

Post-harvest handling, utilization, marketing and processing practices of traditionally produced buttermilk (Arera) in Sidama Regional State

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ABSTRACT

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*Buttermilk (Arera), a byproduct of butter production, contributes to nutrition and livelihoods in the Sidama region, Ethiopia, yet it has been largely overlooked in terms of product characterization. A cross-sectional survey involving 216 smallholders across three agro-ecologies was conducted to assess post-harvest handling, utilization, marketing, and processing practices of traditionally produced buttermilk. Majority of respondents (52.78%) washed their hands before handling buttermilk. All of respondents practiced cleaning equipment with frequency of before and after use, reported by 43.98%, with 49.07% using kacha. Entirely respondents smoked equipment, primarily with wooden chips of *Olea africana* (69.44%). The equipment employed for handling included clay pots (48.15%), calabashes (26.39%), and plastic containers (25.46%). Buttermilk was consumed every two days (54.63%), from home (65.28%). All respondents sold buttermilk through informal market to meet household needs, with average prices being 62.17 ± 0.98 /lit in the dry season and 50.93 ± 0.82 /lit (Ethiopian Birr) in the wet season, showing significant variation across agro-ecologies ($p < 0.05$). Taste emerged as the primary quality determinant (51.39%). Housewives (82.87%) were predominantly responsible for processing. The average churning time was 86.13 ± 0.96 min, varying by agro ecology ($p < 0.05$). The main objectives of processing were product diversification (44.91%) and creating shelf-stable products (22.68%). About 7.33, 6.25, and 5.4 liters in dry season and 8.89, 8.14, and 7.14 liters in wet season produced in highland, lowland, and midland, respectively. More buttermilk is being allocated for selling than for consumption. Seasonality of demand, low raw milk availability, limited shelf life, low pricing, and restricted market access were manifested as marketing constraints. Processing constraints includes lack of small-scale equipment, low milk yield, time-consumption, poor market infrastructure, and labor shortages. To enhance product quality, livelihoods, and nutrition, the study emphasizes the need for interventions to improve raw milk yield and handling equipment, which in turn reduce churning time and alleviate pressures on women.*

KEY WORDS: Agro ecology, Buttermilk, Processing, Sidama region, Marketing, Utilization.

1. INTRODUCTION

In Ethiopia, milk is primarily sourced from cows, camels, goats, and sheep, with cows being the most common; producing a total of 4.96 billion liters annually with the average yield per cow was 1.48lit/day [1]. The dairy sector is hampered by a predominance of local cows, which constituted 98% of cows, and over 60% of the milk is consumed at home due to issues like inadequacy of formal marketing and modern processing technology [2]. However, Ethiopia holds comparative advantage in milk production due to its high livestock population and favorable dairy production conditions compared to neighboring African countries [3].

More than 90 percent of milk produced is consumed as fresh milk; however, processing it into various dairy products enhances value, shelf life, and functional characteristics, that is mainly done through natural fermentation in the country [4]. The main products produced includes traditional butter, yoghurt, *Arera* (sour defatted buttermilk), *Ayib* (cottage cheese), *Metata Ayib* (spiced cottage cheese), *Dhanaan* (Ethiopian fermented camel milk), *Nitir Kibe* (ghee), *Hazo* (spiced buttermilk), and *Ititu* (spontaneously fermented milk curd) [5,6].

Buttermilk is a nutritious fermented dairy product rich in protein and probiotics, beneficial for health by enhancing immune function and fighting infections [7]. Approximately 38% of produced milk is processed into traditional butter in Southern Ethiopia while buttermilk produced alongside butter manufacturing (27% to 42%) [8]. Preparation occurs at household level from spontaneously fermented milk or through cream separation at training centers, cooperatives, and universities [5,9].

Traditional techniques are employed for processing raw milk into fermented products, particularly in rural communities where advanced dairy processing technologies are scarce. These methods often utilize locally available production practices, those contributing to the substandard quality of dairy products produced nationwide. Prior to the processing of milk products, various plant parts are used for washing and fumigating the milk vessels. Among these, *Olea africana* used as the most commonly employed plant, recognized for its role in fumigating milk handling equipment. This practice not only imparts flavor but also enhances cleaning efficiency and improves the sensory qualities of dairy products, as substantiated by multiple studies [5,8,10].

The buttermilk commonly produced and utilized for several purposes in various modes in different parts of the country. It was used for home consumption either directly or processed in to other cooked products (Ethiopian Cottage cheese (*Ayib*) and *Whey*, *Hazo*, *Ajibo*, and *Netea* [6,9,10,12]. According, to [13] the buttermilk amounted to 8.97 liters and 8.20 liters were produced to produce 0.47kg and 0.92kg of Ethiopian Cottage Cheese (*Ayib*), respectively. In addition to that in all regions of the country where fermented milk is produced, the buttermilk is drunk as a beverage that can be either as it is or flavored [6].

In Sidama region, most of the food types prepared with butter were consumed with buttermilk. The consumption of buttermilk in the region is dominant followed by butter and yoghurt [8,14]. Besides, to direct consumption of the buttermilk, it should also be marketed in the region to meet the household demand. However,[15] noted the shorter shelf life of the product mentioned to be 1.2 days which made it to be consumed and marketed with in short period of time. One possible explanation for this should be the high temperatures found in tropical regions combined with restricted availability of appropriate cooling infrastructure. The marketing of milk and milk products in Ethiopia, it is worthy to mention that the product should be channeled to consumers through both formal and informal marketing systems [3,5].

Several studies characterized milk and its products across various regions of the country. Despite this, manufacturers and the scientific community have paid little attention to buttermilk that is produced during the manufacturing process of butter and has several applications. As a result, there is a dearth of knowledge about the product characterization. Thus, for active interventions, designed information is needed from the traditional existing postharvest handling, utilization, marketing and processing of the buttermilk in the current study area. Based on this, the current study is intended to point out postharvest handling, utilization, marketing and processing of the buttermilk in study area.

2. MATERIALS AND METHODS

2.1. Description of Study Area

The study was conducted in Sidama Regional State which is situated between 5°45' to 6° 45 'N latitude and 38°5' to 39°5' E longitude [16]. It is densely populated, with over 460 people per km² and an average household size of 4.99 persons [17]. The region experiences a bimodal rainfall pattern, featuring small rains from February to April, followed by the main wet (rainy) season from July to September. Livestock in the area includes common species such as local cattle, goats, sheep, equines, and poultry, with cattle being predominant and one of the potential area in the country for dairy production. As of the 2020/21 report, the region holds 2,413,482 cattle, 467,858 sheep, 308,903 goats, 34,709 horses, and 16,376 donkeys [1]. The elevation in Sidama varies from 1179 meters above sea level in the northwestern part to over 3127 meters at Mount Garamba. The region primarily utilizes agroforestry and subsistent agriculture, which is essential to its economy [17]. The diverse elevations support mixed agricultural practices, producing major crops such as Enset, coffee, maize, barley, wheat, oat, sorghum, millets, sugar cane, potatoes, and other cereals and vegetables. Notably, coffee, particularly Sidama coffee, serves as a key export crop for Ethiopia [18,19].

2.1.1. Study design, sampling procedure and sample size of Survey

A cross-sectional survey was conducted to collect data from smallholder dairy farmers in a Sidama region. The study used a multi-stage stratified and systematic random sampling method. The region was categorized into three agro ecological zones: highland, midland, and lowland, based on elevation. Three districts; Hula (highland), Dale (midland), and Loka Abaya (lowland) were purposefully selected based on their accessibility, dairy potential, and buttermilk utilization and marketing. Within these districts, six kebeles were purposively chosen, with two kebeles from each district selected based on production potential, accessibility, utilization and marketing. A total of 470 individuals involved in buttermilk production, utilization, and marketing constituted the study population, with respondents selected through systematic random sampling from the chosen kebeles. Next, the sample size determination was done according to the formula provided by [20], equation 1. After that, the second equation employed to determine the households- equation 2 to assure systematic random sampling. Accordingly, a total of 216 target sample households were randomly selected from all target districts and kebeles, and households

having at least one milking cows were sampled at intervals of every 2 households; extending the interval until the target sample size was attained within each district boundary.

$$n = \frac{N}{1 + N(e)^2}$$
, Where; n is the sample size, N is the population size, and e is the level of precision. The estimated population size included in the current study was 470 with 5% of precision. **Thus,**

$$n = \frac{470}{1 + 470(0.05)^2}, \quad n = \frac{470}{1 + 470(0.0025)} = 216. \quad (1)$$

After that the second equation was employed according to [21]:

$i = \frac{N}{n}$; $i =$ implies systematic random sampling formula for household selection interval-(2)

Accordingly, 216 households was selected from four districts proportionally (92 from Dale, 69 from Loka Abaya and 55 from Hula respectively), as indicated in the table 1 below.

Table 1: Sample size selected for the study

Districts	Selected Kebeles	Target population	Sample size
Dale	Gane	115	53
	Ajawa	85	39
Loka Abaya	Kura	81	37
	Barto	69	32
Hula	Gaase	66	30
	Wirama	54	25
Total		470	216

2.1.2. Data Sources, Types and Method of Data Collection

The current study utilized both primary and secondary data sources. Primary data was gathered through pretested semi-structured questionnaires administered to selected households, with translations provided in the local *Sidamigna* language to ensure accurate information collection. The questionnaires included both closed and open-ended questions, and pre-testing was conducted for clarity and appropriateness. Data collection was supplemented by interviews with key informants and group discussions.

Major data collected encompassed the socio-economic characteristics of households such as respondent livelihoods, education status, family size, occupation, and landholding capacity. The post-harvest handling practices of buttermilk producers were examined, focusing on personal

hygiene, equipment cleaning, hand washing practices and water sources used. The study also explored utilization of buttermilk, marketing activities, price, factors affecting pricing, processing practices, and major constraints and opportunities for buttermilk production.

Key informant interviews involving about 10 interviewees, comprising livestock production experts, local development assistants, and community elders from selected districts, were conducted to collect essential study information. Additionally, three focus group discussions comprising 18 participants (one per each district and 6 discussants per group) were undertaken, focusing on individuals with experience in processing traditional dairy products, particularly buttermilk, and its marketing and utilization. Checklists were utilized to draw insights on general postharvest handling practices, marketing, and general manufacturing process. It also incorporated constraints and opportunities related to traditional buttermilk marketing and utilization. Furthermore, secondary data was obtained from agricultural offices, mainly published and sources to complement the primary information gathered.

2.1.3. Data Analysis

The analysis of collected data was conducted using SAS JMP software version 14. Descriptive statistics, including percentage, mean, and graphical representations were deployed to summarize the results. A chi-square (χ^2) test was employed for categorical variables. Comparisons of quantitative variables such as herd size and structure, family size, age, land ownership, fermentation time, buttermilk price, churning time, and buttermilk shelf life were conducted through one-way ANOVA with a significance level set at $p < 0.05$. When significant differences between means were identified, a Tukey HSD test was performed for mean comparison. The ranking will be expressed as an Index = the sum of (5 times first order + 4 times second order + 3 times third order + 2 times fourth order + 1 times fifth order) given for an individual variables divided by the sum of (5 times first order + 4 times second order + 3 times third order + 2 times fourth order + 1 times fifth order) for all variables.

3. RESULT AND DISCUSIONS

3.1. Household Characteristics of respondents in Study Area

3.1.1. Family Size, Age distribution and Land Ownership of respondents in Study Area

Family sizes varied significantly among agro-ecological zones at ($P<0.05$), with an average of 6.89 ± 0.18 as indicated in Table 2. In comparison to the lowland (6.52 ± 0.18) and highland (6.73 ± 0.2), the midland recorded significantly higher (7.41 ± 0.16) family size. According to [22,23] and substantiate the midland's ideal agricultural circumstances, explaining this discrepancy. The average age of the households was 45.1 ± 0.86 . According to [24], family size and age have an impact on household working-age groups and labor conditions. In midland agro ecology, larger family sizes enable these households to engage in a variety of dairy farm activities with significant family effort.

Average land holding was 1.71 ± 0.09 ha, showing significant variations across agro-ecologies at ($P<0.05$). Midland respondents own the lower (1.35 ± 0.08 ha) than the two agro ecologies. Due to favorable conditions, the midland occupied higher family size that might be contributed to smaller land size than the highland and lowland areas, and the result was supported by [23]. The average total area of land used for crop production was 1.2 ± 0.08 ha, with the midland having the lowest allocation of about 0.91 ± 0.07 hectares, and the highland and lowland regions reported larger allocations of about 1.43 ± 0.09 ha and 1.26 ± 0.08 ha, respectively.

Table 2. Family Size, Age distribution and Land Ownership of respondents (Mean $\pm$ SE)

Variable	Agro ecology			Overall (216)	Prob > F
	Highland(N=55)	Midland(N=92)	Lowland(N=69)		
Family Size	6.73 ± 0.2^a	7.41 ± 0.16^b	6.52 ± 0.18^a	6.89 ± 0.18	0.0006
Age distribution	46.2 ± 0.97	43.84 ± 0.75	45.16 ± 0.87	45.1 ± 0.86	0.1472
Land Ownership					
Total land	2.02 ± 0.1^a	1.35 ± 0.08^b	1.76 ± 0.09^a	1.71 ± 0.09	<.0001
Crop land(ha)	1.43 ± 0.09^a	0.91 ± 0.07^b	1.26 ± 0.08^a	1.2 ± 0.08	<.0001
Grazing Land(ha)	0.29 ± 0.14	0.05 ± 0.11	0.22 ± 0.12	0.19 ± 0.14	0.338
Forest and Other Land(ha)	0.31 ± 0.13	0.39 ± 0.11	0.28 ± 0.12	0.33 ± 0.12	0.767

N= Numbers of respondents, Means with different superscripts in the same row differs significantly at $P<0.05$.

3.1.2. Gender, Educational Level, Marital Status and Source of Income of respondents

Concerning the gender of respondents, majority of respondents (71.76%) were male, while female respondents constituted 28.24%, indicating a significant variation in ownership across agro ecology (Table 3). This finding aligns with previous research report by [23,25], but contrasts with [26]. Education emerged as a key factor in adopting new technologies, with respondents showing a diverse educational background but no significant differences across agro ecologies. About 45.34% of the respondents were literate, while 29.2% had primary education, 20.83% were illiterate, and 2.31% had completed secondary school. Slightly higher illiteracy rate was reported in lowland (31.88%) and highland (23.64%) areas compared to midland (10.87%) though variation is insignificant. Citing [27], it was noted that farmers with higher education levels tended to adopt improved dairy husbandry practices more quickly. Regarding marital status, majority (96.76%) of the respondents were married, indicating that family involvement in dairying activities helps to distribute the workload among members.

Majority of respondents, (86.57%) followed Protestant religion, indicating insignificant variation across agro ecology. This suggests that dairy product consumption and marketing are likely unaffected by fasting periods, presenting a continuous opportunity for consumption and marketing throughout the year. Similar findings by [8,23] confirmed a predominance of Protestant followers in Sidama. The farmers engaged in diverse livelihood activities, with significant variations noted across three agro ecologies. The primary income sources include animal and animal products (51.62%), crop production (32.16%), and trade (14.75%), while public and private employment contribute minimally (0.72%). In highland and lowland areas, animal products dominate as the main income source, whereas crop production leads in midland regions. Key crops identified include Coffee and *Khat* in the midlands, *Enset* and vegetables in the highlands, and maize, *Khat*, and haricot beans in the lowlands. The finding was supported by [24,28].

Table 3. Gender, Educational Level, Marital Status and Source of Income of respondent

Variables	Agro ecology			$\chi^2/P\text{-value}$
	HL(N=55)	ML(N=92)	LL(N=69)	
Gender				6.668/0.0357
Male	41(75)	58(63)	56(81)	155(71.76)
Female	14(25)	34(37)	13(19)	61(28.24)
Education				4.927/0.2948
Illiterate	13(23.64)	10(10.87)	22(31.88)	45(22.13)
Primary	17(30.91)	36(39.13)	15(21.74)	63(30.59)
Read and Write	25(45.45)	42(45.65)	31(44.93)	98(45.34)
Secondary	0	4(4.35)	1(1.45)	5(1.93)
Marital Status				11.117/0.1951
Married	53(96.36)	90(97.83)	66(95.65)	209(96.76)
Single	2(3.64)	2(2.17)	1(1.45)	5(2.31)
Divorced	0	0	2(2.91)	2(0.93)
Religion				3.337/0.7655
Protestant	48(87.27)	82 (89.13)	57(82.61)	187(86.57)
Orthodox	4(7.27)	6(6.52)	5(7.25)	15(6.94)
Muslim	1(1.82)	3(3.26)	4(5.81)	8(3.70)
Catholic	2(3.64)	1(1.09)	3(4.35)	6(2.78)
Income source				19.134/0.0142
Animal and their products	32(58.12)	33(35.87)	42(60.87)	107(51.62)
Crop production	16(29.09)	42(45.65)	15 (21.74)	73(32.16)
Trade	7(12.73)	13(14.13)	12(17.39)	32(14.75)
Private employment	0	2(2.17)	0	2(0.72)
Public employment	0	2(2.17)	0	2(0.72)

N= Number of respondents, HL= Highland; ML= Midland; LL= Lowland; N= Number of respondents, Numbers in the brackets represents proportion of respondents; χ^2 = ChiSquare.

1.1.1. Herd size and structure in study Area

The herd encompassed different species in the three agro ecologies depending on the climatic conditions of the environment. The overall cattle population per household was found to be 10.56 ± 0.40 , which is significantly different across agro ecology ($P < 0.05$) (Table 4). The cattle population majorly comprised (Mean $\pm$ SE) (2.72 $\pm$ 0.22), heifer, (2.63 $\pm$ 0.16) dry cows, and (1.89 $\pm$ 0.12) milking cows, respectively. The work done by [29] reported lower average herd size

of the indigenous cattle per household (5.04 ± 0.46) which was lower than the herd size of the current study.

The overall mean of heifers occupied the major part of the total herd of indigenous cattle, followed by milking cows and calves indicating their importance for production and breeding purpose as well as for sustainability of the herd. The overall mean composition of bull and Oxen was comparable and their composition was significantly higher in lowland ($P < 0.05$) than the two agro ecology. The bulls serves for the natural mating while the Oxen provides the traction power for plowing the crop land in the study area. The current finding was supported by [28].

Sheep was significantly higher in highland while the goat population was significantly different in lowland ($P < 0.05$). This variation might be attributed to the nature of environment that leads to the difference in adaptation to the livestock species to variable environmental conditions. Similarly, [22] also noted that the importance of sheep in highland agro ecology is a typical feature of a highland area as sheep are better adapted to cooler climatic conditions than the hot lowlands. The sheep and goat play critical role in serving as the source of immediate cash and asset.

In regard with the equine (horse and donkey) population, the recoded overall mean was 1.36 ± 0.15 and 2.35 ± 0.27 for horse and donkey respectively. It was noted from the table that the mean value for both horse and donkey were significantly lower in midland (0.04 ± 0.13) than the highland (2.21 ± 0.16) and lowland (1.84 ± 0.15). On the other hand, the donkey population was also significantly higher in highland (4.27 ± 0.31) ($P < 0.05$) than the two agro ecology while it was not different between midland (1.01 ± 0.24) and lowland (1.77 ± 0.27). The horse and donkey should serve as a means of transport to agricultural goods from place to place. They brought vegetables (cabbage, onion, *enset* mainly used for cultivation, etc.) from highland to midland and take coffee and sugarcane to highland and make profit to use as a source of livelihood for the family. The finding of the current work was in agreement with the result reported by [22,28]. The highest cattle population was encountered in lowland 14.23 ± 0.41 followed by the highland and midland.

Table 4. Herd size and herd structure, Mean±SE

Variables	Agro-ecology			Overall	P>F
	Highland	Midland	Lowland		
Milking cow	1.84±0.13 ^a	1.42±0.1 ^b	2.42±0.12 ^c	1.89±0.12	<.0001
Dry cow	2.38±0.18 ^a	2.04±0.14 ^a	3.46±0.16 ^b	2.63±0.16	<.0001
Oxen	0.58±0.12 ^a	0.36±0.09 ^b	1.16±0.11 ^b	0.71±0.11	<.0001
Heifer	2.87±0.25 ^b	1.76±0.19 ^b	3.55±0.22 ^a	2.72±0.22	<.0001
Bull	0.54±0.11 ^a	0.35±0.09 ^a	1.35±0.10 ^b	0.75±0.1	<.0001
Calves	1.84±0.12 ^a	1.47±0.09 ^b	2.29±0.1 ^c	1.87±0.1	<.0001
Total Cattle	10.05±0.91^a	7.40±0.35^b	14.23±0.41^c	10.56±0.40	<.0001
Sheep	3.21±0.23 ^a	1.12±0.18 ^b	1.68±0.20 ^b	2.0±0.200	<.0001
Goats	0.72±0.41 ^a	1.91±0.31 ^a	8.42±0.37 ^b	3.68±0.36	<.0001
Horse	2.21±0.16 ^a	0.04±0.13 ^b	1.84±0.15 ^a	1.36±0.15	<.0001
Donkey	4.27 ±0.31 ^a	1.01±0.24 ^b	1.77±0.27 ^b	2.35±0.27	<.0001

Means with different letters of superscripts in the same row differs significantly at **P<0.05**.

1.2. Post-Harvest Handling Practices of Buttermilk in the Study Area

1.2.1. Personal hygiene, water sources used and handling equipment of buttermilk in study area

Table 5 reveals personal hygiene practices and water sources used during buttermilk handling in the study area. The study showed that (52.78%) of respondents practiced hand washing, with significant differences across agro-ecologies. Higher proportion was recorded in highland (63.64%) and lowland (68.12%) which might be attributed to gap in awareness about aseptic buttermilk handling which should be point of intervention. Most individuals used water alone for washing (95.61%), with no significant variation noted across agro-ecologies. This contrasts with findings from Central Highlands of Ethiopia, where interviewees preferred warm water and detergents for washing [24].

According to the survey, respondents mostly obtained their water from boreholes (50.46%) and tap water (40.28%) demonstrating significant variation across agro-ecologies. It was also noted that (54%) of respondents had access to tap water for cleaning in central Ethiopia [24]. Indeed another author stressed the importance of filtering and heat treating non-tap water since it affects bacterial counts [5]. In contrast, the current study revealed that just only (24.54%) of respondents treating their water indicating no significant variations among agro-ecological zones. Filtration was majorly practiced (77.36%) as main techniques used by individuals who did treat their water.

Significant variation was observed in equipment utilized. The equipment's mainly employed included clay pots (48.15%), calabashes (26.39%) and plastic equipment (25.46%). While (62.32%) and (51.09%) of people in lowland and midland regions, respectively, choose clay pots, 58.18% of people in highland regions prefer plastic. The work done by [30,31] also showed similar finding. However, [5], illustrated materials that are simple to clean are preferred, with stainless steel and aluminum being preferred due to their versatility.

Table 5: Personal hygiene, water sources and handling equipment used in the study area.

Variables	Agro ecology			Overall (N=216)	χ^2	Prob>Chisq
	HL (N=55)	ML (N=92)	LL (N=69)			
Hand wash					42.003	<.0001
Yes	20(36.6)	72(78.26)	22(31.88)	114(52.78)		
No	35(63.64)	20(21.74)	47(68.12)	102(47.22)		
Washing mode					1.154	0.5617
Water alone	20(100)	68(94.44)	21(95.45)	109(95.61)		
Water and soap	-	4(5.56)	4(4.55)	5(4.69)		
Water Source					13.923	0.0075
River	6(10.91)	9(9.78)	2(2.90)	17(7.87)		
Borehole	32(58.18)	31(33.70)	37(53.62)	100(50.46)		
Tap water	17(30.91)	52(56.52)	30(43.48)	99(45.83)		
Treat water					1.200	0.5487
Yes	12(21.82)	26(28.26)	15(21.74)	53(24.54)		
No	43(78.26)	66(71.74)	(78.26)	163(75.46)		
Treatment means					3.619	0.4600
Boiling	0	2(7.69)	0	2(3.77)		
Filtration	9(75)	21(80.77)	11(73.33)	41(77.36)		
Boiling and filtration	3(25)	3(11.54)	4(26.67)	10(18.87)		
Handling equipment					51.529	<0.0001
Calabash	9(16.36)	36(39.13)	12(17.39)	57(26.39)		
Clay pot	14(25.45)	47(51.09)	43(62.32)	104(48.15)		
Plastic equipment	32(58.18)	9(9.78)	14(20.3)	55(25.46)		

HL= Highland; ML= Midland; LL= Lowland; N= Number of respondents, Numbers in the brackets represents proportion of respondents; χ^2 = ChiSquare

1.2.2. Equipment cleaning practice and cleaning frequency

All of the respondents reported they undertake cleaning of equipment majorly both before and after use as reported by (43.98%) of them (Table 6). Washing and drying were the most common cleaning techniques, along with smoking. “Tenadam” (*Ruta chalepensis* L.), leaf of “Weira” (*Olea africana*) (26.85%), “Nec Bahirzaf” (*Eucalyptus globules* Labill.) (12.96%), and “Kacha” (a byproduct of the “Enset” plant, (*Ensete ventricosum*) (49.07%) were the materials used for cleaning. Due to the tradition of cultivation “Enset” in the study area, “Kacha” was the most popular cleaning product in highland and midland areas, used by 60% and 56.52% of respondents, respectively. This aligns with findings by [8], which noted the use of various plant parts for cleaning dairy handling equipment in southern Ethiopia.

Smoking milk and milk products is purposefully used as a norm for handling equipment in several regions of Ethiopia, with varying beliefs among smallholders. Accordingly, all of the respondents (100%) stated that they smoked the equipment across agro ecology. The most common wood chips used to smoke the equipment are “Weira” (*Olea africana*) (69.44%), “Tside” (*Juniperous procera*) (15.28%), “Bamboo” (*Bambusa vulgaris*) (9.26%), and “Neci bahrizaf” (*Eucalyptus globules* Labill.) (6.02%). Participants in the study and those who participated in group discussions attested to the fact that they typically employed plant root, stem, and or leaf portions. The current result's supporting findings were also published by [32]. The primary benefit of smoking was to increase of flavor and aroma (69.91%), which is followed by an extension of shelf life (17.13%) and an improvement in cleanliness (12.96%). “Weira” *Olea africana* is often utilized for its positive effects on the flavor, aroma, and shelf life of fermented milk, according to several authors' [3,5,8,33]. However, the study by [34] contradicted the traditional beliefs of respondents regarding smoking milk utensils and storage jars, which were thought to prolong fermentation and enhance shelf life. Indeed, the same authors agreed that the main objectives were to improve the acceptability and desirability of products for customers.

Table 6. Equipment cleaning practices and related activities.

Variables		Agro ecology			
		HL(55)	ML(92)	LL(69)	Overall(N=216)
Do you clean equipment	Yes	55(100)	92(100)	69(100)	216(100)
	No	-	-	-	-
Frequency of cleaning	After use	16(29.09)	21(22.83)	19(27.54)	56(25.92)
	Before use	14(25.45)	23(25)	28(40)	65(30.09)
	Before and after use	25(45.45)	48(52.17)	22(31.88)	95(43.98)
Cleaning Plants	Enset part (<i>Ensete ventricosum</i>)	33(60)	52(56.52)	21(30.43)	106(49.07)
	Nechi Bahirzaf (<i>Eucalyptus globules Labill.</i>)	12(21.82)	13(14.13)	3(4.35)	28(12.96)
	Woira (<i>Olea africana</i>)	4(7.27)	16(17.39)	38(55.07)	58(26.85)
	Tenadam (<i>Ruta chalepensis L</i>)	6(10.91)	11(11.96)	7(10.14)	24(11.11)
Smoke equipment	Yes	55(100)	92(100)	69(100)	216(100)
	No	-	-	-	-
Role of smoking equipment	Good flavor and aroma	44(80.0)	59(64.13)	48(69.56)	151(69.91)
	Shelf life increment	3(5.45)	28(30.44)	6(8.70)	37(17.13)
	Enhancement of cleaning	8(14.45)	5(5.43)	15(21.74)	28(12.96)
Plants used for smoking	Weira (<i>Olea Africana</i>)	13(23.64)	73(79.35)	64(92.75)	150(69.44)
	Bamboo (<i>Bambusa Vulgaris</i>)	20(36.36)	-	-	20(9.26)
	Tside (<i>Juniperous Procera</i>)	18(32.73)	10(10.87)	5(7.25)	33(15.28)
	Neci Bahrizaf (<i>Eucalyptus globules Labill.</i>)	4(7.27)	9(9.78)	-	13(6.02)

N= Number of respondents, Numbers in the brackets represents proportion of respondents; HL= Highland; ML= Midland; LL= Lowland.

1.3. Consumption and utilization practices of buttermilk in study area

Table 7 presents the buttermilk consumption practices in the study area, indicating unanimous (100%) consumption alongside traditional foods, with no variation across agro-ecologies. Common traditional foods include *Kocho*-based dishes such as *Bursame* and *Chukame*, typically

consumed with buttermilk. Respondents prefer buttermilk for its digestibility, attributed to its low fat content, making it suitable even for individuals with gastric intolerant and child's.

Its classification as a functional food is supported by its water-soluble components, including polar lipids and milk fat globule membrane (MFGM) molecules [35]. Prior research also highlighted buttermilk as a key dairy product in the Sidama area, typically consumed with traditional dishes [14]. Recent finding in Southern Ethiopia suggested variations in milk and milk product consumption, highlighting opportunities for enhancing household nutrition [8]. The majority of respondents (54.63%) noted that they consume once in two days showing significant variation across agro ecologies. The variation might be attributed to the variation in processing frequency which might also affect the availability of the buttermilk. In agreement with the current study, [8] distinguished that more than 75% of smallholders were consumed the buttermilk on a daily to twice weekly basis across the four dairy production systems in Southern Ethiopia.

Table 7. Consumption and Utilization Practices of Buttermilk in Study Area

Variables		Agro ecology			Overalla (N=216)	χ^2 /P-value
		HL (N=55)	ML (N=92)	LL (N=69)		
Do you consume buttermilk	Yes	55(100)	92(100)	69(100)	216(100)	-
	No	-	-	-	-	
Way of consumption	Consumed with traditional foods	55(100)	92(100)	69(100)	216(100)	-
Source of buttermilk	Produced at home	36(65.46)	58(63.04)	47(68.12)	141(65.28)	0.449/0.7991
	Produced at home and purchased	19(34.54)	34(36.96)	22(31.88)	75(34.72)	
Do you give priority?	Yes	55(100)	92(100)	69(100)	216(100)	-
	No	-	-	-	-	
Priority given	Family head	48(87.27)	87(94.57)	51(73.91)	186(86.11)	14.14/0.0008
	Vulnerable person	7(12.73)	5(5.43)	18(26.09)	30(13.89)	
Consumption frequency	Everyday	6(10.91)	11(11.96)	9(13.04)	26(12.04)	13.795/0.008
	Once in two	30(54.54)	40(43.48)	48(69.56)	118(54.63)	

days				
Twice in a week	19(34.54)	41(44.56)	12(17.39)	72(33.33)

N= Number of respondents, Numbers in the brackets represent proportion of respondents; HL= Highland; ML= Midland; LL= Lowland; χ^2 = ChiSquare.

1.4. Buttermilk marketing practices in the study area

1.4.1. Marketing activities of the buttermilk in the current study area.

As noted from table 8 all of the respondents (100%) were involved in the buttermilk marketing. They entirely (100%) mentioned that the major purpose of buttermilk selling was to meet household demand. The finding was in agreement with [36] who noted that the buttermilk was one of the dairy products produced and marketed in northern Ethiopia. In addition to that, all of them (100%) practiced selling of buttermilk through informal marketing system. The system involves direct selling of the produce to the direct consumers. In this system, the hygienic condition of milk and milk products is very poor. This is mainly due to the prevailing situation where producers have limited knowledge of dairy product handling coupled with the inadequacy of dairy infrastructure such as electricity and clean water in the production areas [5]. In line with the outlets of marketing, the respondents sold mainly (39.81%) at local market, while (32.41%) of them sell at home and the remaining (24.07%) and (3.07%) of them sell both at home and local market and Kioskis respectively.

The major part (76.85%) of buttermilk marketing was undertaken by housewives indicating that marketing of the buttermilk served as the major income source for women ensuring their economic benefits. The current study was supported with other result noted by [24] that showed housewives were mainly responsible for butter marketing as well as butter making in Central highland of Ethiopia. Besides, [37] also illustrated the same result in accordance with the current finding.

Table 8: Marketing activities of the buttermilk in the current study area.

Variables		HL(N=55)	Agro ecology ML(N=92)	LL(N=69)	Overall(N=216)
Do you sell buttermilk?	Yes	55(100)	92(100)	69(100)	216(100)
	No	-	-	-	-
Type of market	Formal	-	-	-	-
	Informal	55(100)	92(100)	69(100)	216(100)
Purpose of selling	Meet household demand	-	-	-	-
Major customers (Outlets)	Home customers	17(31.1)	20(21.74)	15(21.74)	52(24.07)
	Local market	20(36.36)	40(43.48)	26(37.68)	86(39.81)
	Home and local market	10(18.18)LL	32 (34.78)	28(40.58)	70(32.41)()
	Kioskis	8(15)	-	-	8(3.70)
Responsible person	Housewife	39(70.91)	80(86.96)	47(68.12)	166(76.85)
	Daughter	7(12.73)	11(11.96)	8(11.59)	26(12.04)
	Housewife and daughter	9(16.36)	1(1.087)	14(20.29)	24(11.11)

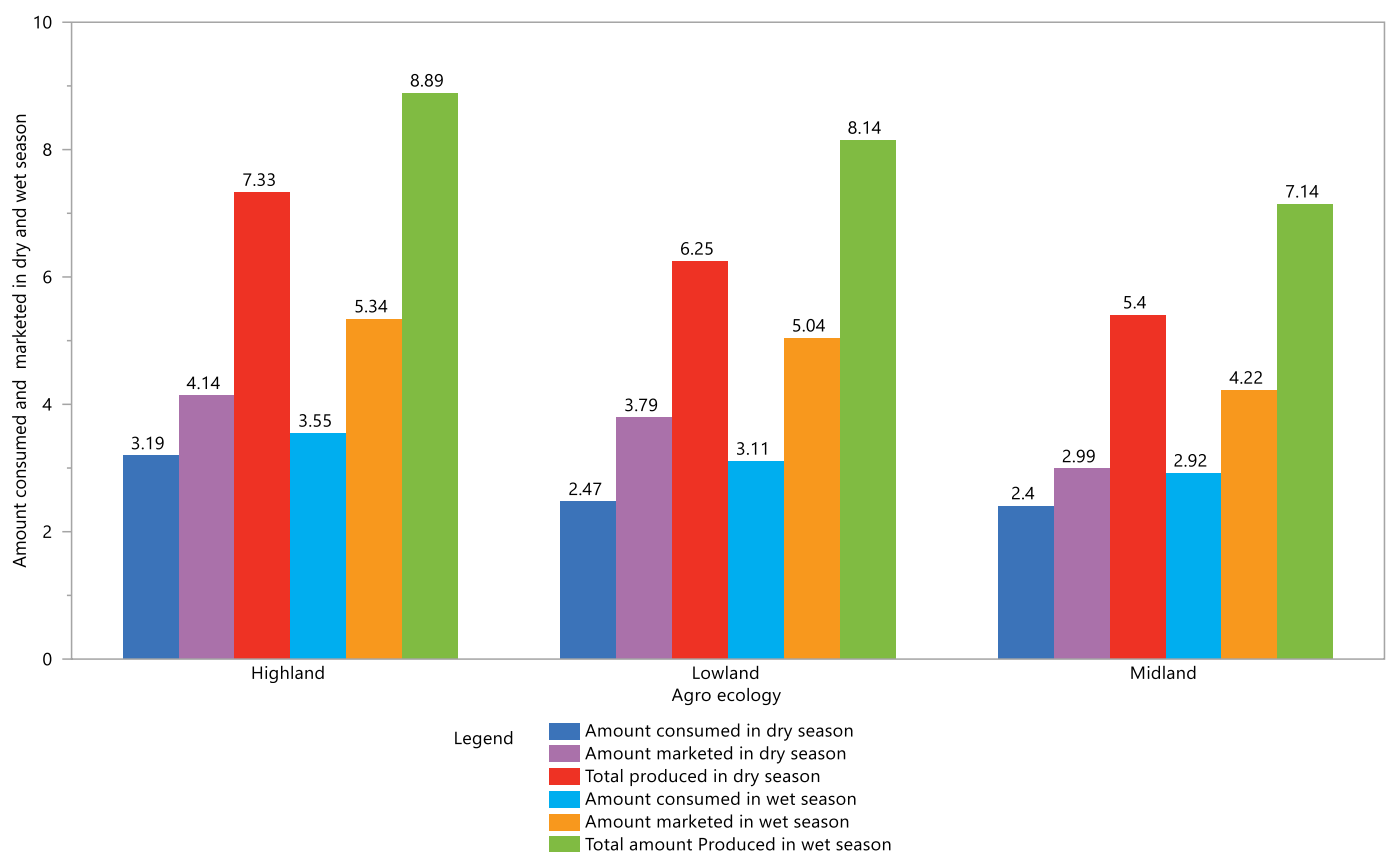
N= Number of respondents, Numbers in the brackets represent proportion of respondents, HL= Highland; ML= Midland; LL= Lowland.

1.4.2. Amount of Buttermilk Consumed, Sold and Produced in Study Area

The estimated amount of buttermilk (*Arera*) consumed, sold and total produced in wet and dry season across agro ecology was indicated in Figure 1. Accordingly, the amount of buttermilk consumed, sold and total produced was varied across agro ecologies and season. The recorded total amount of buttermilk produced was 7.33, 6.25 and 5.4 lit/day in dry season whereas it was 8.89, 8.14 and 7.14lit/day respectively for highland, lowland and midland respectively during wet season. The work done by [13] reported the production of buttermilk about 8.97 liters and 8.20 liters produce 0.47kg and 0.92kg of Ethiopian Cottage Cheese (*Ayib*), respectively. The variation in average buttermilk produced might be attributed to the number of milking animals per household, the available feed for the animals and the processing frequencies in the study area. The buttermilk produced was primarily utilized for either home consumption or sold at nearby local market. In this regard, the estimated average amount of buttermilk consumed in highland, lowland and midland was 3.19, 2.47 and 2.4 for dry season while 4.14, 3.79 and

2.99lit/day for wet season respectively. Corresponding to the buttermilk allocated for the market in both wet and dry season, the variation was observed across agro ecology. The study revealed allocation of more amount of buttermilk (*Arera*) for selling purpose to obtain income than the buttermilk allocated for home consumption. However, in other parts of the country though the buttermilk was produced adjacent to the butter manufacturing, it was mainly utilized for other purposes like production of cooked food items like Ethiopian Cottage cheese or if extra produced, it was provided for dogs and calf [5,8,42].

Fig 2. Amount of buttermilk consumed, marketed and produced in study area



1.4.3. Season encountering constraints, quality parameters considered during marketing and seasonal price

The study respondents entirely (100%) noted that the existence of constraints related with buttermilk marketing across the study area (Table 9). Majority of respondents (71.76%) mentioned that they faced these constraints in wet (rainy) season with significant variation across agro ecology which could be associated with increased production during wet season due to

available feed resources for lactating animals. However, fasting season in the current study area was not mentioned as major determinant factor which might create a good opportunity for the producers to undertake the marketing of dairy products throughout the year. This might be due to the fact that the majority of participants in the study area were protestant religion believers those don't abstained from consuming dairy products during fasting. Similar result was done by [8]. Contrary to the current study, [3] reported that (93.3%) of surveyed respondents noted that fasting days were the major constraints for the consumption of traditional cheese varieties. Similarly, [38,39] also reported contrasting result with the current finding mentioning lower milk consumptions during fasting by Ethiopian Orthodox believers.

No variation across agro ecologies was observed in relation to various sensory quality aspects considered during buttermilk marketing (Table 9). Taste (51.39%) was reported to share higher proportion as determinant of the buttermilk quality followed by freshness (31.52%), odor (21.76%), color (17.39%) and texture (6.02%). The organoleptic tests should be employed to determine the quality of the dairy products due to lack of advanced quality determination technology across smallholder producers in different parts of the country. Accordingly, [3] indicated that the major factors considered during marketing of traditional cheese varieties were freshness, aroma and flavor and cleans followed by amount of whey and color as determinant for price determination. The work of [24] similarly illustrated that sensory methods/organoleptic tests such as color, odor, and texture, are used to judge freshness stated that this test helps customers to evaluate the freshness; taste and acidity of the products thereby avoid buying products of poor organoleptic qualities.

However, the major limit of this type of test is only partly associated with the effects of putrefactive microorganisms that can be detected by a simple tongue test. The presence of pathogenic microorganisms, however, couldn't be detected by such test. The regular follow up and quality based payment system must be implemented to guarantee the health of consumers and promote the production of quality products [5].

In regard with the buttermilk selling price, significant variation was observed in price in dry and wet season as indicated in table 9. The overall mean price per liter in ETB (Ethiopian Birr) in dry and wet season was reported to be 62.17 ± 0.98 and 50.93 ± 0.82 for dry and wet season respectively. In midland the average price noted to be 69.27 ± 0.80 and 59.36 ± 0.71 respectively in dry and wet season was significantly higher than the price of buttermilk recorded in highland and

low land in both dry and wet season. This might be attributed to the increased income generated from diversified agricultural activities in midland than both highland and lowland. In the study area the group discussants and interviewees mentioned that there was no practices of raw milk marketing due lack of tradition. However, the cooperative established at Yirgalem (midland) recently should collect the raw milk from the producers by 60 birr which was comparable price with the current price of buttermilk. The key informants and group discussants also noted the comparative advantage of buttermilk production and marketing in comparison with raw milk marketing that they have opportunity to butter production and in turn they should obtain additional income from butter selling.

Table 9: Season encountering constraints, seasonal price and quality parameters considered:

Variables		Agro ecology			Overall (N=216)	χ^2 /P-value
		HL (N=55)	ML (N=92)	LL (N=69)		
Marketing constraints	Yes	55(100)	92(100)	69(100)	216(100)	0.000
	No	-	-	-	-	
Period of constraint	Wet	31(56.36)	75(81.52)	49(71.01)	155(71.76)	16.086/0.0029
	Fasting	10(18.18)	4(4.35)	3(4.35)	17(7.87)	
	Both	14(25.45)	13(14.13)	17(24.64)	44(20.37)	
Quality parameter consideration						-
	Yes	55(100)	92(100)	69(100)	216(100)	10.251/0.2478
	No	-	-	-	-	
Parameters considered	Color	3(5.455)	4(4.35)	9(13.04)	16(17.39)	
	Freshness	12(21.818)	10(10.87)	7(15.94)	29(31.52)	
	Odor	13(23.64)	19(20.65)	15(21.74)	47(21.76)	
	Taste	25(45.45)	52(56.52)	34(49.28)	111(51.39)	
	Texture	2(3.636)	7(7.61)	4(5.80)	13(6.02)	
Seasonal price/lit(ETB Mean+SE)	In Dry	57.2±1.04 ^c	69.27±0.80 ^a	60.04±1.11 ^b	62.17± 0.98	<.0001
	In Rainy	45.8±0.92 ^c	59.36±0.71 ^a	47.62±0.83 ^b	50.93± 0.82	<.0001

N= Number of respondents, HL= Highland; ML= Midland; LL= Lowland; Numbers in the brackets represents proportion of respondents; χ^2 = ChiSquare; ETB= Ethiopian Birr; SE, Standard Error; Mean values represented with different superscripts in the same row differs significantly (P<0.05).

1.5. Buttermilk Processing Practices in the study Area

There was no significant difference in buttermilk production amongst agro-ecologies. All study participants (100%) made buttermilk from locally fermented milk, locally called *Geinitto*. This is consistent with the result of [36], who found that 88% of participants made sour milk buttermilk. About (82.87%) of buttermilk production was done by housewives, with insignificant differences amongst agro-ecologies. Furthermore, [37] found that women are mostly involved in different action from farm to processing. As a result, the findings imply that women must actively participate in attempts to enhance this sector as their involvement is essential to achieving desired improvements.

Significant variation was found in the frequency of buttermilk production across agro-ecologies. The majority of smallholders (59.72%) reported producing buttermilk three times a week, while (40.28%) produced it twice in a week. In contrast to the midland (72.83%) and lowland (82.61%) regions, where a greater desire to create buttermilk three times a week was indicated, (90.91%) of smallholders in the highland region generally processed it twice a week. These discrepancies are probably caused by changes in the surrounding temperature; raw milk must ferment for a longer period of time in the highland due to its colder climate than in the midland and lowland. The finding of the current study aligns with [8].

The average churning time (86.13 ± 0.96 min.) in the current study area showed significant variation at ($P < 0.05$) across agro ecology. The time consumed during churning in highland agro ecology (100.03 ± 1.02 min.) was significantly higher than the midland (90.15 ± 0.85 min.) and lowland (68.21 ± 1.00 min.) at $P < 0.05$. The lower churning time was reported by previous scholars (40min.) and (63.4 ± 1.8 min) by [36] and [31] respectively while [24] reported relatively similar report of (96min). Different ambient temperatures at which the milk churned might be the cause for variations in churning time.

In regard with manufacturing objective of the product production, product diversification (44.91%), shelf stability (22.68%), nutritional enhancement (18.52%), and value addition (13.89%) were the major reasons given by smallholders for producing buttermilk. It was also noted that found that majority of respondents (79%) of respondents processed milk mainly to

increase household income [31]. Additionally, [36] also reported consistent finding in northern Ethiopia.

In the food sector, natural items like spices are good substitutes for chemical preservatives since they extend shelf life and have fewer negative effects available spices on the characteristics and consumer acceptability of traditional fermented milk products [40]. Despite this, no significant variation observed in the survey area in seasoning buttermilk with spices, mostly because they are unaware of the practice. Furthermore, the research work conducted by [41] stated the significance of comprehending the effects of locally available spices on the characteristics and consumer acceptability of traditional fermented milk products. So, this needs the scientific investigation of application of spices on the buttermilk and its characterization to commercialize the products due to the majority of the smallholder farmers do have long tradition of buttermilk utilization in comparison with other dairy products in the current study area.

A product's shelf life shows how long it can be kept in a safe manner before the product become unacceptable. Accordingly, the average shelf life of buttermilk is $(2.06 \pm 0.06 \text{ day})$ with significant differences across agro ecological zones at $(P < 0.05)$. The recorded shelf life in highland was significantly higher $(3.06 \pm 0.07 \text{ day})$ than in midland $(1.9 \pm 0.05 \text{ day})$ and lowland $(1.22 \pm 0.06 \text{ day})$, perhaps as a result of temperature variations. The high moisture content of the buttermilk might be attributed for its short shelf life, which encourages smallholder's immediate consumption or sells it right away. Unlike the current study area, smallholders in other parts of the country practiced immediately processing of the buttermilk in to shelf stable products like *Hazo*, *Ajibo* (spiced buttermilk) and *Ayib* (Ethiopian cottage cheese). At room temperature, the shelf life of *Ayib* and *Hazo* cheese is 9.0 ± 0.48 to 9.6 ± 0.45 days, but *Metata* cheese may survive up to 12.4 years. At room temperature, *Ayib* and *Hazo* cheese can survive 9.0 ± 0.48 to $9.6 \pm 0.45 \text{ day}$ respectively, although *Metata* cheese can last up to 12.4 years in some locations. The spices employed in manufacture also have an impact on shelf life variability [3].

Table 10. Manufacturing practices and shelf life of buttermilk in the study Area

Variables	HL (N=55)	ML (N=92)	LL (N=69)	Overall (N=216)	χ^2/P-value
Process buttermilk					
Yes	55(100)	92(100)	69(100)	216(100)	-
No	-	-	-	-	
Source of buttermilk					
Fermented milk	55(100)	92(100)	69(100)	216(100)	
Responsible person	48(87.27)	75(81.52)	56(81.16)	179(82.87)	1.523/0.82
Housewife	5(9.09)	10(10.87)	9(13.04)	24(11.11)	
Daughter	2(3.64)	7(7.61)	4(5.80)	13(6.02)	
Son					
Frequency of processing					80.206/<.0001
Twice a week	50(90.91)	25(27.17)	12(17.39)	87(40.28)	
Three times a week	5(9.09)	67(72.83)	57(82.61)	129(59.72)	
Role of processing					19.483/0.0034
Shelf stable products	6(10.91)	25(27.17)	18(26.09)	49(22.68)	
Enhancing nutritional quality	14(25.45)	18(19.57)	8(11.94)	40(18.52)	
Product diversification	27(49.09)	44(47.83)	26(37.68)	97(44.91)	
Value addition	8(14.55)	5(5.43)	17(24.64)	30(13.89)	
Churning time(min)	100.03±1.02 ^a	90.15±0.84 ^b	68.22±0.97 ^c	86.13±0.96	<.0001
Shelf life (in days)	3.06±0.07 ^a	1.9 ±0.05 ^b	1.22±0.06 ^c	2.06±0.06	<.0001
Use spices					-
Yes	-	-	-	-	
No	55(100)	92(100)	69(100)	216(100)	

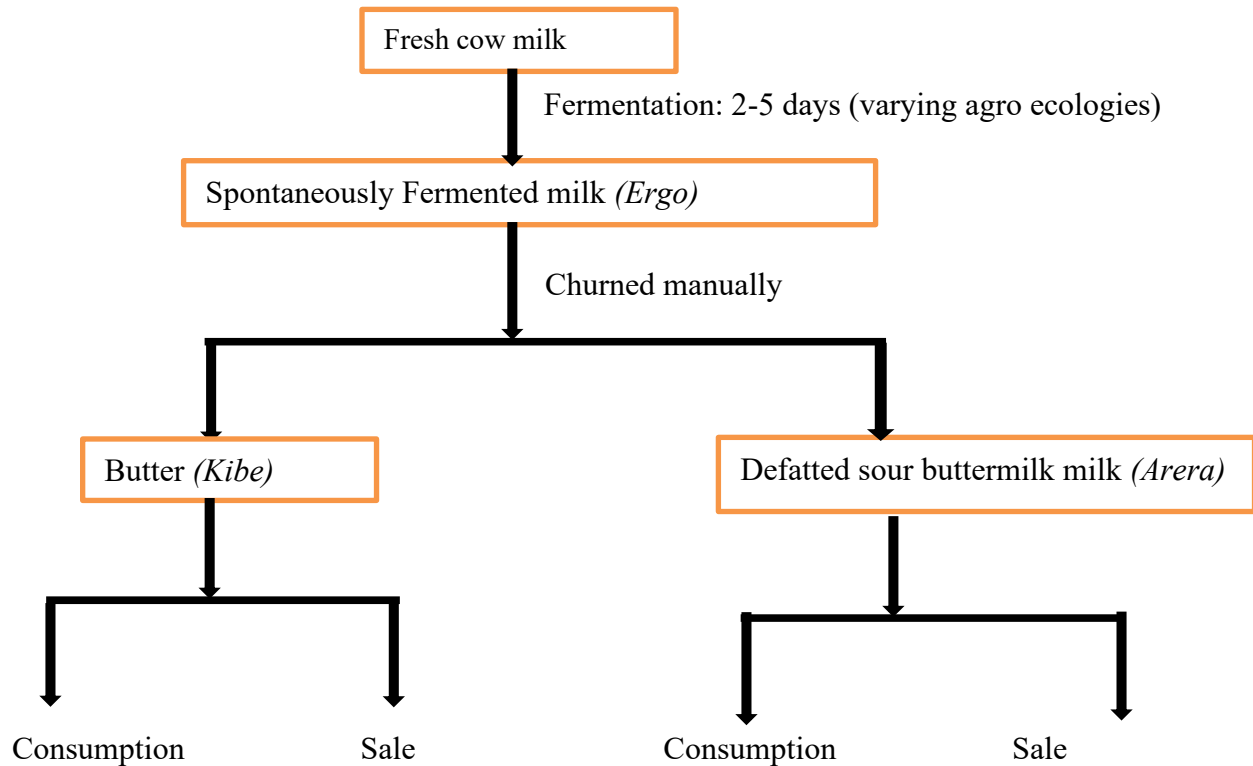
N= Number of respondents, Numbers in the brackets represent proportion of respondents, Mean values represented with different superscripts in the same row differs significantly (P<0.05). SE, Standard Error.

1.6. Smallholder's buttermilk processing scheme in the study area

Generally, spontaneous fermentation of milk, more especially, *Ergo* without particular starter cultures is the main starting point in the country for processing. Raw milk is mixed with earlier batches and let to ferment for up to five days at room temperature. The difficulties in maintaining milk quality in tropical environments gave rise to this technique [44]. Lactic acid bacteria transform milk sugar during fermentation, producing the required acidity. On the other hand, milk is sterilized at temperatures higher than 100°C in nations with developed dairy industries before being cooled and inoculated with certain starter cultures for regulated fermentation [45].

Similar to other parts of the country, spontaneously fermented milk is churned to make buttermilk as a byproduct of butter production (Fig.1). Fresh milk is traditionally gathered and fermented for two to three days in traditional equipment that is sealed with materials obtained from false banana (*Enset*). After removing the lid, processors check for curd buildup on the milk's surface to determine whether it is ready for churning. If curds cover the surface of fermented milk, it is ready to churn and the respondents churn manually. A shift in sound during agitation indicates the formation of butter. They would add small amount of water perceiving facilitation of churning process and increase the volume of buttermilk. This might be considered as adulterant which might affect the quality of the end product. The butter lumps are generated by rotating the churn to concentrate the clumped butter particles. Then after, the buttermilk should be filtered and collected to other equipment that is washed, dried, smoked and cleaned, through specifically designed outlet upon the churner. The butter is collected and then cleaned to get rid of extra buttermilk. This approach is consistent with strategies seen in earlier academic publications ([3,5,36,42].

Figure 1, Buttermilk manufacturing scheme in study area.



1.7. Buttermilk marketing and processing related constraints and opportunity in the study area.

In regard with constraints related to buttermilk marketing, the index value showed seasonality of demand (0.61), low amount of raw milk obtained (0.12), limited shelf life (0.10), low price of buttermilk (0.09) and limited access to market (0.08) as the major constraints according to their degree of importance across the study area. The respondents noted that, the wet season should be considered as major factor affecting the marketing activity of the buttermilk across agro ecology. Thus, they faced challenges in marketing mainly making them to fetch lower price of the buttermilk. The work done by [3], similarly noted that farmers are challenged by price decline for their produce as their supply increases beyond the market size of their village or nearby small town. The same authors indicated that the decline in the net value of return from milk and milk products. In this essence, production of value added, shelf stable products, during surplus production season possibly be important to enhance the livelihoods of smallholders.

The unavailability of small-scale processing equipment (0.39), low milk yield for processing (0.35%), time consumption (0.15), poor market infrastructure (0.08), and a manpower scarcity (0.02) were the major constraints reported by study respondents according to their importance in line with processing. The study participants noted the inefficiencies of processing equipment majorly clay pots and its easily breakable nature, leading to longer churning time and additional cost of processing, were major constraints in buttermilk production. For improving product quality, shortening processing time, and decreasing labor, small-scale processing equipment is essential. Moreover, the effectiveness of butter recovery is hampered by churning techniques which in turn affects income of the smallholder processors. Women's load in churning might be minimized and butter output could be increased by introducing better churners and increasing knowledge of its advantages. Furthermore, low-milk yielding cows are the main source of buttermilk for smallholders affecting the amount of buttermilk produced. The study also identified the need for interventions to improve milk yields of local breeds through crossbreeding with more productive dairy animals to enhance the raw milk yield for processing. The development of market access for smallholder producers might also be considered as vital for providing their products to the nearest market. The finding was supported by previous report done by [14,23].

Despite this, there are certain opportunities raised by the group discussants during the group discussions. These are favorable environmental conditions that possibly boost local dairy production and the yield of raw milk thus improving the output of the buttermilk. Additionally, engagement of smallholders in producing diversified crops intended for increased income might also mentioned as a good opportunity for the sustainable production of dairy products including the buttermilk. Furthermore, the consumer preferences for buttermilk over other dairy products, due to its nutritional properties and also driven by cultural traditions on its consumption during various occasions, might also be considered as golden opportunity for the buttermilk production and consumption in current study area. Based on this, governmental and non-governmental initiatives aimed at enhancing livelihoods and food security could facilitate the conditions for smallholders in producing a variety of dairy products. Finally, recognizing the selling price per liter for buttermilk at competitive prices is crucial for sustaining production and improving the livelihoods and nutrition of smallholders in the area. The study conducted by [9] also identified rising demand, stakeholder involvement, and dairy cooperatives as opportunities in Northern

Ethiopia, while poor hygiene, housing issues, and lack of technology were noted as constraints in buttermilk processing.

Table 11: Constraints related to marketing and processing of Buttermilk

Constraints related to buttermilk market			Constraints related to Buttermilk processing		
	Index	Rank		Index	Rank
Seasonality of demand	0.61	1	Low milk yield for processing	0.35	2
Low amount of raw milk	0.12	2	Poor market infrastructure	0.08	4
Limited access to market	0.08	5	Shortage of labor	0.02	5
Limited shelf life	0.10	3	Time taking	0.15	3
Low price of buttermilk	0.09	4	Unavailability of small scale processing equipment	0.39	1

2. CONCLUSIONS AND RECOMMENDATIONS

The goal of the current study is to examine postharvest handling practices, utilization, marketing, and processing of traditionally produced buttermilk in Sidama regional state, Ethiopia. The study noticed that mostly animals and their products served as major source of income in study area for participants. Conventional buttermilk equipment employed for handling were not food grade which cannot be the most hygienic, affecting the quality of the end product. Washing hands and equipment and utilizing plant materials for cleaning and smoking-handling devices, all of which are perceived to improve product quality and flavor, are important handling practices mentioned by surveyed participants. In this context, *Olea Africana* was notably used for smoking equipment to improve flavor. In the region, buttermilk is an important dairy product that is mostly consumed from household sources and valued for its nutritional importance thus boosting the food security. In addition to being consumed, it served as the source of income through sales majorly employing informal market where women takes lion share for product selling. The study stated that although smallholders were limited by certain constraints in marketing and processing of buttermilk, the product was preferably consumed throughout the region. Seasonality of demand was top ranked marketing constraint followed by low amount of raw milk, limited shelf life, low price, and limited market access whereas lack of small-scale processing equipment, low milk yield, time-taking processes, poor market infrastructure, and shortage of labor were

identified as processing constraints though the area equipped with enthusiastic opportunities. Thus, according to the current finding, gender-inclusive training and interventions to identified constraints should improve and standardize available practices across the smallholders thus enhancing smallholders' livelihoods and boost nutrition.

Ethical approval: The study protocol was reviewed and approved by the Haramaya University, School of Animal and Range sciences ethical committee in accordance with the guidelines and regulations set forth by 1964 Helsinki declaration and its later amendments.

Consent to participate: Verbal consent was obtained from involved participants prior to the start of the survey. The participants were informed about the importance of the information they would provide, assured of the privacy of their responses, and undoubtedly told about their autonomy to withdraw from the research at any time.

Data availability: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of competing interest: The authors declare that they have no competing financial interests.

CRedit authorship contribution statement: AY: Conceptualization, research, formal analysis, data gathering, data analysis, writing the original draft, reviewing, and editing; ME: Planning, supervision, directing, reviewing, and revising; TW: Conceptualization, supervision, reviewing, and editing; TB: Planning, supervision, directing, reviewing, and revising; UG: supervision, reviewing, and editing; FK: Planning, supervision, directing, reviewing, and revising; DA: supervision, reviewing; All authors reviewed the results and approved the final version of the manuscript.

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Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the authors used Quillbot for manuscript to paraphrase, rewrite, and improve their text. The authors reviewed and edited the output as needed and take full responsibility for the content of the published article.

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