Original Article

Milk yield performance of local cows, handling practices, physicochemical properties, and milk production constraints in Kucha district, Southern Ethiopia

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Abstract

The study assessed milk production performance of local cows, milk handling practices, physicochemical properties, and milk production constraints in Kucha District, Southern Ethiopia. A purposive and random sampling technique was employed to select 138 respondents for the interview. For physicochemical property assessment, milk samples were collected from 90 interviewed households. Majorities (76.7%) of the respondents were males, and the average family size was 6.82±0.25. Mean daily milk yield (DMY) of 1.80±0.07, 1.94±0.06, and 1.52±0.09 liters was recorded for local cows, respectively, in early, mid, and late lactation stages. All respondents in the area use hand milking and wash their hands before milking. Milking was mainly the responsibility of Women (68.9%). Most (94.9%) respondents store milk for one day using clay and plastic jars. The overall average fat, solid not fat (SNF), protein, lactose, density (g/mL), and pH were recorded as 4.54±0.13, 8.15±0.22, 3.33±0.07, 4.65±0.12, 1.03±0.00, and 5.70±0.11, respectively. Feed and land shortage, low milk yield of local cows, disease, water shortage, and lack of credit were the prominent constraints of dairy farming in the area. Awareness on hygienic milk production, handling, and improved cattle management practices should be created among the smallholder dairy farmers in the study area.

Keywords: agro-ecology, cattle, constraints, handling, milk

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Received June 16, 2025
Accepted August 31, 2025
https://doi.org/10.56808/2985-1130.3886

Introduction

Ethiopia has a huge cattle population of 71 million (CSA, 2023) and numerous species of livestock due to its wide-ranging agro-ecological setups (Temesgen *et al.,* 2023). Almost all rural farmers in Ethiopia practice dairy production (Ayalew and Abateneh, 2018). Dairy production plays a significant role in the livelihood of smallholder farmers (Tegegne *et al.,* 2013). Cattle are the main source of milk (Dekebo and Kebede, 2023).

The dairy sector of Ethiopia performs poorly, compared to neighboring East African countries (Desalegn, 2023). Milking cows in Ethiopia are mainly indigenous cattle with low productivity performances (Guya *et al.*, 2019). Indigenous cows have a low daily milk yield of 1.371 liters and a lactation length of 6 months (CSA, 2018). Disease and parasites, shortage of feed and water are the major constraints hindering milk production efficiency of cattle in Ethiopia (Guadu and Mengistie, 2016). Physical and chemical properties of milk can be influenced by the origin of the milk, breed and genotype, health, age and size of the lactating animal, environment, nutrition of the lactating animal, and stage of lactation (Ahmad *et al.,* 2012).

To devise an appropriate intervention strategy for the development of the dairy sector requires an understanding of the existing dairy system (Yayeh *et al.,* 2017). Kucha District is known for its huge cattle population and milk production practices. However, regardless of the potential, little is known about the productivity levels of local cows, milk handling practices, quality, and constraints associated with milk production. There is no information available on the physical and nutritional properties of milk in the district. Thus, the study was initiated with the objective of assessing milk production performance of local cows, milk handling practices, physicochemical properties, and milk production constraints in the district.

Materials and Methods

Study area description: The study was conducted in the Kucha district, Gamo Zone, Southern Ethiopia. Kucha district is positioned between 6° 05" N-6° 30"N latitude and 37° l7" E - 37 ° 40" E longitude (SERA, 2000). Elevation of the district varies between 1000 and 2250 meters above sea level, and agro-ecologically, the district is divided into two: midland and lowland, accounting for about 51% and 49% of the total area, respectively (CSA, 2012).

The total cattle population of the district is 176,496, including oxen, cows, bulls, calves, and heifers. It has 82,787 heads of small ruminants, 5,246 of equine, 87,931 of chickens, and 11,481 of bee hives.

Sampling and sample size: Purposive and random sampling techniques were used to select study kebeles (the smallest administrative units) and respondent households. In the first place, the district was stratified into two based on agro-ecology as midland (51%) and lowland (49%). Then three representative kebeles from each agro-ecology were selected purposively based on cattle population, milk production potential, and road accessibility. Kebeles with relatively higher cattle numbers, established milk production activity, and adequate road accessibility—facilitating data collection and sample transportation—were considered for inclusion in the study.

Households having local cattle breeds and experiences in cattle keeping in each kebele are identified and registered. Finally, respondent households were selected randomly from the registered list. Sample size was determined using the Cochran (1977) formula.

$$n = \frac{Z^2\ (PQ)}{D^2}$$

Where n is the desired sample size, Z is the variance (1.96) with a 95% confidence interval, P is the proportion of the study population from the total, the researcher decided it to be 10%, and D is the margin of error (5%). Hence: P+Q=1, so Q=0.90

Accordingly: $n = \frac{(1.96)^2(0.10*0.90)}{(0.05)^2} = 138.29 \approx 138.$ Hence, a total of 138 respondent households were used for this study.

To evaluate milk physicochemical properties, milk samples were collected from 90 households (45 from midland and 45 from lowland agro-ecology). A total of 138 respondents were used to gather data on socio-economic characteristics, performance of local cows, milk handling practices, and milk production constraints across the selected kebeles. However, due to financial and resource constraints such as laboratory capacity, sample handling requirements, and analysis costs, only 90 households were sampled for milk physicochemical analysis. These 90 households were randomly selected from the larger survey group to ensure that the milk samples remained representative of the broader population while maintaining analytical feasibility. From those selected households, raw milk samples were collected using a sterile container for laboratory analysis.

Data collection: Data collection was held during the dry season from December 2023 to April 2024. Data on household characteristics, milking and milk storage practices, equipment used, milk yield of local cows, and milk production constraints were collected using a structured questionnaire. The milk physicochemical properties were also evaluated.

Milk sample collection and evaluation of physicochemical properties: Milk samples (100 mL) were collected from each selected household in properly washed and cleaned polyethylene bottles. Milk was analyzed in triplicate for physicochemical properties. Milk samples were then transported to Arba Minch University chemistry laboratory using an icebox for conducting various physicochemical analyses. All of the samples were collected according to the recommendations of the literature and following rigorous procedures (Oliver *et al.*, 2009). Fat (%), protein (%), solids-not-fat (SNF, %), lactose (%), density (kg/m³), added water (%), and temperature (°C) were analyzed in triplicate using a lactoscan analyzer (L-18-617, Bulgaria).

Data analysis: The data were analyzed using SPSS (Statistical Package for Social Science) version 20 statistical software. The results were presented using tables, percentages, means, and standard error of means. The means of quantitative data between agro-ecologies were compared by employing one-way analysis of variance. Mean separation was done using Tukey`s test. Cross-tabulation was used for qualitative data analysis.

Parameters that require ranking were analyzed by calculating an index value according to the method described by Kosgey (2004). A model employed for data analysis was: $Yij = \mu + \alpha i + \varepsilon ij$; Where Yij = response variable due to the i^{th} and j^{th} factor, μ = the overall mean, αi =the fixed effect of factor i (agro-ecology), Ɛij =random error.

Results and Discussion

Demographic characteristics of respondents: The results about respondent households' sex, family size, educational background, and age group are published in Table 1. The mean family size of 6.82±0.25 per household was recorded in the study area. Comparable family sizes of 7.8 and 6.2 were reported, respectively, by Worku *et al. (*2014) in the Borana area and Belew (2009) in the Bure district. Ayza *et al.* (2013) also noted a family size of 7.2 persons per family in Boditi Wolaita. Regarding the educational level of household heads, the majority (47.8%) of them were illiterate and very few (2.9%) attended grades 11-12. Similarly, Gemechu and Amene (2017) reported 47.4% of illiteracy for dairy farmers in the Bench Maji zone. On the other hand, Shewangizaw *et al.* (2016) revealed that 46.7% of respondent households attended elementary education in Gonder town.

The majority (76.1%) of the respondent households were male, and the rest (23.9%) were female. The dominance of male-headed households in the current study agreed with the report of Duguma and Janssens (2014), who noted 75.9% male dairy farmers in the Jimma area. Ayza *et al.* (2013) reported that the majority (35.8% literate respondents of dairy producer farmers in Boditi, Wolaita. The variation in educational level of dairy farmers in different locations might be due to the difference in access to education and the awareness of individuals to attend school.

Milk yield of indigenous breeds of cows: The mean daily milk production per cow was significantly different (P<0.05) between agro-ecologies in all lactation stages (Table 2). The variation of milk yield between agro-ecologies might be due to the variation of altitude, which in turn is related to rainfall distribution and feed availability. The average daily milk yield per cow in early, mid, and late lactation stages was 1.80±0.07, 1.94±0.06, and 1.52±0.09 liters, respectively. Tsegaye *et al.* (2023) recorded 1.91 to 2.50 liters of daily milk yield for Boran cattle. Similarly, Bitew *et al.* (2021) noted milk yield of 1.75 ± 0.02liters for grazing fogera cows. Average daily milk yield of 2.98 liters/day/cow was noted in West Hararghe (Musa and Mummed, 2020). Daily milk yield (DMY) of 2.8 liters was also reported for local cows in Gondar town, Ethiopia (Adane and Ayalew, 2020).

Milking practices: The milking practices of dairy cows in the study area are shown in Table 3. All respondents in the area use hand milking, clean hands, and 76.1% of them washed the udder of cows before milking. All milkers washed their hands before milking in Gonder Town, Amhara Region (Shewangizaw *et al.,* 2016). On the other hand, Bereda *et al.* (2013) reported that washing of the cow udder was not practiced.

About 95% of the respondents milk their cows two times a day. Dairy farmers in the North Wollo zone milk their cows during morning and evening times (Gelaw *et al*., 2024). The majority (69.4%) of dairy farmers use river water for hand and udder washing in Cheha District of Gurage Zone, Southern Ethiopia (Babege *et al*., 2020). Only small proportions (19%) of respondents practice washing the cow's udder before milking (Teshome *et al*., 2024). 79% of the respondents clean the cattle barn twice a day. Contrary to this, 42.8% of the households in the Cheha District of Gurage Zone clean cattle house once a day (Babege *et al*., 2020).

Table 1 Household characteristics of respondents.

Variables (%)		Agro ecology		Overall	X^2- test	*P-value*
		Midland	Lowland			
Sex	Male	73.3	79.4	76.1	12.3	0.040
	Female	26.7	20.6	23.9		
	Total	100	100	100		
Educational level	Illiterate	53.3	41.3	47.8	9.44	0.490
	Grades 1-6	24.0	23.8	23.9		
	Grades 7-8	16.0	22.2	18.8		
	Grades 9-10	4.0	9.5	6.5		
	Grades 11-12	2.7	3.2	2.9		
	Total	100	100	100		
Age group	0-14	16.0	22.2	18.9	5.93	0.186
	15-30	70.7	66.7	68.8		
	31-64	13.3	11.1	12.3		
	>65	0	0	0		
	Total	100	100	100		
Family Size (Mean±SE)	Male	3.44±0.12^a	2.65±0.21^b	3.05±0.17	-	0.030
	Female	3.79±0.36	3.76±0.28	3.78±0.32	-	0.760
	Total	7.23±0.48	6.41±0.49	6.82±0.25	-	0.060

N = total sample size, n = number of respondents, HHs = households, SEM = standard error of mean, and $^{a, b}$ means with different superscripts in the same row indicate significant differences at P≤0.05.

Table 2 The mean estimated milk yield (L) per day per cow in the study area.

Estimated milk yield/day/cow (L)	Agro-ecology		Overall	*P-value*
	Midhighland	Lowland		
Early lactation (0-3 months)	1.96±0.06[a]	1.64±0.07[b]	1.80±0.07	0.041
Mid lactation (4-6 months)	2.09±0.05[a]	1.78±0.06[b]	1.94±0.06	0.032
Late lactation (7-9 months)	1.73±0.08[a]	1.31±0.09[b]	1.52±0.09	0.017

N = sample size, L = liter, SEM = standard error of mean, and [a,b] means with different superscripts indicate that mean comparisons are significant across agro-ecologies at $P \leq 0.05$.

Table 3 Milking practices.

Variables		Agro-ecology		Overall
		Midland	Lowland	
Responsibilities for milking	Women	62.7	76.2	68.9
	Women and children	37.3	23.8	31.1
	Total	100	100	100
Milking frequency/day	Twice	73.3	92.0	94.9
	Three times	26.7	8.0	5.1
	Total	100	100	100
Wash the cow's udder	Yes	72.0	80.9	76.1
	No	28.0	19.1	23.9
	Total	100	100	100
Water source for hand & udder wash	Tap water	53.3	73.0	62.3
	Spring water	28.0	15.9	22.5
	River water	18.7	11.1	15.2
	Total	100	100	100
Frequency of barn cleaning	Once a day	14	30.2	21
	Twice a day	86	69.8	79
	Total	100	100	100

Milk storage practices: Milk storage practices are indicated in Table 4. Most (94.9%) of the respondents store milk only for one day. The majority (77.7%) of the respondents in the present study use a clay pot and a plastic jar for storing milk. In southern Ethiopia, plastic containers and clay pots are commonly used for milk and milk products storage (Bereda *et al.,* 2013). Amanuel and Haftom (unpublished data) also found that 92% of dairy producers use a clay pot for the storage of milk.

Physicochemical properties of milk: The constituents of raw milk used for butter making are presented in Table 5. Except for lactose, the remaining constituents of raw milk were significantly different ($P<0.05$) between agro-ecologies. The fat, solid not fat (SNF), protein, and pH of milk from the midland agro-ecology were significantly higher; whereas the density, added water, and temperature of lowland agro-ecology milk were significantly higher. Gemechu *et al.* (2015) reported 4.28±0.01%, 8.59±0.07%, 3.43±0.00%, and 4.43±0.06%, respectively, for fat, SNF, protein, and lactose contents in the Shashemene area. Haile (2016) also reported lower results of 3.5% and 3.09% respectively, for fat and protein contents in Adea Berga and Ejerie districts of West Shewa zone. Similarly, Gemechu and Beyene (2012) reported 3.76%, 3.10%, 5.08% and 8.56%, respectively, for fat, protein, lactose, and SNF of raw milk used for butter making in Ejere, Walmera, Selale, and Debre Berhan areas in the central highlands of Ethiopia. The nutritional as well as the economic value of milk is directly associated with its constituents; as a result, milk with better contents has good nutritional value and more of a milk product can be made (Pandy and Voskuil, 2011). Average values of 4.09±0.63 and 12.71±0.44, respectively, for milk fat and total solids (TS) were reported (Getabalew *et al.*, 2024)

Milk production constraints: The rank of milk production constraints in the study area was presented in Table 6. According to this study, feed and land shortages and low milk yield of indigenous animal breeds were the major problems in both agro-ecologies. The feed scarcity was more severe in lowland agro-ecology with a higher intensity of the index than in mid-highland. This might be due to the shortage of rainfall and the higher intensity of ambient temperature, which limits the availability of feed resources. Feed shortage (73%) and drought (44.8%) were the major constraints in South Ari and Malle Districts, southern Ethiopia. Ayalew (2017) also revealed animal diseases and feed shortage as constraints for dairy production in Amhara Regional State. Feed and land shortage are the major constraints of dairy production (Alemu, 2019; Hailemariam *et al.*, 2022).

Table 4 Milk storage practices.

Variables	Agro-ecology		Overall
	Midland	Lowland	
Do you store milk?			
Yes	100	100	100
Storing time			
One day	96	93.6	94.9
Two days	4	6.3	5.1
Materials for milk storage			
Clay pot only (*manacha*)	17.3	28.6	22.4
Clay pot and plastic jar	82.7	71.4	77.7

Table 5 Constituents (Mean±S.E) of raw milk in the study area.

Parameters	Agro-ecology		Overall	*P*-value
	Midland	Lowland		
Fat%	4.76±0.12[a]	4.31±0.13[b]	4.54±0.13	0.014
SNF%	8.66±0.11[a]	7.45±0.38[b]	8.15±0.25	0.002
Density (g/ml)	1.02±0.00[b]	1.03±0.00[a]	1.03±0.00	0.006
Lactose %	4.75±0.06	4.55±0.17	4.65±0.12	0.280
Protein%	3.65±0.04[a]	3.01±0.09[b]	3.33±0.07	0.001
pH	6.08±0.10[a]	5.32±0.12[b]	5.70±0.11	0.001
Added water	0.32±0.24[b]	5.42±1.24[a]	2.87±0.74	0.001
Temperature in ^0C	29.14±0.28[b]	31.22±0.20[a]	30.18±0.24	0.001

L = liter, g = gram, SNF = solids none fat, N = number of samples, SEM = standard error of mean, and [a,b,] means with different superscripts indicate that mean comparisons are significant across agro-ecologies at $P \leq 0.05$.

Table 6 Ranked constraints of milk production.

Constraints	Agro-ecology			
	Midland		Lowland	
	Index	Rank	Index	Rank
Feed scarcity	0.296	1st	0.323	1st
Land shortage	0.255	2nd	0.182	2nd
Low milk yield of an animal	0.168	3rd	0.166	3rd
Disease	0.082	6th	0.109	5th
Water shortage	0.101	4rth	0.107	6th
Financial problem	0.097	5th	0.112	4rth

In conclusion, the study revealed that local cows had low milk production performances in all lactation stages (early, mid, and late lactation stages). Hand milking was practiced by all respondents. The majority of the respondents use a clay pot and a plastic jar for storing milk. Most of the physicochemical constituents of raw milk were significantly affected by agro-ecologies. Feed and land shortage, low milk yield of indigenous cattle, disease, and lack of credit were the major problems in both agro-ecologies. Dairy-producing farmers in the area should be trained about hygienic milk and proper handling practices to enhance milk quality and safety.

Acknowledgments

Arba Minch University is highly appreciated for financing this research.

Conflict of interest: There are no competing interests among authors.

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