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Full-Length Research Article

Traditional Dairy Production and Milk Handling Practices in Mareka District, Dawuro Zone, Southwestern Ethiopia

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ABSTRACT

This study aimed to assess traditional dairy production, management, and milk handling practices in the Mareka district of the Dawuro zone in southwestern Ethiopia. Samples included 96 dairy cattle-producing households across three agroecological zones. Data collection methods were structured questionnaires, observations, and discussions with key informants. Statistical analysis was performed using the Statistical Package for the Social Sciences. According to the study's findings, lactating cows constituted 28% of the overall herd population in the highlands and lowlands and 27% in the midlands. While 83% of households kept animals in the same house as their family, 15% housed them in the kitchen. Notably, cows in the highlands had a significantly shorter calving interval (17.3±0.78 months) compared to the midland (24.5±1.46 months) and lowlands (23.2±1.58 months). Average lactation lasted 229.3±6.69 days, with milking starting 51.6 days after calving. During peak periods, daily milk production per cow varied from 1.22±0.06 liters in the lowland and midland to 1.63±0.10 liters in the highlands. The average lactation yield per cow was 198.82 liters, with higher yields observed in highland cows, followed by midland and lowland cows. The study emphasizes the importance of empowering farmers and improving management practices to enhance the impact of traditional dairy practices on human nutrition and community livelihoods.

Keywords: traditional dairy production, calving interval, lactation length

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1. INTRODUCTION

Ethiopia's traditional dairy farming sector benefits from favorable climate conditions, diverse native cattle breeds, and varied agroecological settings. The development of this sector holds significant potential for poverty alleviation and community nutrition enhancement in the country (Gustafson, 2020; Minten *et al*., 2020). Specifically, dairy development, particularly at the smallholder level, can positively impact nutritional outcomes by increasing accessibility to milk and boosting household income (Randolph *et al*., 2007; Sadler *et al*., 2012).

The dairy sector plays a crucial role in achieving two of the Sustainable Development Goals (SDGs), namely poverty reduction (SDG 1) and hunger eradication (SDG 2) (FAO *et al*., 2018). Rural women particularly benefit from dairy production as it generates cash and helps fulfill social obligations (Edemo, 2017).

The connection between livestock and nutrition, especially for children, is significant (Delay *et al*., 2020). Smallholder dairy farming households often exhibit better nutritional status, benefiting both mothers and school-aged children (Hoorweg *et al*., 2000; Walton *et al*., 2012). Moreover, women's ownership of livestock correlates positively with children's weight-for-age Z scores (Jin and Iannotti, 2014).

The characteristics of traditional dairy production serve as crucial indicators for the growth of the dairy sector in Ethiopia. The United Nations' SDGs underscore poverty eradication, hunger reduction, and sustainable resource management, aligning with the goals of dairy development.

While the challenges related to low cow productivity in Ethiopia are well-documented, there remains a gap in understanding the decision-making behavior and efficient resource utilization to enhance cattle production and reduce calving intervals. Despite the widely recognized importance of cattle in Ethiopia, system-specific data on cattle productivity and value are lacking, hindering our comprehensive analysis of these systems (Li *et al*., 2023). Additionally, the long-term impact of animal reproduction on human nutrition downstream is either underrepresented or concentrated in specific areas. This study aims to examine the causal relationship between dairy production, management techniques, and milk and milk product handling in Mareka district, Dawuro zone, southwestern Ethiopia.

2. MATERIALS AND METHODS

2.1. Descriptions of the Study Area

This survey was conducted in the Mareka District of the Dawuro Zone in the Southern Western Region. The Dawuro Zone borders the Woliyta Zone to the east, the Gamo, Gofa, and Basket Zones to the south, the Konta Zones to the west, the Oromiya Region to the north, and Kenbata and Tembaro Zones to the northeast. Mareka District is situated in the central part of the Dawuro Zone. Tercha is the capital of the Dawuro Zone and is located at 7°09'N and 37°30'E, some 500 kilometers southwest of Addis Abeba. Dawuro Zone is characterized by hilly and mountainous terrain. The zone covers a total area of 446,082 hectares. The primary forest cover includes the Kechi-Yama-Dode-Kella natural forest, spanning approximately 32,000 hectares (MOA, 2006). The Chebera Churchura National Park, situated between Dawuro and Konta Zones, contributes to the region's biodiversity. Dawuro Zone is crisscrossed by several perennial rivers, all of which are tributaries to the Gojeb and Omo rivers (Amejo, 2019). Altitude ranges from 500 meters above sea level in the lower Omo Valley to 2,800 meters above sea level at the Tocha Tuta Ridge (Amejo, 2019). The climate experiences a mean annual rainfall of 1,500 mm and an average temperature of 20°C. The rainfall distribution follows a bimodal pattern.

Mixed crop-livestock production is the predominant farming system in the rural areas of the study zone. The key annual crop components include maize, *teff*, sorghum, beans, peas, wheat, barley, haricot beans, sesame, taro, potatoes, and sweet potatoes. Perennial crops include coffee, sugar cane, bananas, mangoes, avocados and soon. Notably, *enset* (*Ensete ventricosum*) plays a crucial role. It sustains high population density by providing substantial yields from small land plots. *Enset* also serves as a mono diet during certain periods when other crops are not yet mature in the fields or stored. While various tree species exist, the eucalyptus tree has recently become invasive in both arable and non-arable lands in the highlands of the study area. Livestock production encompasses cattle, sheep, goats, equines, and poultry. Cows serve as the primary source of milk in the zone. Additionally, Dawuro *kibe* (butter) holds cultural significance as an indigenous resource. Mareka district was selected for this study among the other 11 districts in the zone since it is the business and potential center of the zone and therefore hosts a representative portion of dairy production and marketing activities of the zone.

2.2. Sample Size and Sampling Technique

Three kebeles (farmer's associations) were purposefully selected from the Mareka district to collect household data. These kebeles are named Waka, Gozoshasho, and Tarcha. Before selecting the kebeles, the district was stratified into three altitudinal categories such as highland, midland and lowland. From each agroecological zone, one kebele was randomly sampled (Table 1). The goal was to ensure representation from different ecological contexts. The percentage area coverage of the kebeles in agroecology was roughly similar throughout the district. Next, households were randomly picked from each kebele based on their level of involvement in milk production, as well as the number and type of dairy animals they possessed.

Table 1 Proportion sample size in each unit (kebele) in the Mareka district

Agro-ecology	Altitude in meters above sea level	Kebele	Number of households
Highland	>2200	Waka	32
Midland	1650-1900	Gozoshasho	32
Lowland	< 1450	Tercha	32
Total		3	96

2.3. Method of Data Collection

During the survey, both primary and secondary data were collected. Structured and pre-tested questionnaires were used to gather information directly from sampled households. The questionnaires were administered through house-to-house visits, involving direct interviews with farm families. Researchers conducted personal observations and engaged in discussions with key informants. Women, particularly those involved in dairying and having close interactions with cows, were specifically interviewed. Secondary data were obtained from relevant governmental and non-governmental organizations. These sources provided additional context and background information. The survey covered various aspects, including family sizes, dairy cow holdings, cows' production and reproduction performance, handling practices exercised by the family, milking utensils, and local herbs used for milk preservation and flavoring.

2.4. Data Analysis

The data from the survey was analyzed using various descriptive statistics such as means, percent and frequency. The percentage of farmers (respondents) who had given similar responses to the questionnaire was calculated out of the total number of respondents who responded to each questionnaire. Those who did not respond to certain questions were excluded from the calculation. Results of the statistical summary were presented in Tables. Some of the variables analyzed using the mentioned descriptive procedures include, household size, reasons for the non-availability of cattle barns for farm households, and the population that utilizes warm water to make hygienic practices were summarized. The Statistical Package for the Social Sciences (SPSS) was used for data analysis.

3. RESULTS AND DISCUSSION

3.1. Demographic Characteristics

In the study area, the average family size was 7.29 members with minimum and maximum of 2 and 13, respectively. The average number of males and females per household under 15 years was 1.66 and 1.84; between 15 to 64 years was 1.83 and 1.84, respectively. The average number of females was slightly greater than males and the female-to-male ratio was 1.05: 1. The old age, above 64 years was very few in both genders. This study's average family size was comparable to those reported by Amejo *et al*. (2017) in the same locality (6.9 (SE=0.2)) and in the Alaba special districts of the SNNP region (6.7±0.18) (Ketema, 2007). However, it exceeds the national (5.2) and SNNP (5.1) area averages (CACC, 2003).

3.2. Agricultural Features and Dairy Husbandry

Household holdings of the different categories of cattle were comparable in the three agroecologies (Table 2). The average number of lactating cows from the total herd population was 28% in the highlands and lowlands and 27% in the midlands, which exceeded all other herd structures included in the area, except for calf holding. Yoseph *et al*. (2003) reported the proportion of cows in urban and peri-urban dairy herd was higher than other cattle groups. It is unavoidable for a family to own at least one milking cow. Respondents stressed the importance of a dairy cow in the family as a breeding stock, nutritional source, and source of income for many small producers, particularly women.

According to FAO *et al*. (2018), dairy cow ownership and/or production improvement consistently had a substantial positive and nearly always statistically significant influence on a variety of parameters. Several research, countries, and indices give compelling evidence that dairying was the cause, not the effect, of increased household welfare. Whalen, (1984) stated that in the Ethiopian highlands, revenue from the sale of butter and cheese is the main source of income for women. In most traditional dairy production practices women are responsible for milk allocation and use part or all of the income from the sale of dairy products to purchase goods for the family.

According to Coppock (1994), Borana women in southern Ethiopia are responsible for milking animals, selling milk, and purchasing family necessities. Women's dairy product sales generate 20% of Borana's annual household income in southern Ethiopia (Holden and Coppock 1992). The Borana men in northern Kenya own and are responsible for the livestock. According to FAO (1979), women are responsible for caring for calves and small ruminants, milking cows, processing milk, and using the revenues as needed. Similarly, Whalen (1984) reported that in the Ethiopian highland mixed crop-livestock production system, women are responsible for decision-making concerning dairy management such as watering, feeding, milking, cleaning animals and preparing beds, assigning young children to different activities, selling milk and using dairy income for household needs.

Table 2 Mean (±S.E) cattle holding of households in three agroecologies of Mareka district

Group of cattle	Agroecology			Total
	Highland	Midland	Lowland	
	Mean (±S.E)	Mean (±S.E)	Mean (±S.E)	Mean (±S.E)
Calves	1.6(0.10)	1.7(0.10)	1.4(0 .12)	1.6(0.06)
N	30	32	32	94
Heifers	1.3(0.13)	1.6(0.17)	1.4(0.15)	1.4(0.09)
N	13	20	17	50
Bulls	1.1(0.10)	1.3(0.12)	1.6(0.2)	1.4(0.09)
N	14	21	14	49
Dry cows	1.3(0.1)	1.3(0.16)	1.4(0.12)	1.3(0.07)
N	19	14	18	51
Lactating cows	1.6(0.1)	1.7(0.10)	1.4(0.12)	1.6(0.06)
N	30	32	32	94

Furthermore, the community's nutritional needs necessitate the presence of at least one milking cow in the herd to supplement the family diet. A bread loaf prepared from *enset* (*Ensete ventricosum*), a commonly grown crop, or other cereal grains found in the research area is extremely difficult to make without milk and milk products. This type of cuisine demands an additional nourishing diet or recipe.

3.3. Cattle Housing

Of the total respondents, 83% kept their animals in the same house where the family lived 15% kept them in the kitchen and only 2% housed them in a separate barn (roofed house) (Table 3). According to the respondents, the cattle herd is confined at night in the following order: oxen, bulls, heifers, dry cows, lactating cows, and calves, left to right. This setting facilitates indoor action and night milking. Calves are separately kept until the dam dries off to protect unwanted calf suckling.

There are several reasons for the respondents not to keep their animals in separate houses. The most important ones they claimed include, separately housing animals is not a cultural practice (22%), separately housing for animals is uneconomical (19%), keeping animals in the same house as humans protect animals from theft and/or wild animals (17%) or it protects animals from theft alone (13%). The other important attributes of the respondents such early identification of diseased animals when entering and living in the house, protecting animals from cold stress and disease, making animals docile, facilitating immediate aid if they are sustained, getting personal satisfaction and protecting them and the owners from various types of harmful conditions accounts 12%.

According to Croney and Botheras (2010), the strength of the human-animal bond is likely to influence people's thought processes about how animals should be treated, because people form close emotional connections to animals they consider companions, and those relationships are likely to influence how they think about, view, and value other animals, including those used for food. Concerns about livestock animal welfare may stem from attitudes about companion animals (Croney and Botheras, 2010).

Table 3 Livestock housing in three agro-ecologies of Mareka district

Barn type	**Agroecology**			**Total**
	Highland	**Midland**	**Lowland**	
	Frequency (%)	**Frequency (%)**	**Frequency (%)**	**Frequency (%)**
Common house (human and animals)	19(60)	31(97)	30(94)	80(83)
Separate barn	2(6)	0(0)	0(0)	2(2)
Kitchen	11(34)	1(3)	2(6)	14(15)

3.4. Reproductive and Productive Performance of Cattle

Cows in the three agroecological patterns were significantly different ($p \leq 0.001$) in the mean calving interval (Table 4). The overall mean calving interval of cows in the study area was 21.8 months, but cows in the highland had significantly shorter calving interval (17.3±0.78 months) than those in the midland (24.5±1.46 months) and in lowlands (23.2±1.58 months). This may be due to a relatively better feeding condition in the highland areas. Highland cows may receive better feeding from residue and other supplemental feeds while lactating and thus may induce them to become in heat and conceive while they are still lactating. On the other hand, under range management conditions, especially when the nutrition is marginal, cows do not conceive while lactating and hence calving interval is extended (Mukasa-Mugerwa, 1989, Tegegne, 1981, Ash, 1991). Thus, the latter situation may be reflected in midland and lowland areas of Mareka district, Dawuro zone. Similarly, many studies showed prolonged calving intervals to cause significant problems in Ethiopia. For example, a study in Belesa, Northern Amhara region indicated that calving intervals of cows ranged from 2 to 4 years (Tessema *et al*., 2003).

The ideal calving interval for milk production in a dairy herd is 12 months (Peters, 1984; Gaines and Palfrey, 1931; Fetrow *et al*., 2007; DeLay *et al*., 2020). To achieve this target the management aspect must be very good; estrus detection must be in the best condition; and depend on the cattle breed. Mekonnen and Goshu (1987) reported an average calving interval of 453 ± 106 days for indigenous Fogera cows in Gonder, which is shorter than the present study. On the other hand, the average calving interval of cows in the Dawuro zone was roughly comparable to 25 months reported by (Zelelem and Inger, 2002) for local cows in central highland mixed smallholder.

Table 4 Mean (±S.E) reproductive and productive performances of cattle in three agroecological areas of Mareka district

Cows performance	**Agroecology**			**Total**
	Highland Mean (±S.E)	**Midland Mean (±S.E)**	**Lowland Mean (±S.E)**	**Mean (±S.E)**
Calving interval (months)	17.3 (0.78) ^{a}	24.5 (1.46) ^{b}	23.2 (1.58) ^{b}	21.8(0.83)
N	30	32	32	94
Milking start after calving (d)	50.0 (1.81)	53.91 (2.00)	50.8 (1.83)	51.6(1.09)
N	30	32	32	94
Lactation length (d)	243.0 (12.42)	233.4 (13.52)	211.9 (8.19)	229.3(6.69)
N	30	32	32	94
Peak milk yield period (d)	144.0 (8.56) ^{b}	113.4 (6.83) ^{a}	106.9 (6.99) ^{a}	121.0(4.57)
N	30	32	32	94
Lean milk yield period (d)	49 (8.6) ^{a}	65.2 (10.1) ^{b}	54.7 (5.5) ^{ab}	56.3(8.2)
N	30	32	32	94
Peak milk yield lit/cow/day	1.63 (0.10) ^{b}	1.22 (0.06) ^{a}	1.22 (0.06) ^{a}	1.35(0.05)
N	30	32	32	94
Lean milk yield lit/cow/day	0.76 (0.05) ^{b}	0.63 (0.02) ^{a}	0.62 (0.03) ^{a}	0.67(0.02)
N	30	32	32	94
Lactation milk yield/liters/cow*	271.96^{b}	179.5^{a}	164.3^{a}	201.07
N	30	32	32	94

Row means with different superscripts are significantly different ($p< 0.05$) (Tukey test).

*Does not include calf off-take at either period, (d) Indicate days

In general, it is believed that calving rates and intervals in eastern Africa remain inefficient when compared to those obtained in the United States, Europe, and other countries with well-developed dairy businesses (DeLay *et al*., 2020). Many studies (Odima *et al*., 1994; Zalla, 1974; Dahl and Hjort, 1976; Staal *et al*., 1997) discovered that normal calving rates were between 25 and 60%, with calving intervals of up to four years in many East African countries. While observed differences in the calving interval between cattle of Dawuro zone and the other stocks may be attributed to differences in management conditions and genotype of the cow. The mean lactation length in the study area was about 229.3±6.69 days (Table 4). In most modern dairy farms, a lactation length of 305 days is commonly accepted as a standard. However, such a standard lactation length might not work for smallholder dairy cows in which the lactation length is considerably shorter in most cases (Masama *et al*., 2003; Teodoro and Madalena, 2003; Msangi *et al*., 2005). The study conducted by Alemu and Zinash, (2002) showed the average lactation length of a zebu cow to be 150-200 days. Probably farmers in Dawuro milk cows until they are quite dry. However, this milking practice harms the calving interval, next-season milk and productive efficiency of the cow. Some scholars, however, argue that such an extended lactation period has practical significance for the smallholder dairy farmer as it provides compensation for the usually extended calving interval (Tanner *et al*., 1998). However, sometimes the profitability of short or extended lactation length gets the interest of the farm family in different ways. Men like cows dry off shortly and enter into the next gestation, whereas women need extended lactation. The former harvests calf crops from successive births while the latter needs to precede the ongoing lactation to fulfill the milk demand of the family. Numerous studies have documented that additional days in which cows are not pregnant beyond the optimal time post-calving are costly (Groenendaal *et al*., 2004; Meadows *et al*., 2005).

The average time lapse between calving and starting milking was comparable in the three agroecological levels (Table 4). On average farmers in Dawuro commence milking their cows after 51.6 days, which is a typical feature in the study area. Normally in most areas, cows are left not milked during the first week after parturition and in some cases, milking can be delayed at most until the middle of the second week. In Dawuro, farmers believe that allowing such an extended period of suckling improves calf growth and health. However, such a practice results in inefficient use of milk, and possibly the nutrition of the calf can be topped up using milk replacer and the milk can be made available for human use. Cows in the three agroecological areas of Dawuro significantly differed ($p<0.01$) in the average length of peak milk yield period (Table 4). The mean length of the peak milk yield period in the highlands (144±8.16 days) was significantly longer than in the lowlands (106.9± 6.99 days) and in the midlands (113.4 ± 6.83 days). Conversely, the average length of the lean milking period was shorter in the highlands than in the lowland and midland areas. The milking frequency was twice per day in all parts of the studied area mainly early morning and evening. Mean daily milk production per cow during the peak period was 1.35 liters with variation from (1.22±0.06) liters in lowland and midland areas to (1.63±0.10) liters in the highland and differences were significant ($p<0.01$). Zelelem and Inger (2002) reported that indigenous cows' average daily milk yield of 1 to 1.5 liters in the central highland of Ethiopia. Similarly, daily mean milk/cow during the lean period was significantly higher ($p<0.01$) in the highland (0.76±0.05 liters) than in the midland (0.63±0.02 liters) and lowland (0.62±0.03 liters) (Table 4).

The low milk productivity in the lowland and midland compared to the highland could be a long period of infestation of the former areas with tsetse flies. The problem of trypanosomes is widely distributed in all parts of the Dawuro zone (MOA, 2006). Lowland areas in all five districts are totally or partially infested with tsetse and trypanosomes (MOA, 2006). As a result, the disease causes enormous losses in animal productivity in terms of lower milk and meat output, as well as the costs of treating the disease and/or controlling the vector (MOA, 2006).

The overall mean lactation yield of milk in the study area was 198.82 liters per cow but cows on average gave significantly higher lactation yield in the highland (271.6 lit/lactation) followed by midland (179.5 lit/lactation) and lowland (164.3lit/lactation). This lactation yield does not include the amount of milk off-take by calves either during free suckling period before the start of milking (2 months) or during milking time.

Various studies have shown that calves on average consume 32% of the total milk produced in rural small-scale production systems (Gebrewold *et al*., 2000; Feleke and Geda, 2001; Redda, 2001). As a result, the average lactation yield of cows in Dawuro obtained in this study could underestimate the true performance of the cows as they abstained from milking for quite an extended period (nearly 2 months) after calving. Thus, this may explain the low average lactation yield estimated in the present study compared to average values commonly reported for indigenous zebu cattle under a smallholder production system.

For instance, Ahmed *et al*. (2003) reported the average lactation yield for zebu cows to be range between 400 to 680 kg of milk/cow. On the other hand, the average yield estimated in the present study for highland cows in Dawuro (271.96 lit/lactation) was found to be on the upper range of the lactation yield reported by Alemu and Zinash (2002) in Ethiopia (200-250 lit/lactation/cow). However, the estimated average for the lowland and midland cows is still lower reflecting twofold effects of trypanosomes as well as the extended period of abstaining cows from milking, management and genotype effect.

3.5. Milking, Milk Handling and Processing

3.5.2. Milking and milk handling practices

Cows are milked twice a day during the early morning before breakfast and evening before dinner in all three agroecologies. According to the respondents, milking cows twice daily is a recent practice adopted after the cows become less and less yielder. However, in the old days, cows used to be milked three times a day. During milking, calves are allowed to suckle for a few minutes just to stimulate the milk let down and moisten the teat. Calves are then withdrawn and tied in front of the dam, in position to give maternity by licking and sniffing the young. This gives partial or full docility to the cow. Otherwise, the cow can become furious and it is therefore necessary to attach the cow to a pole. When the milk let downfalls, calves are allowed to suckle in between to re-stimulate the cow once again. Then milking resumes for the second time and there calves are left to suckle their dam until the herd leaves for grazing or the family household go for outdoor activities. Cows are exclusively milked indoors either in the same house where they are sheltered with the family or in the kitchen where food is prepared for the family. It is uncustomary to take out cows elsewhere for milking; believing that moving them away from their usual place can disturb and affect milk let down. In general, indoor milking is preferable for hygienic milk production, unlike outdoor environments, which can expose the milk to contaminants from the environment. In addition, moving insects (humans, animals, etc) can provoke cows and they can become tense or alert if milked outdoors, which is a condition that disturbs the cow and affects milk letdown. However, it has been witnessed during the fieldwork that the place where cows stand during milking is quite muddy and unclean as well as the bodies of the cows are untidy. Thus, the environment in which cows were milked was generally unclean. The frequency distribution of traditional hygienic practices during milking and milk product handling is presented in Table 5. All respondents wash their hands and milk equipment before milking, except for 3% of respondents in the highland. On the other hand, 72% of the highlanders, 41% of the midland and 50% of the lowland, respectively wash udder before milking. However, in most situations, udders are not washed because it is believed that the calf cleans the teat when nursing.Washing udder after milking was practiced by 9% of highlanders, 6% of the mid, and none of the lowlanders. In most cases, the latter hygienic practice was left for the calf and the calf completely suckled the rest of the milk and cleaned the teat part of the dam.

All respondents did not filter milk after milking; instead, they mixed it directly with the previous lot in a vessel (jar) or used it for other purposes. From the respondents, 13% of the highlanders, 3% of the midland and 9% of the lowlanders used warm water for washing udder before milking. Warm water is also used to wash equipment by 38% of the households in the highland. Most respondents mentioned that time insufficiency, labour scarcity, equipment shortage as well as the habit of the cow refrained from using warm water for udder wash.

Table 5 Frequency in traditional hygienic practice during milk product handling in three agroecologies of Mareka district

Hygienic practices	Agroecology			Total n =96
	Highland N =32 Frequency (%)	Midland N=32 Frequency (%)	Lowland N =32 Frequency (%)	Frequency (%)
WH/WUBM/WE	22(69)	12(38)	16(50)	50(52)
WH/WE	7(22)	17(53)	14(44)	38(40)
WH/WUBMI/WE	0(0)	1(3)	2 (6)	3(3)
WH/WUBMI/WUAM	1(3)	0(0)	0(0)	1(1)
All*	1(3)	1(3)	0(0)	2(2)
All except WUBM	1(3)	1(3)	0(0)	2(2)

WH=washing hand, WUBM =Washing udder before milking, WUAM=Washing udder after milking, WUBMI=Washing udder before milking if dirty, WE=Washing equipment, *All= WH/WUBM/WUAM/WUBMI/WE.

Smoking dairy equipment is not a common practice in the study area. Ashenafi and Fekadu (1993) however indicated that smoked containers tend to lower the microbial load of milk contained therein as compared to unsmoked containers.

Table 6 shows households within and across the three agroecologies that used different types of milking equipment. Highlanders mostly used plastic containers for milking (41%) or clay pot (22%) or both clay pot and gourd (25%). In the midland, the majority used clay pots (56%) or both clay pots and gourd (25%) for milking, whereas in the lowlands, clay pots were exclusively used for milking by most households (82%) and usage of other types of equipment for milking was fairly uncommon. In general, the use of plastic containers for milking was fairly common in the highlands than clay pots alone or together with gourd, whereas the reverse was true in midland and lowland areas. Early urbanization in the highlands and therefore availability of plastic containers has allowed the use of such equipment commonly by the highlanders. Gourd fruit plant grows and mixed social (such as potter maker) group inhabitants may provide the opportunity to frequently use gourd and clay pots in the midland and lowland areas.

Clay pot and gourd were most frequently used for the storage and fermentation of milk, however, variations were observed among the three agroecologies regarding the preference between the two types of equipment for storage and fermentation purposes. Households in highland and midland most frequently used clay pots to ferment milk (41% and 56%, respectively) followed by both clay pots and gourd (25% each) or gourd alone (16% each). Whereas in the lowlands, either clay pot or gourd alone was used for milk fermentation (40% and 47%, respectively) and households that used both equipment interchangeably were relatively few.

According to the key informants, the size of the clay pot and gourd used for milking, storage or fermentation, process, and churning varied greatly in size. For example, clay pots used for milking are locally called *butia* and in similar categories, equipment used for storage or fermentation and cheese making is locally known as *Tsaroa*. The size of these two equipment ranges from 1 to 3 liters. Most of the respondents said that they do not like to store or ferment milk in extra-large-sized clay pot. This is probably related to problems encountered during handling because of its large size and its sensitivity to easily damage. On the other hand, the gourd used for milking is locally called *bacha*, which is the smallest in volume. *Qaraba* is the respective name of the gourd in the area and is commonly used for storage and/or fermentation. *Qaraba* also used milk drinking purposes. The churn equipment locally called *Ma'nachia* is the largest in volume of all.

Table 6 Equipment used for milking, storage and processing of milk and milk products in three agro-ecologies of Mareka district

Equipment and their purpose	**Agroecology**			**Total** N=96
	Highland N=32	**Midland** N=32	**Lowland** N=32	
Milking	**Frequency (%)**	**Frequency (%)**	**Frequency (%)**	**Frequency (%)**
Clay pot	7(22)	18(56)	26(82)	51(53)
Gourd	0(0)	3(9)	1(3)	4(4)
Plastic	13(41)	3(9)	2(6)	18(19)
Clay pot/ Gourd	8(25)	8(25)	2(6)	18(19)
Gourd/Plastic	3(9)	0(0)	1(3)	4(4)
Clay Pot/Gourd/Plastic	1(3)	0(0)	0(0)	1(1)
Fermentation	N=32	N=32	N=32	N=96
Clay pot	13(41)	18(56)	15(47)	46(48)
Gourd	5(16)	6(19)	13(40)	24(25)
Plastics	3(9)	0(0)	0 (0)	3(3)
Metals	2(6)	0(0)	0 (0)	2(2)
Clay Pot/ Gourd	8(25)	8(25)	4(13)	20(21)
Gourd/Plastic	1(3)	0(0)	0(0)	1(1)
Churning	N=27	N=28	N=30	N=85
Gourd	27(100)	28(100)	30(100)	85(100)
Cheese processing	N=27	N=28	N=30	N=85
Clay pot	27(100)	28(100)	30(100)	85(100)
Cheese storage	N=27	N=28	N=30	N=87
Clay pot	7(26)	11(32)	16(53)	34(39)
Plastics	1(4)	1(4)	3(10)	5(6)
Metals	3(11)	0(0)	0(0)	3(3)
Enset leaf	7(26)	0(0)	0(0)	7(8)
Clay Pot /*Eenset* leaf	7(26)	18(64)	11(37)	36(41)
Clay Pot/Plastic	2(7)	0(0)	0(0)	2(2)

In all parts of the study area, *Ma'nachia* (churning gourd) is exclusively used for churning purposes. *Ma'nachia* with appropriate volume and wider mouth was selected for churning. Selected *Ma'nachia is* placed on the ceiling of the roof; dried for several days by the smoke and the vent is opened at one side of the neck, which is later used as a gas outlet. During churning, the mouth of *Ma'nachia is* packed tight with dried *enset* leaf. Churning is performed by women or female children sitting on a flat floor, stretching both legs one over the other, and gently rocking the *Ma'nachia* back and forth over the knee.

From the available total milk during the peak lactation period, 89% of household churn *ergo* to buttermilk and 89% make cheese from buttermilk (Table 6). The other respondents did not produce cheese or churn milk for a variety of reasons, including a lack of milk, the usage of whole liquid milk for household use, and a poor source of milk from a specific breed for cheese-making. Clay pots, *enset* leaf, and either clay pot or *enset* leaf made up 26% of cheese storage materials in the highland. In contrast, 37% of households in the midland and 53% of those in the lowland utilized clay pots to store cottage cheese. Furthermore, 64% of households in the midlands and 37% in the lowlands utilized a clay pot or an *enset* leaf to store homemade cheese. According to the respondents, *enset* leaf is common packaging material used to transport cheese to the market while clay pot is used for indoor storage purposes. During the wet season, *enset* leaf is known to host a variety of worms (adult or larvae), including snails, which can have an influence on both product quality and client health. On the other side, respondents asserted that *enset* leaf used for cheese handling is wilted with fire or sunlight, which kills or dislodges the worms.

3.5.2. Fermentation

In the study area, fermented milk is called *meo'matha.* It was not standard practice in the study area to use a starter from the previous batch for milk fermentation. Fresh milk is simply added to previously stored milk that is being fermented. Fermented milk is the basis of further processing into different products. Fermented milk products fulfill multiple purposes in rural society (O'Mahony, 1988). According to the respondents, cheese and buttermilk are good examples of dairy products fulfilling social functions. *Bik'ya* is the practice of donating (sharing) milk and milk products to neighbours or other close groups during a specific period and receiving them back later when scarcity occurs in the home.

According to the key informants, butter is one of the fermented milk products that have a primary role in settling marriage between the bride and groom family. Furthermore, butter provides multiple purposes for the family as cooking oil, food flavoring, cosmetics for hair and body, medicinal value when applied through the nasal cavity, as well as serving as a good source of income among other dairy products. Whey and other miscellaneous products obtained from churning *ergo* used by both genders of children for consumption. According to key informants, *qessa* is the cow's first milk after parturition (synonymous with colostrum but with a longer lap after calving), collected in a jar and blended with fenugreek (*Trifolium foenum graecum*) for many days before being drunk with neighbors.

According to the respondents, different factors such as ambient temperature, cleaning of equipment, breed type, lactation period, and/or health status of the cow affect the fermentation time of raw milk in the study area (Table 7). As the majority of respondents indicated, cool temperature retarded the fermentation process and thereby extend fermentation time more in the highland (31%) and midland (47%) than in the lowland (9%). This is expected because the high ambient temperature in the lowlands accelerates the fermentation process of milk. Unclean equipment contaminates the milk with a high microbial load, which in turn acidifies the milk and results in undesirable fermentation. The separate effect of unclean milk equipment on fermentation time was not a common problem in the three agroecologies as seen from the low frequency of the respondents. This may relate to the possibility of control through cleaning of the containers, which is reflected in the households where almost the entire population washes the equipment.

A considerable percentage of respondents in the three agroecologies i.e., 16% in the highlands, 25% both in the midlands and lowlands indicated the interactive effect of temperature and usage of unclean equipment on the fermentation process. Higher temperature coupled with high contamination quickly acidifies the milk and changes it to undesirable sour milk. A relatively higher frequency of respondents checked the combined effect of the two factors in the lowlands than in the highlands, indicating that deterioration of milk due to unhygienic handling is much worse under high ambient temperatures than relatively cooler temperatures. Additionally, the increased challenge of the combined effect may probably related to the uncommon practice of the households smoking milk containers that believed smoked containers tend to lower the microbial load of milk (Ashenafi and Fekadu 1993), which in turn reduces unintended fermentation by reducing microbial acidification.

Table 7 Frequency distribution of factors that affect fermentation time of raw milk to *ergo* in three agro-ecologies of Mareka district

Factors	**Agroecology**			**Total N=94**
	Highland N =32	**Midland N =31**	**Lowland N =31**	
	Frequency (%)	**Frequency (%)**	**Frequency (%)**	**Frequency (%)**
Temperature	10(31)	15(48)	3(10)	28(30)
Cleaning material	0(0)	3(10)	1(3)	4(4)
Cow types	0(0)	2(6)	1(3)	3(3)
Lactation period	1(3)	1(3)	1(3)	3(3)
Disease of cow	0(0)	1(3)	0(0)	1(1)
Temperature/Cleaning material	5(16)	8(26)	8(26)	21(22)
T^0/CM/DC	1(3)		0(0)	1(1)
CM/CT/DC	1(3)	0(0)	0(0)	1(1)
T^0/CM/CT/LP	2(6)	0(0)	2(6)	4(4)
T^0/DC	1(3)	1(3)	2(6)	4(4)
T^0/CM/LP	7(22)	0(0)	8(26)	15(16)
CM/CT	1(3)	0(0)	0(0)	1(1)
T^0/CT/LP	1(3)	0(0)	0(0)	1(1)
T^0/CM/CT	1(3)	0(0)	0(0)	1(1)
CM/LP	1(3)	0(0)	2(6)	3(3)
T^0/LP	0(0)	0(0)	3(10)	3(3)

T^0=Temperature, CM= Cleaning material, CT= Cow type, LP=Lactation period, DC=Disease of cow

The respondents also associated the influence of lean lactation period on fermentation hours. As indicated by Andryus (2005) this might be linked to the low organic constituents of milk produced during lean period. In contrast to non-organic constituent, the organic part of the milk causes quicker drop in pH (from 6.7 to 4.7), which enhances the fermentation processes within 24 hrs. Despite this fact, the separate effect of the lactation period on fermentation was quite not important, as seen from the low frequency of respondents in the respective agroecologies (Table 7). This is probably related to the immediate use of milk rather than setting longer hours because of insufficiency during the lean period. On the other hand, a considerable proportion of respondents (22-25%) indicated a highly pronounced interactive effect of temperature, unclean equipment and lean lactation period when combined. This suggests that under the prevailing ambient high temperature, households should be more considerate of the level of hygiene when handling milk during the lean lactation period. Otherwise, this may increase post-harvest loss of milk due to refusal.

The effect of disease on the fermentation of milk may be related to mastitis. Mastitis reduces the lactose content of milk, which is the main precursor for fermentation by increasing free fatty acids while lowering the pH of the milk. In addition, mastitic milk shows a higher pH, meaning that such milk is less acidic or more alkaline. Ogola *et al*. (2007) found that high SCC milk and infected quarters had higher concentrations of non-casein fractions, sodium, chloride, and free fatty acid ($p < 0.05$), while casein content, lactose, casein-to-total protein, potassium, and calcium were lower ($p < 0.05$) compared to normal quarters, which are crucial for milk fermentation. Furthermore, Keys *et al*. (1976) found that it takes 15 hours for normal milk, 49 hours for colostrum, 29 hours for untreated mastitic milk, and 53 hours for treated mastitic milk to reach a pH of 4.7 after multiple milkings.

Nonetheless, the effect of mastitis on fermentation either separately or in combination with the other factors was not important in the area as seen from the low frequency of households who checked this category (Table 7). Likewise, few households indicated the presence of differences in the fermentation time of milk depending on the breed of cow. This is related to factors such as the body conditions of the cow, the fat percentage of the cow milk and the season of lactation, which may aggravate the situation.

3.5.3. Plant materials used for milk handling and processing

The most commonly used plants/herbs for washing milk equipment in the study area is presented in Table 8. In the highland *Ocidinum hardiense 32%, either Ocidinum hardiense* or *Ruta cynopogan* 25% and *Ruta cynopogan* 13% of the household were used for washing milk utensils. Likewise, *Ocidinum hardiense* in the midland 34% and in the lowland 25%, of the households used for the above similar purposes (Table 8). Households used plant materials for washing milk utensils were more exchangeable in both agroecology in general, and diverse lowland in particular, which probably related to species diversity in the area. Ayantu (2006) found that *gulowa* (*Achynthus aspera*), t*enadam* (*Ruta graveolens*), and *kosoratya* (*Ocimum hardieneie*) were used to clean milk vessels for milking, storing, and processing. According to field observations, the majority of respondents grew important plants and herbs in their backyards. Otherwise, they get it from neighboring zones. The majority of these activities are handled by women.

The survey result showed that 76% of the households used flavoring/taste plants for milk and milk product handling. *Tenadam* (*Ruta graueolens)* is the most dominantly used flavoring/taste herb, which accounts for 53% in the highland; 47%in the midland and 88% in the lowland (Table 8). Also, 6% of highlanders use fenugreek for flavoring or taste. In another study, Ayantu (2006) found that 16.7% of respondents in Delbo Atwero, 6.1% in Zala Shasha, and 14.1% in Delbo Wegere kebele mix butter with spices; similarly, *tenadam* (*Ruta chalepenis*) and garlic (*Allium sativum*) are commonly used in the processing and storage of traditional cottage cheese (Aleganesh, 2002)

Table 8 Frequency distributions of plants and local herbs for milk and milk product handling in three agro-ecologies of Mareka district

Purposes and plants/ herbs	**Agroecology**			**Total**
	Highland	**Midland**	**Lowland**	
	Frequency (%)	**Frequency (%)**	**Frequency (%)**	**Frequency (%)**
Washing	N=32	N=32	N=32	N=96
Oh	10(32)	11(34)	8(25)	29(30)
Oh/Cc	1(3)	1(3)	10(31)	12(13)
Oh/Cs	0(0)	9(28)	6(19)	15(16)
Oh/Rc	8(25)	5(16)	2(6)	15(16)
Oh/Cm	1(3)	3(9)	0(0)	4(4)
Cc/Cm	0(0)	0(0)	5(16)	5(5)
Oh/Cyc	2(6)	1(3)	1(3)	4(4)
Oh/Cs/Cyc	2(6)	0(0)	0(0)	2(2)
Oh/Rc/Cyc	2(6)	0(0)	0(0)	2(2)
Cm/Rc	2(6)	0(0)	0(0)	2(2)
Rc	4(13)	2(6)	0(0)	6(6)
Flavour/Taste	N=24	N=23	N=29	N=76
Oh/Cs	1(3)	1(3)	1(1)	3(4)
Rg	17(53)	16(50)	28(88)	61(80)
Tfg	2(6)	0(0)	0(0)	2(3)
Oh/Rg	4(13)	0(0)	0(0)	4(5)
Rg/Cs	0(0)	6(19)	0(0)	6(8)

Cs= *Coriand sativum*, Cc= *Chenopodium chenopodiaceae*, Cm= *Cymbopogan martini*, Cyc=*Cymbopogan citralus*, Oh= Ocidinum hardiense, Rg= Ruta graueolens, Rc= *Ruta cynopogan*,Tfg=Trifolium foenum graecum,

4. CONCLUSIONS

Agriculture plays a central role in the livelihoods of a significant portion of the population in the rural areas of Dawuro, Both crop cultivation and livestock production contribute to family income, nutrition, and social well-being. Among livestock, cows hold particular importance. The average number of lactating cows is comparable across three agro-ecologies. However, their reproductive performance varies. Cows in the highlands exhibit shorter calving intervals and better lactation yields compared to those in the midland and lowland areas. In the highland, cows have a longer peak milk yield period but a shorter lean milk yield phase than their counterparts in the midland and lowland regions. The observed differences in production and reproductive performance may stem from disease prevalence and suboptimal management practices. Calves continue to suckle from their mothers for a long time after calving before genuine milking begins. While this practice is important for calf growth and health, it may lead to an underestimation of the cow's lactation yield. Additionally, it reduces the availability of milk for human consumption and sale. Reevaluating the duration of calf suckling is essential, considering both calf well-being and economic factors.

During the peak milk production period, a significant proportion of milk is processed into traditional dairy products such as butter and cheese. Notably, 89% of households in the region process milk into milk products (mostly butter and cottage cheese), increasing income and diversifying their product offerings for consumption. However, challenges arise during lean periods of milk production due to insufficient milk for further processing. To address this, small-scale dairy producers should collaborate by pooling their resources together. Collecting small portions of milk collectively can ensure sufficient quantities for making butter and cheese per production unit. This collaborative approach has the potential to improve the income of milk producers, especially when selling stable products in distant markets. Regional extension services should emphasize comprehensive management practices to enhance dairy husbandry across all agroecologies. By focusing on improved management and sustainable practices, it is possible to empower farmers and strengthen their productive assets. Waiting for provisional support is less effective than proactive intervention.

Conflict of Interest

The authors declare no conflict of interest.

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