Original Research Article||

Dairy Cattle Production under Changing Crop-Livestock Production Systems: Performance in Milk Production, Reproduction and Quality of Milk in Selected Districts of West Arsi Zone, Oromia Region, Ethiopia

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Abstract

This study was conducted in the central highlands of Ethiopia, which has a long history of improved dairy cattle management. The study area is found in one of the most developed milk sheds as a potential area to develop dairying in the country. However, the current performance of dairy cattle needs to be investigated and documented. This study evaluated the production and reproductive performance of cows, and microbial quality of milk. A total of 124 smallholder farmers were randomly selected from lists of households who at least keep one lactating crossbred cow in 12 kebeles of Kofele, Shashemene and Dodola districts. For microbial analysis, 60 milk samples were collected from producers, milk collectors and consumers. Farmers usually keep mixed herds of local breed cows, HF and a few Jersey crosses. Farmers in Kofele district have the highest HF crossbred cows. The overall production and reproduction performance of dairy cows show the positive legacies/experience of improved dairy cattle management in the area, with an overall mean daily milk yield of 7.24+0.217 litres, at first calving of 33.54+0.82 months, calving intervals of 16.70+0.61 months, and a lactation length of 9.70+0.54 months for crossbred cows. Significant differences were observed between breeds and districts. The overall total bacterial, coliform and yeast and mould counts were 6.51+0.31, 4.74+0.24 and 3.55+0.20 log10cfu/ml, respectively. The microbial quality of the milk was satisfactory and it has acceptable ranges of Ethiopian standards. Farmers perceived feed shortage, the declining trends in crossbreeding programs and lack of sufficient services as market as important barriers to improve milk production. Farmers are switching from typical dairy farmers to cash crop producers. Maintaining the extension systems, good cattle feeding systems, breed improvements practices as well as connecting farmers to the market would stimulate dairy farmers to regain their position as typical dairy production/milk sheds.

Keywords: Production and reproduction traits, microbiological quality of milk, Arsi cattle breed, handling practices, crossbred cows

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INTRODUCTION

Ethiopia has the largest cattle population in Africa with over 70 million heads (CSA, 2021). However, the total milk production from cattle is below its potential,that is estimated at 4.9 billion litres per year (without considering the amount which is produced from urban dairy cattle production systems) (CSA, 2021). This is due to the low milk production from the dominant (over

97%) local cattle breeds, with an estimated 1.48 litres milk production per cow/day. Despite modest increases in recent years, Ethiopia has one of the lowest per capita consumption of milk in Africa. However, milk is a vital component of the diet and serves as a significant source of income for many peri-urban and rural households in the country. A recent report by FAO (2018) showed that per capita milk consumption in Ethiopia is more than 40 litres.

Although smallholder dairy production is a viable economic sector in Ethiopia, it is constrained, among others, by poor access to good nutrition, improved breeds, and output markets i.e. dominated by inadequate processing and informal milk markets. Crossbreeding indigenous cattle with exotic breeds has been shown to substantially contribute to increases in milk production, and to reproduction performances of cattle (Osei-Amponsah et al., 2020).

In addition to the issues of milk production and productivities, quality and safety of dairy products are issues of concern to smallholder systems, including Ethiopia. High microbial counts and the occurrence of pathogens in milk are likely to affect the safety of consumers and keeping quality and shelf life of products derived from it (Abebe et al., 2018). Minten et al. (2021) showed that with the growth in dairy products consumption and rapidly increasing dairy processing companies in the country, it is high time for smallholder dairy farmers to satisfy this growing market for high volume and high quality milk.

This study was conducted in the West Arsi zone, which had several decades of smallholder dairy interventions by successive governments and programs in the country. It is an area where crossbreeding programs on Arsi cattle breeds were heavily implemented for several decades (Aboagye, 2014; Teshome et al., 2019). Arsi cattle are among the tropical zebu cattle breeds not genetically advantaged in terms of milk production, but are well adapted to the area. Arsi Rural Development Unit (ARDU) program, which was established in the 60s, and Gobe Cattle Breeding Ranch (GCBR) played an important role in dairy development in the area, where over 10,000 crossbreed dairy cows were distributed to smallholder farmers in the area (Ulfina et al., 2013). The GCBR, which was in service for over eight decades, was a public institution, which provided several services to smallholder farmers particularly in the neighbouring districts of Kofele, Kore, Dodola, Gedeb, Adaba and Shashemene districts in West Arsi Zone. For several years, the GCBR, before it was privatized in 2018, gave technical trainings to farmers on improved dairy cattle management and milk production. Oghaiki et al. (2021), when mapping Ethiopian milk sheds, identified key biophysical and socio-economic variables that describe the milk shed and concluded that the current study area/milk shed is the second most important region, after North Shoa, with the highest potential to develop dairying in Ethiopia. Even though the study area was famous in terms of its historical dairy development practices, and mentioned as one of the most developed milk sheds in the country, the current performance of dairy cattle and farms needs to be investigated and documented. Thus, this study was conducted to evaluate the current performance of crossbred cows in terms of milk production, reproductive performance, as well as the microbial quality of milk produced by smallholder farmers and compared three different districts which are located at different distances from GCBR.

MATERIALS AND METHODS

Study Sites

The research was conducted in three purposively selected districts namely: Kofele, Shashemene and Dodola districts of the West Arsi zone, Oromia Region, Ethiopia. The West Arsi zone has large number of cattle with 2,095,572 heads, out of which 74, 913 are crossbreds (CSA, 2020). The study area has the highest number of total cattle population as well as crossbred cattle among Ethiopian highlands (Oghaiki et al., 2021) and is amongst the few milk sheds with huge potential for dairying. This is attributed to the long years of dairy interventions in the area, due to the presence of a crossbreeding ranch called Gobe Ranch and several dairy development programs. Gobe Ranch is found in Kofele district, and had a total of 1,800 hectares of land and served the community for over eight decades. Gobe Ranch, which was later named Gobe Cattle Breeding Ranch since 1960s, played key roles in the development of the dairy sector in the area. This ranch was established in 1928-1930 by Swedish government aid under Swedish International Development Agency (Sida) for the selection of Arsi livestock species, and since 1960s it has been used for improving dairy cattle production by distributing crossbred heifers of Arsi cattle and Holstein Friesian to the farmers.

Kofele, Shashemene and Dodola are districts which are known for their high crossbreds Holstein Friesian and Jersey among the districts in the West Arsi zone. These districts were selected by considering its distance from GCBR.

Kofele district's main town-Kofele is located at 7° 00' 0.00" N and 38° 44' 59.99" E, respectively. The district receives an annual average rainfall of 1,232 ml. The mean annual temperature ranges between 11 and 25°C (KLDO, 2021). Shashemene district's main town is Shashemene which is located at 7° 11' 50.2692" N and 38° 36' 1.9188" E. The area has an annual average temperature ranging from 12 to 28°C and annual rainfall in the ranges of 1500 to 2000mm (ShLDO, 2021). Dodola district's main town is Dodola which is located at 06°54'20"N and 39°13'50"E. It is located at an elevation ranging between 2490 to 3218 m.a.s.l. The mean annual rainfall is 964 mm. The mean monthly minimum and maximum temperatures are about 5°C and 27°C, respectively (DLDO, 2021).

Study Designs

Sampling and Data Collection for Household Survey

Data were gathered from milk producers using semi-structured questionnaire. After purposive sampling of the three districts, a total of 12 rural kebeles which are located within 10 km radius from urban center were selected. It means 4 kebeles were selected from each district, and at this stage randomization was applied. The required number of samples of farmers was determined by Yamane formula (1967).

$$n = \frac{N}{1+N\,(e2)} \qquad (1)$$

Where n = sample size, N = population size and e = level of precision (at 5%).

The sampling framework was narrowed down by listing the names of farmers who keep at least one crossbred lactating cows in each of the selected 12 kebeles. Accordingly, 124 households were randomly selected. It was then proportionally distributed to each district, and hence 43 farmers from Kofele, 41 from Shashemene, 40 farmers from Dodola were selected.

A pre-tested questionnaire was used to collect farm household data including, socioeconomic variables, herd sources, current herd compositions, as well as, on production reproduction performance of cows. A progeny history survey approach, which consider cows as research units rather than the household itself. Accordingly data calving intervals (CI), Age at first calving (AFC), lactation length (LL), daily milk yield (DMY), and number of services per conception (NSC) were generated.

Sampling and Data Collection for Laboratory Analysis

A total of 60 raw cow milk samples were randomly collected for laboratory analysis from 30 milk producers, 12 milk cooperatives (pooled samples) and 18 consumers from the three study districts. Raw milk samples were collected into a sterilized labelled sample bottles in an icebox and transferred into a refrigerator adjusted at a temperature of 4°c. Then samples were transported to Hawassa University Dairy Technology Laboratory for microbial analysis, which was completed within 24 hours.

Total Bacteria Count (TBC), Coliform Count (CC) and Yeast and Mould counts (YMC) were conducted using standard procedures (Richardson, 1985). One ml of milk sample was added into sterilized test tube having 9ml autoclaved at 120°C for 15 minutes peptone water. Standard serial dilutions were made using the sterilized multiple test tubes. The right diluted milk samples were pour-plated onto 20ml autoclaved culture media prepared for TBC, CC, and YMC. Nutrient Agar was prepared for TBC and YMC, whereas non-autoclaved Violet Red Bile Agar was prepared for CC, which was mixed thoroughly. The plates of samples were allowed to solidify and then inverted to incubate at 32°C for 48hrs for TBC, at 32°C for 24hrs for CC and at 25°C for 5 days for YMC. Each analysis was made in duplicate and precision of the analysis was determined at 5% level.

Bacterial and yeast/mould colonies were counted using colony counter (Richardson, 1985). The following formula was used to calculate the counts for total bacterial coliform and yeast and mould counts.

$N = \frac{\Sigma c}{[(1xn1)+(0.1xn2)]xd}$................................ (2)

Where N = number of colonies per ml of milk; Σc = sum of all colonies on all plates counted; n1 = number of plates in first dilution counted; n2 = number of plates in second dilution counted; d = dilution from which the first counts were obtained.

Statistical Analysis

The household survey data were analyzed using descriptive as well as General Linear Model (GLM) procedures, as one way and two-way ANOVA depending on the variables using by the Statistical Package for Social Sciences Software (SPSS, version 25). The effect of district was taken for socio economic variables, while both district and breeds of cattle were used for production and reproduction traits analysis. Data of microbial counts were log transformed (log10cfu/ml) before analysis. The transformed microbial count value was analyzed using SPSS software General Linear Model (GLM) procedure. Mean separation was carried out using the Tukey technique when analysis of variance shows significant differences between means and differences were considered significant at $P < 0.05$.

The statistical model used for this study was $Yij = \mu + \alpha i + \beta j + \alpha\beta k + eijk$.................. (3)

Where, Yij: microbial count (TBC, CC, YMC);

μ: the overall mean;

αi: effect of districts;

βj: effect of milk sources

αβk: interaction effect

eijk: random error term.

Ranking Methods

Parameters which need ranking were expressed by calculating an index. Index mean was calculated in Microsoft Excel as shown below and multiplied by hundred to get the aggregate value for the ranking of needed parameters compared in the study areas.

Index mean = Σ [(n × no of R for 1st rank) + (n-1 × no of R for 2nd rank)+……+(1× no of R last)]/ Σ [(n × total R for 1st rank) +(n-1×total R for 2nd rank)+....+1 × total R for last)]

Where: R=number of response, n=value given for the factor, no=number

RESULTS AND DISCUSSION

Household Characteristics

The overall mean of male and female headed households of the study districts were 66% and 34%, respectively (Table 1). There were large numbers of female headed households in Kofele district than Dodola and Shashemene districts. The respondents had different educational status, 46% were able to read and write; 34.7% did not have any kind of formal education and 10.5% of those surveyed had attended high school and 8.9% college education (Table 1).

Table 1. Socio-economic characteristics of respondents in the study areas

	Districts			
Variables	Kofele n=43	Dodola n=40	Shashemene n=41	Overall mean n=124
Sex of household head (%)	N (%)	N (%)	N (%)	N (%)
• Male	23 (53.5)	33 (82.50)	26 (63.41)	82 (66)
• Female	20 (46.5)	7 (16.28)	15 (34.88)	42 (34)
Education level of hh head (%)				
• None literate	13 (30.2)	18 (45.0)	12 (29.3)	43 (34.7)
• Read and write	22 (51.2)	17 (42.5)	18 (43.9)	57 (46.0)
• High school level education	4 (9.3)	2 (5.0)	7 (17.1)	13 (10.5)
• College level education	4 (9.3)	3 (7.5)	4 (9.8)	11 (8.9)
Family size in ranges (%)				
• 0-5	14 (32.6)	27 (67.5)	29 (70.7)	70 (56.5)
• 6-10	24 (55.8)	8 (20)	9 (22)	41 (33)
• Above 10	5 (11.6)	5 (12.5)	3 (7.3)	13 (10.5)

N= number of respondents, hhs = households

Dairy Cattle Herd Structures, Sources and Contributions of Gobe Ranch

As shown in Table 2, the overall mean cattle holding and proportion of HF crossbred cows in the Kofele district was significantly ($p<0.05$) higher than Dodola and Shashemene districts. This study revealed that the overall mean cattle holding per household with 16.95±0.72TLU, is one of the highest among the highlands of Ethiopia. Belete (2006) reported that the average cattle holding per household level was 7.3 in the northern Fogera districts. Table 3, further shows the original sources of cattle herds, showing that Gobe Ranch has contributed to these differences .

Table 2. Herd sizes (TLU) and composition by breeds of cattle owned by smallholder farmers in the study areas (M±SE)

	Study districts				
Variable	Kofele N=43	Shashemene N=41	Dodola N=40	Over all N=124	P - value
Total Cattle herd size	$18.84±1.18^{b}$	$15.44±1.05^{a}$	$16.63±1.23^{a}$	16.95±0.72	0.001
Local breed	5.76±0.36	5.58±0.40	6.63±0.46	6.01±0.25	0.11
HF crosses	$9.36±0.80^{b}$	$6.16±0.65^{a}$	$6.30±0.76^{a}$	7.23±0.46	0.02
Jersey crosses	3.72±0.02	3.70±0.0	3.70±0.0	3.71±0.72	0.534

Means with different superscripts in the same row shows significant difference between districts (P<0.05). TLU=tropical livestock unit, was calculated with standard reference of 1.2 for crossbred cows and bulls, 0.8 for local breed cows and bulls, 0.5 for heifers and 0.25 for calves)

Farmers in the Kofele district seem to benefit more from Gobe ranch due to its proximity. Interestingly, the number of farmers and crossbred cow populations decreases with increasing distance of farm households from Gobe Ranch, even within the district Kofele. Farmers in all the three districts know the Gobe ranch and benefitted in different forms. However, the majority of farmers in Kofele got their first crossbred herds from Gobe ranch, while in Shashemene and Dodola they mainly got their first crossbred cows via AI services from proximate service providers.

Table 3. Sources of cattle herd and experience of farmers in keeping crossbred cattle in the study districts

	Districts			
Variables	Kofele N=43	Dodola N=40	Shashemene N=41	Over all N=124
Original source of crossbred cows				
• Gobe Ranch	15 (34.9)	4 (10.0)	11 (26.8)	30 (24.2)
• From market	10 (23.3)	8 (20.0)	10 (24.4)	28 (22.6)
• AI with own cow	9 (20.9)	21 (52.5)	14 (34.1)	44 (35.5)
• From neighbour	9 (20.9)	7 (17.5)	6 (14.6)	22 (17.7)
Years since linked to Gobe Ranch				
• 5-10	5 (11.6)	4 (10)	3 (7.3)	12 (9.7)
• 10-30	22 (51.2)	25 (62.5)	18 (43.9)	65 (52.4)
• Above 30	16 (37.2)	11 (27.5)	20 (48.8)	47 (37.9)
Benefits from Gobe Ranch				
• Heifer	20 (46.5)	11 (27.5)	17 (41.5)	48 (39)
• Sire	6 (14)	5 (12.5)	7 (17.1)	18 (14.5)
• Cows	10 (23.2)	5 (12.5)	9 (22.0)	24 (19)
• Job	5 (11.6)	0 (0.0)	1 (2.4)	6 (5)
• Other services	2 (4.7)	19 (47.5)	7 (17.1)	28 (22.5)

Reproductive and Productive Performances of Cows Calving Interval (CI): the overall mean calving interval in the study areas was 16.70+0.61 months which is significantly different ($p<0.05$) between study districts, and breeds of cows (Table 4). The calving interval was longer for local cows than crosses of Jersey and HF. The overall mean calving interval of the study area was less than that reported by Mitiku et al. (2019) who documented 18.82 months for local breeds of cattle in Meta district of the East Hararghe zone and greater than the report of Megersa (2016) which shows 14.3 months for HF crosses in West Shoa and Dessalegn et al. (2016) which is 13 months for Bishoftu & Akaki towns. CI is affected mainly by management, the longer it takes during open days before cows are inseminated for the next calving, it would result in longer CI. The longer calving interval reported for local and crossbred cows in various parts of the country mainly attributes to the poor reproduction management practices (such as poor heat detection, untimely bull and AI service provisions) as well as poor access to all season feeding management. Poor nutrition leads to poor body condition that prevents cows from showing true estrus (Law et al., 2009).

Lactation Length (LL): the overall mean lactation length was 9.70 ± 0.54 months, and it is significantly different ($p<0.05$) between breeds of cows and districts (Table 4). This overall mean result is similar to the finding of most studies in similar highlands of Ethiopia. For example, Dessalegn *et al.* (2016) and Lemma (2004) reported 9.2 and 9.5 months, respectively for Bishoftu & Akaki towns in the East Shoa zone, respectively. However, the study area has a better lactation length than the national average of 7 months (CSA, 2021). The national average usually reflects the LL of local cows, as 97% of cattle in Ethiopia are local breeds. The lactation length was reported in this study was similar between local and crosses of Jersey cows, but differs from HF crossbred cows. It means, Holstein Friesians are in lactation for more months than local and crossbred

Jersey cows. This result was similar to the report of Megersa (2016) who reported 11.8 months for crossbred cows in the West Shoa zone of Oromia Region, Ethiopia. Like the CI, LL is also affected also by the plane of nutrition. Lactation physiology demands continues supply of nutrients to the mammary gland. Udder and reproduction management practices also play pivotal roles to lactation persistency. Most hormones that affect reproduction cycle also affects lactation physiology (Law et al., 2009). Longer lactation length beyond optimal and recommended level indicates that farmers in the study area milk cows until cows naturally stop milking, and there is not lactation length control/management in the area. However, this practice may have negative effect on calving interval, next season milk and overall productive efficiency of the cow.

Daily Milk Yield: The overall mean daily milk yield in the study districts was 7.24±0.22 litres per cow per day, which was significantly different ($p<0.05$) between breeds cows and also districts. The present result indicates that crossbred cows were better performing thanJersey crosses and local cows. The overall average milk yield of cross bred cows was 10.30±0.31 litres per day, which is less than reported by Abebe *et al.* (2014) with 14.8 litres average value of daily milk yield in Ezha Districts of the Gurage Zone under improved urban dairy management conditions. The quantity and quality of feed resources available to dairy animals is likely the primarily factor for such low performance. Crossbreeding has led to higher milk production per animal, higher income for the families and provision of high-value food and is thus an important livestock improvement tool in the tropics (Richard et al., 2020).

Table 4. Mean (± SE) Reproductive and Productive Performances of Cows owned by smallholder farmers

		Districts				
Variable	Breeds	Kofele n=43	Shashemene n=41	Dodola n=40	Overall mean	P-value
CI	Local	16.46 ± 1.09^{a}	22.24 ± 0.99^{a}	16.94 ± 1.06	18.54 ± 0.55^{a}	
	Jersey crosses	14.71 ± 1.36^{ab}	17.00 ± 1.66^{ab}	16.89 ± 1.45	16.2 ± 0.78^{ab}	
	HF cross	13.36 ± 0.72^{ab}	15.03 ± 0.96^{ab}	17.71 ± 1.16	15.38 ± 0.49^{ab}	
	Overall mean	14.84 ± 0.63^{A}	18.09 ± 0.72^{AB}	17.18 ± 0.71^{AB}	16.70 ± 0.61	0.01
	P-value	0.01	0.00	0.86	0.000	
LL	Local	7.55 ± 0.95^{a}	7.32 ± 0.76^{a}	8.94 ± 0.71	7.94 ± 0.48^{ab}	
	Jersey crosses	11.86 ± 1.1^{ab}	9.00 ± 1.28^{ab}	7.78 ± 0.8	9.55 ± 0.68^{ab}	
	HF cross	13.84 ± 0.63^{ab}	10.75 ± 0.74^{b}	10.21 ± 0.78	11.60 ± 0.43^{a}	
	Overall mean	11.08 ± 0.55^{B}	9.25 ± 0.56^{A}	8.98 ± 0.52^{A}	9.70 ± 0.54	0.009
	P-value	0.00	0.012	0.16	0.000	
DMY	Local	3.59 ± 0.72^{a}	3.14 ± 0.63^{a}	2.60 ± 0.48^{a}	3.11 ± 0.356^{a}	
	Jersey crosses	7.07 ± 0.10^{b}	7.00 ± 1.07^{b}	7.86 ± 0.66^{ab}	7.31 ± 0.505^{b}	
	HF cross	11.14 ± 0.47^{c}	10.83 ± 0.62^{c}	8.93 ± 0.53^{ab}	10.30 ± 0.313^{c}	
	Overall mean	7.26 ± 0.41^{B}	6.99 ± 0.41^{AB}	6.46 ± 0.38^{A}	7.24 ± 0.217	0.017
	P-value	0.00	0.00	0.00	0.000	
AFC	Local	38.23 ± 2.48^{b}	39.53 ± 1.99^{a}	36.76 ± 1.99	38.17 ± 1.25^{b}	
	Jersey crosses	28.57 ± 3.11^{a}	37.17 ± 3.36^{b}	32.56 ± 2.74	32.77 ± 1.78^{a}	
	HF cross	26.08 ± 1.64^{a}	28.33 ± 1.94^{b}	34.64 ± 2.20	29.69 ± 1.12^{a}	
	Overall mean	30.96 ± 1.14	35.01 ± 1.47	35.65 ± 1.58	33.54 ± 0.82	0.089
	P-value	0.000	0.001	0.560	0.000	
NSC	Local	2.64 ± 0.81^{ab}	2.71+1.10	2.65 ± 1.00	2.68 ± 0.14^{b}	
	Jersey crosses	2.29 ± 0.95^{ab}	2.00 ± 0.89	2.11 ± 0.78	2.24 ± 0.20^{ab}	
	HF cross	1.76 ± 0.78^{a}	1.89 ± 0.83	2.21 ± 10.97	2.00 ± 0.13^{a}	
	Overall mean	2.23 ± 0.16	2.20 ± 0.16	2.53 ± 0.152	2.32 ± 0.92	0.261
	P-value	0.014	0.060	0.700	0.003	

N=number of respondents. CI = Calving Interval (in months), LL = lactation length (in months), DMY = Daily milk yield (litres/day/cow), NSC=number of services per conception (counts). Means with different lower superscripts that compares breeds of cows in the column, shows significant difference (p<0.05), , whereas upper superscripts compares districts for overall values of the respective production and reproduction traits (p<0.05).

Age at First Calving (AFC): The overall mean age at first calving in the study districts was 33.54±0.82 months. The mean age at first calving for local, Jersey and HF crossbred cows were 38.17±1.25, 32.77±1.78 and 29.69±1.12 months, respectively and is significantly different (p<0.05) between breeds of cows (Table 4). This result was higher than that reported by Megersa (2016) who found AFC of 31.2 months for crossbred dairy cows in the West Shoa zone and less than that reported by Belay *et al*. (2012) with 36.6 months for Zebu × Holstein-Friesian crossbred dairy cows in Jimma.

Number of Services per Conception (NSPC): the overall average mean number of services per conception in the study districts was 2.32±0.92. The means number of services per conception for local, jersey and crossbred cows were 2.68±0.14, 2.24±0.20 and 2.0±0.13, respectively (Table 4). The finding in the present study agrees with the 2.0 services per conception reported for cows at Asella (Negussie *et al*., 1998), but higher than that reported by Megersa (2016) with 1.8. As explained above, this is an important factor that determines the reproduction cycles of cows, notably the CI.

Major Milk Production Constraints of the Study Area

The majority of the respondents ranked feed shortage as the first constraint which contributes to the low performance of dairy cows in the area (Table 5). Feed shortage ranked as the most significant production constraint likely due to declining communal and private grazing lands due to the rapid expansion of crop fields, such as malt barley, pasta wheat and vegetables for cash income. The second most important challenge perceived by farmers affecting the performance of dairy cattle in the area was poor management practices. This was followed by lack of improved breeds of cattle and AI services. This is in line with a previous qualitative study conducted by Oghaiki et al. (2021), showing that currently farmers could not get sufficient services for breed improvement or heifers. With the growing attention to other cash crops, less land is dedicated to feed production for cattle. As typical small holder mixed crop-livestock systems, more land is dedicated for crop production and hence feed shortage is among the top ranked problems of farmers. Land use change have been shown to affect the dairy potential of milk sheds/clusters (Oghaiki et al., 2021). Especially getting pasture land is one of the key challenges for dairy producers. This study area in particular is unique in that in the past three decades there was a huge/wide expansion of land for malt barely, pasta wheat and various types of vegetable production as alternate income source for smallholder farmers. When dairy development programs, such as breed improvement programs are introduced, they have to be holistically designed in such a way that farmers get sustainable and stable market for their products.

Table 5. Major Milk production constraints of the study area ranked by farm households

	Districts							
	Kofele N= 43		Shashemene N= 41		Dodola N= 40		Overall N=124	
Constraints	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Shortage of feed	0.3	1st	0.23	1st	0.25	2nd	0.25	1st
Lack of improved breed	0.2	3rd	0.19	3rd	0.22	3rd	0.20	3rd
Poor herd management	0.3	2nd	0.17	5th	0.28	1st	0.23	2nd
Limited services like AI and vet health	0.1	5th	0.22	2nd	0.14	4th	0.16	4th
Low access to market	0.2	4th	0.19	4th	0.11	5th	0.15	5th

N= number of respondents, Index =the sum of (5 times 1st order + 4 times 2nd order +3 times 3rd order+ 2 times 4th order + 1 times 5th order) given for individual variables divided by the sum of (5 times 1st order + 4 times 2nd order +3 times 3rd order+ 2 times 4th order + 1 times 5th order) for all preferred respondents; AI=Artificial insemination

Microbial Quality of Raw Cow Milk in the Study Districts

Total Bacterial Count (TBC)

Table 6 summarizes the bacterial loads of milk samples collected from producers, cooperatives and consumers found in the study districts. The overall mean TBC was 6.51±0.31 log_{10}cfu/ml. A significant difference was observed between districts and milk sources (Table 6). The contamination of milk might be due to initial contamination originating from the udder surface, quality of water, milking utensils, and also during transportation. The overall mean of TBC reported for the Meta district of the Eastern Hararghe zone by Mitiku *et al.* (2019) was 6.21$\pm$0.05 log_{10}cfu/ml and a report from Shashemene by Teshome and Tesfaye (2017), was 6.62±0.05 log_{10}cfu/ml. The lower TBC in this study could attribute to a strong traditional smoking practices for all type of milk containers. Abebe *et al.* (2018) has reported similar practices in Ethiopia showing how smoking practice reduces microbial loads in milk. Since 2021, the Ethiopian Standard Authority has declared compulsory standards for four dairy products including raw cow milk (ESA, 2021). According to this standard, the acceptable TBC for a raw cow milk in Ethiopian market is 10^6 cfu/ml. Therefore, the study area has acceptable ranges of TBC established for raw cow milk.

Coliform count (CC)

The overall mean of coliform count/ml of raw milk from different milk sources was 4.74$\pm$0.24log_{10}cfu/ml (Table 6). The mean coliform count was significantly different (P < 0.05) between districts and milk sources. The overall mean coliform count (CC) obtained from raw milk in the current study was comparable with the findings of Mitiku *et al.* (2019) who reported 4.82$\pm$0.082 log_{10}cfu/ml. In another study by Fufa *et al.* (2019) higher CC with 5.56 log_{10}cfu/ml from sub-cites of Addis Ababa has been reported. Overall our study has CC below the acceptable value 5 x 10^4 set by the Ethiopian Standard Authority (ESA, 2021). In the current study area, still it was observed that dairy cos are managed in muddy barn and a poor hygienic conditions are practiced, which might expose the milk for more contamination, increases the microbial count. The presence of coliform in milk indicates that the milk has been contaminated with fecal materials and this could be attributed to insufficient pre-milking udder hygienic practices. Bulk milk coliform bacteria are used as a good indicator for presence of pathogens in milk.

Table 6. Microbial counts (log_{10}cfu/ml) of fresh cow milk from different milk sources

		Districts				
Variables	Sampling unit	Kofele N=22 (P =12 C = 4 Cs = 6)	Shashemene N = 20 (P =10 C = 4 Cs = 6)	Dodola N = 18 (P =8 C = 4 Cs = 6)	Overall mean	P-value
TBC	Producer	6.20$\pm$0.21^A	6.62$\pm$0.23^A	6.50$\pm$0.23^A	6.42$\pm$0.29^A	
	Cooperative	6.79$\pm$0.11^C	7.01$\pm$0.04^B	6.86$\pm$0.05^B	6.88$\pm$0.11^B	
	Consumer	6.49$\pm$0.19^B	6.48$\pm$0.32^A	6.30$\pm$0.19^A	6.42$\pm$0.24^A	
	Overall mean	6.38$\pm$0.30^a	6.66$\pm$0.30^b	6.51$\pm$0.28^{ab}	6.51$\pm$0.31	0.014
	P-value	0.000	0.010	0.002	0.000	
CC	Producer	4.63$\pm$0.19	4.91$\pm$0.06^{AB}	4.53$\pm$0.23	4.70$\pm$0.23^A	
	Cooperative	4.85$\pm$0.14	5.04$\pm$0.06^B	4.82$\pm$0.14	4.90$\pm$0.15^B	
	Consumer	4.76$\pm$0.13	4.89$\pm$0.14^A	4.43$\pm$0.29	4.69$\pm$0.28^A	
	Overall mean	4.71$\pm$0.18^b	4.93$\pm$0.10^c	4.56$\pm$0.27^a	4.74$\pm$0.24	0.000
	P-value	0.081	0.050	0.064	0.002	
YMC	Producer	3.39$\pm$0.16	3.61$\pm$0.12	3.52$\pm$0.18^{AB}	3.50$\pm$0.18^A	
	Cooperative	3.49$\pm$0.09	3.79$\pm$0.14	3.78$\pm$0.08^B	3.69$\pm$0.17^B	
	Consumer	3.51$\pm$0.07	3.71$\pm$0.18	3.41$\pm$0.23^A	3.55$\pm$0.21^A	
	Overall mean	3.44$\pm$0.14^a	3.67$\pm$0.15^b	3.54$\pm$0.22^a	3.55$\pm$0.20	0.000
	P-value	0.173	0.110	0.022	0.005	

Means followed by different lower superscript within rows (compare districts) and different superscript upper superscripts within columns (for milk sources) are significantly different at P < 0.05, N= number of sample. P=producers, C = Cooperative, Cs = consumers

Yeast and Mould Count (YMC)

Yeast and mould are considered to be spoilage microorganisms. The overall mean of 3.55±0.20 log_{10}cfu/ml showed a fairly good quality milk. The mean value of yeast and mould counts was significantly different ($P<0.05$) between districts as well as milk sources (Table 6). This yeast and mould result is also related to the finding of Mitiku *et al.*, (2019) who reported 3.9±0.08 log_{10}cfu/ml for raw cow's milk from Meta district, Hararghe Zone and the report of Teshome and Tesfaye (2017) shows 3.902±0.477 log_{10}cfu/ml for raw cow's milk from Bench Maji-Zone, Ethiopia. According to Ethiopian Standard Authority, YMC in raw milk samples should be lower than 2.1 log_{10}cfu/ml, but this result was higher than that set for maximum YMC. The presence of yeasts and moulds in milk from the producers, cooperative and consumers is higher than the acceptance levels of yeast and moulds in raw milk. The high YMC observed in milk obtained from milk collector and cooperative might be attributed to contamination from dust, air, containers, water used, poor personal hygiene, and poor hygiene of milk selling environment along the value chains. The YMC is not listed under compulsory standards of ESA.

CONCLUSIONS

The study area has been shown to exhibit a positive legacy of previous dairy development programs and the presence of institutions like the Gobe crossbreeding ranch has contributed to the relatively high crossbred HF crosses in the study area. It was also observed that closer a district to the Gobe ranch, in this case Kofele district, had more numbers of crossbred dairy herds it had, notably HF crosses. On the other hand the production and reproduction traits shows that the study area is among the few milk sheds with good production and reproduction performance of crossbred dairy cows under rural smallholder management conditions. Even the microbial quality of raw milk collected from farm households and milk collection units (of cooperatives) are fairly good compared to the national standards. These are some of the legacies of previous dairy development programs and such institutions like the Gobe cattle cross breeding institutions. However, farmers perceived that the attention given to the sector in recent years have exposed them to problems such as feed shortage, breed improvement and access to services such as veterinary and AI services. Overall, the study area is known for long years of dairy development initiatives, showing a great potential for further development as there exist large number of crossbred dairy cows and well experienced smallholder dairy farmers. However, with the growing attention to other cash crops in the study area, less land is dedicated to feed production, whereas the market is not well developed for milk and milk products. This will have less incentive for dairy farmers in order to still dedicate themselves for improving the reproductive and production performance of dairy cows as well as for further improvements on the quality of milk. Therefore, should farmers and the sector benefit from the dairy development in the study area and the whole milk shed, re-strengthening the extension systems, availing services for improved feeding management, breed improvement and health management as well as availing stable and sustained markets for milk and milk products is necessary.

CONFLICTS of INTEREST

The authors declare that they have no conflicts of interest.

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