of homemade concentrates needs to be met. There is need to educate the farmers on the need of utilizing farm residues such as green or dry maize stalks which are available in the smallholder farms to make quality homemade concentrates. This will not only ensure better feeds availability for farm animals but also increase milk production with reduced feed cost.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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