ORIGINAL ARTICLE

Butter production, processing and handling practices at smallholders level in the central highlands and southwest midlands of Ethiopia

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ABSTRACT

Cross-sectional study of smallholder butter production, processing and handling practices was conducted in the central highlands and south-western midlands of Ethiopia. Semi-structured questionnaire was pre-tested and used for data collection and 532 respondents were purposively selected and interviewed. Statistical Package for Social Sciences and SAS were used to analyse the data. Results show that, women were entirely responsible for butter production and handling and the produt is mainly used for income generation, flavouring of locally made foods and stews and hair dressing in the study areas. Amount of raw milk fermented for butter making at a time (7.16 ± 2.43 litres), fermentation time (3.92 ± 0.71 days), churning time (2.12 ± 0.21 hours), quantity of butter produced (0.49 ± 0.01 kg), butter sold /week (0.49 ± 0.02 kg) and butter used for different purposes (0.28 ± 0.06 kg/week) varied significantly ($P< 0.05$) between the sites. Local butter preservation methods include ghee making, salting and spicing are major ones. PHL of butter occurs in the study areas due to different reasons. Copying mechanisms to mitigate the loss includes use of umbrella to shield butter from direct sunlight and heat while traveling to and in the local markets, storing butter for overnight in buckets of cold water before transporting butter to local markets. Processing, storage, and packaging materials (clay pots and gourds) used for local butter, handling and preservation practices such as spicing and salting were not optimized. Cost-effective strategies can be applied to optimize the current practices to supply adequate, better quality and safe butter. There is a need of dairy processing technologies and dependable marketing systems in the rural areas. It is also vital to assure the safe production, handling and delivery of local butter by creating awareness to the smallholder butter producers.

Keywords: butter, central highland, Ethiopia, handling, production, marketing, southwest midland

INTRODUCTION

Butter is defined as the semi-solid white/ yellow emulsion of fat, air and water made exclusively by churning of milk or cream or both with/without addition of colouring materials and salt; contains not less than 80% by weight of milk fat (Robert and Marianne, 2009). Butter is traditionally produced and consumed in many African countries (Almaz et al., 1999). It can also be categorized as cultured or sour cream butter made from bacteriologically soured cream (Mallia et al., 2008). But, in Ethiopia, butter is made from spontaneously fermented milk (O'Connor, 1995; Gebremedhin et al., 2014; Debela et al., *2016*) from cow milk for preparing different traditional diets and for hair dressing purposes. Milk for churning is accumulated for three to four days by adding fresh milk to milk stored in a clay pot or gourd and is left for spontaneous fermentation (O'Connor, 1995; Debela et al., 2016). Fermented milk is thoroughly mixed with a wooden stick and churned in a gourd/clay pot at about 70% of its holding capacity (O'Connor, 1995). Butter grains are formed and float in the water-based portion called buttermilk. The buttermilk is then drained; grains are then pressed and kneaded together (Gebremedhin et al., 2014) to make the final butter.

About 98% of milk products in Ethiopia come from the informal production system through informal markets (Tsehay, 1998). Dairy products form part of the diet of many Ethiopians consumed either in fresh (48%) or fermented forms, 47 % is used for butter making and only 5% is marketed (Shapiro et al., 202017). About 62% of the total milk produced in Ethiopia is converted in to butter (Gebremedhin et al., 2014).

The production of quality dairy products begins on the farm and continues through processing. However, in most cases, under smallholder producers conditions production of clean milk is difficult due to poor dairy cattle barn, poor personnel hygienic conditions, insufficient udder washing, inaccessibility of clean water, inadequate sanitation and hygein local vessels, and lack of cold storage facilities. Thus, all factors contribute to production of poor quality milk and subsequent poor quality products including butter. In the traditional butter making, microbial contamination can also come from unclean working surfaces, the butter maker, the churn and storage vessels and the wash water (Abebe, 2018). Storage and packaging materials such as leaves of different plants, local vessels and churners can also represent important sources of contamination of butter. Moreover, market places are open dusty or muddy fields with crowds of people and high risks of cross contamination by microorganisms and dominated by unlicensed operate, low cost of operation, and no regulation of operations ((O" Connor, 1995; Abebe, 2018).

On the other hand, in the country, there is an increase in population pressure and demand for butter and other dairy products. The study locations represent high and mid altitude areas with high dairy potential milk shed supplying butter to the central and southwestern midland markets, respectively. However, there are limited research findings on the production, handling, and processing of butter in these areas. Therefore, assessment of the production, processing, and handling systems is important in the application of cost-effective strategies to supply adequate, better quality and safe butter. Hence, the objective of this study was to assess the production, handling and processing of butter by smallholder producers in Wolmera District in the central highlands and Kersa and Mena Districts of the southwest midlands of Ethiopia and to recommend possible interventions to address the key constraints.

MATERIALS AND METHODS

Description of the study areas

Description of the study areas is presented in Fig 1. A cross-sectional study was conducted in the central highlands (Wolmera District) and south-western midlands (Kersa and Mena Districts) of Jimma zone in the south western midlands of Ethiopia. The locations were characterized as high potential dairy production areas supplying butter to central and south-western midland markets, respectively.

Wolmera district is one of the districts in the special zones of Oromia National Regional State surrounding Addis Ababa, the capital city of the country. The district experiences bimodal rainfall, with a short rainy season from February to April and a long rainy season from mid-June to September. The range of annual temperature and rainfall are 18–24°C and 1000–1100 mm, respectively (Wolmera district Agricultural Office personnel communication, 2019).
Kersa district is located in the Jimma zone of Oromia National Regional State, 355 kilo meters to the southwest of Addis Ababa. Its altitude ranges from 1740-2660 meters above sea level. It is characterized by a tropical highland climate with heavy rainfall and long rainy season. The mean annual rainfall and temperature are 1200-2500 mm and 11-22.5°C, respectively (Kersa district Agricultural Office personnel communication, 2019).

Mena district is located in the central part of Jimma zone. It lies between 1,470-2,610 meters above sea level. The mean annual temperature and rainfall ranges are 13-24.8°C and 1,467mm, respectively (Mena district Agricultural Office personnel communication, 2019).

Sampling

A cross-sectional study was conducted using semi-structured questionnaire to collect qualitative and quantitative data using mixed methods research design (Creswell and Clark, 2011). The mixed method approach was used to provide a richer and more detailed set of data, and allowed to ask questions in details to draw more information. The questionnaire was pre-tested during the pilot phase. Purposive sampling technique was used to identify high-potential 'kebeles' (lowest political administration structure in Ethiopia) in each district. In Wolmera, out of 26 'kebeles' four were selected for the study.

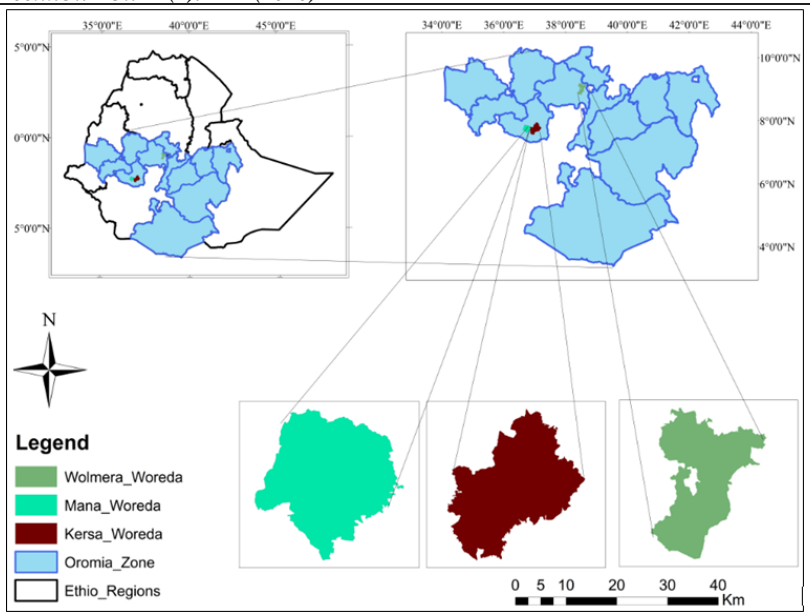

Figure 1. Study sites in the central high lands and south western-mid lands of Ethiopia

A total of 75 households/'kebele' owning at least one milking cow, producing butter and having experience in butter production and handling were randomly selected and individually interviewed. In Mena districts (Bebela kusa, Erguye and Haro) and in Kersa (Shewa Tottobi, Bulbul and Gelo) 'kebeles' were randomly selected for the study. In the two latter districts, 39 households per 'kebele' were randomly selected for the interview using identical procedure as that of Wolmera. The sample size was determined using the following equation,

$no = \frac{z^2 * p * q}{d^2}$ (Singh and Masuku, 2014).

where, $n_{o=}$ desired sample size, z=standard normal deviation (1.96 for 95% confidence level), P=0.5 (proportion of population to be included in sample/respondents. i.e. 50 %), q = 1-P, i.e. (0.5), the proportion of population to be included into the sample/ respondents were considered to be 50 % because very limited research was previously undertaken on butter production and handling practices in the study sites. Hence, it was assumed that there is a large population; but the variability in the proportion of the population that locally produce and handles local butter was unknown. Therefore, maximum variability was considered (p=0.5), d=desired degree of accuracy level of precision (0.05). Accordingly, each respondent were purposively selected from each 'kebele' and calculated for each study site (Singh and Masuku, 2014). Based on the above equation, the number of respondents per site equals 384. During the interview, there were some non-responses due to unwillingness of the respondents to participate in the interview; and this was later compensated by the multi-location approach. Altogether, from Wolmera (300), Kersa (118) and Mena (114) districts, totally 532 producers were selected and interviewed Women smallholder producers were mainly selected from the three districts and individually interviewed face to face.

During the execution of the research, the Ho (null hypothesis) stated that there are certain limitations in local butter production, processing and handling practices among respondents in study populations. Whereas, the alternate hypothesis (H1) stated that there were no imitations in the local butter production and handling techniques among the existing local butter production and handling practices in the study populations.

Data was collected on the scio-demographics of the study population, purposes of local butter, reasons for making butter, traditional butter making procedures, frequency of butter making, handling and preservation practices, spices used for local ghee making, and post-harvest losses of local butter and their mitigation strategies. The cost of butter produced and used for sales, consumption at house hold level and for hair dressing was estimated by considering the estimated amount of butter produced and used for each purpose and the actual price of butter in each site during the data collection.

Statistical analysis

The data were cleaned and analysed using SPSS (statistical package for social sciences) (SPSS, 2016). Percentages, chi-square tests and p values were calculated using the non-parametric tests to reject or accept the hypothesis. The set hypothesis was tested as follows. The expected values were calculated; the observed and expected values were used to calculate the chi-square test statistic. The level of significance was established at 95% confidence interval where p =0.05. Using the number of degrees of freedom and chi-square statistic the critical value from the table were compared. Finally, decision about the hypothesis was made. Analysis of variance was conducted to compute the means, standard deviations and the differences between the quantities of milk products used in butter making and utilization. The levels of significance were compared at 5%. Least significant difference (LSD) test was used for mean separation (SAS, 2009).

RESULTS AND DISCUSSION

Socio demographic characteristics of the study populations

The result of socio demographic characteristics of the study sites is indicated in Table 1. The sex of respondents in the study areas was 100 % female in Kersa and Mena, and 98 % in Wolmera. Overall, only 0.67% of the study population were male. Another study conducted in Damot Woyde district of Southern Ethiopia on the assessment of butter marketing system in the supply chain also revealed that 85 % of the respondents were female. The same report also revealed that in Southern Ethiopia women are entirely engaged in butter processing and marketing (Amistu et al., 2016). Besides, the current result is in agreement with a study report from Wolmera by Alganesh et al. (2016) that revealed that 80 % and 13.3 % of dairy products processing, handling and transportation activities are conducted by women and their daughters, respectively. The current report implied that butter production and handling is entirely the role of female and that was why it was necessary to purposively select and interview the women smallholder farmers for the study.

Age categories of the respondents showed that 20, 66 and 14 % were 18-30, 31-45 and 46 years and above years old, respectively for Kersa districts. In same order, the age categories of respondents in Mena district were 14 56 and 30 % were in the ranges of 18-30, 31-45 and 46 and above years old, respectively. Similarly, in Welmera, the age categories of 20 , 45 and 35% of the study population were 18-30, 31-45 and 46 years and above old, respectively. There were 18, 55.67 and 26.33 of 18-30 years, 31-45 years and 46 and above years of age, respectively. From the result it can be observed that the majority of the respondents who are engaged in the butter production, processing and handling were in the age category of 31-45 years, productive age group. The current finding is in agreement with similar study conducted in Dire Inchini area of Ambo zone by Debela et al. (2016) where 59.09% of respondents represented productive age group of 19-59 years of age. Similar result was also reported from Southern Ethiopia in Damot Woyde district where 88.3% of the respondents were in the age range of 31-35 years. Another survey report by Kasahun et al. (2018) also revealed that the majority of respondents involved in dairy products handling are in the average age of 43.1±2.9 years of age.

The educational status of the respondents in the study areas was 72, 24, 1.3 and 2.7 % were illiterate, attended elementary schools, secondary schools and Diploma holders and above, respectively in Kersa. While in Mena 68, 25, 6 and 1 % were illiterate, attended elementary schools, secondary schools and diploma holders and above, respectively. In Wolmera district, 74, 21, 4 and 1% of the study population were illiterate, attended elementary schools, secondary schools and diploma holders and above, respectively. The overall result of educational status of respondents in the three study sites were 71.33 % illiterate, 23.33 % attended elementary schools, 3.77 % of them attended secondary schools and 7 % diploma holders and above. In the three study sites, the majority of respondents were illiterate followed by those who attended elementary schools. While the proportion of those who attended secondary schools and diploma holders and above were very low. The current report is different from a report by Belay and Janssens (2014) who reported that the majority (35.5%) of respondents in Jimma town had college level education, while 24.1 % and 7.4% had senior secondary schools and university level education, respectively. The difference might be due to the fact that urban residents have better access to education than rural dwellers. Similar report by Amistu et al. (2016) revealed that 75% of the respondents in Damot Woyde district of Southern Ethiopia were at a level of education of 5-8th grades. The same report from southern Ethiopia also revealed that 13.3% and 11.7% were at certificate and diploma levels, respectively. Another similar study by Bilatu et al. (2018) also revealed that 2, 5.7, 6.1, 25.5, 27.7, 14 and 19% were at education levels of degree and above, diploma holders, certificates, secondary schools, elementary schools complete, can read and write and illiterate, respectively. The majority of the respondents in the current report are illiterate and the high level of illiteracy has negative impact on butter production, processing and handling in terms of production and delivery of safe and quality product in the supply chain. This could be associated with the fact that rural communities in the country have generally less access to education, but it is usually their culture to rear cattle and produce dairy products including butter.

Handling practices of vessels used for fermentation of milk and churners

The chi-square test results of handling practices of vessels used for fermentation of milk and churners are indicated in Table 2. Accordingly, use of hot water, smoking with chips of woods and rubbing with aromatic herbs showed significant difference at $p<0.05$.

There was no significant difference in the chi-square test of washing the vessels and churners using hot water, detergents and smoking using chips of wood. Similarly, there was significant difference ($p<0.05$) between washing of milk vessels and churners using cold water and smoking using chips of woods. According to the respondents, from Kersa (65%), Mena (53.5%) and Wolmera (71.1%), cleaning of vessels used for milk fermentation and churners was done using hot water. In the study areas, only 1/5th of the producers from Kersa and fewer from the two districts indicated that milk containers are cleaned using hot water and detergents before and after milking. Milk vessels and churners were commonly cleaned before and after milking using cold water and detergents according to 1/3rd of the respondents from Mena, Kersa (31%) and only 8% of respondents from Wolmera.

Table 1. Socio demographic characteristics of small holder butter producers in the study areas

Variable	Kersa N=118 (%)	Mena N=114(%)	Welmera N=297(%)	Overall N(%)
Sex of respondent				
Male	-	-	5(2)	5(0.7)
Female	118(100)	114(100)	292(98)	524(98.3)
Age of respondents				
18-30 years	24(20)	16(14)	59(20)	99(18)
31-45 years	78(66)	64(56)	134(45)	276(55.7)
46 and above years	16(14)	34(30)	104(35)	154(26.3)
Educational status of respondent				
Illiterate	85(72)	77(68)	221(74)	383(71.3)
Attended elementary school	28(24)	29(25)	61(21)	118(23.3)
Attended secondary school	2(1.3)	7(6)	12(4)	21(3.8)
Diploma holder and above	3(2.7)	1(1)	3(1)	7

N= Number of respondents

Use of hot water for washing milk vessels and churners can potentially reduce the risks of contamination in the dairy products in two ways. Heating/boiling the water can reduce contamination level that from water borne pathogens and it can also facilitate through cleaning of milk vessels and churners compard to cold water.

All respondents in the study areas indicated that smoke from burning of chips of wood of *Olea africana* and rubbing vessels with herbs of *Ocimum hardiense* are used to give desirable aroma and flavour to butter. The equipment handling practices and techniques used to clean milk vessels and churners observed in the present study are similar to a report by Sale et al. (2018) where respondents in East Gojam smoked milk vessels to improve the taste and flavour of milk products (76.1%), reduce microbial spoilage (16.6%) and improve fermentation process (7.3%). Lemma (2004); Mekdes (2008) and Eyasu and Asaminew (2014) also reported that herbs and plant-based smokes are used for cleaning and flavouring purposes.

Purposes of butter in the study areas

More than 23% of the respondents reported that butter was used for cooking of traditional stews, porridge, 'Chachabsa' and other types of traditional foods as indicated by some proportion of respondents in Kersa and Mena, and about 1/3 of the respondents in Wolmera (Table 2). 'Chachabsa 'is a traditional pancake made from unleavened dough of red varieties of *Eragrostis tef*. The pan cake is chopped and mixed with freshly made traditional ghee made from freshly made butter and salt; and is served as breakfasts or snacks with or without fermented milk'. 'Chororsa' (Soft cheese on which mixture of clarified butter and 'kochkocha' (green paper, herbal spices, tubers of ginger and garlic are mixed together and ground with some salt) served with Ethiopian flat bread (Tef injera), 'Qori' (Roasted barley seeds mixed with traditionally spiced ghee), porridge, 'chiko' (traditional food made of roasted barley powder, where barley powder is thoroughly mixed with fresh traditional ghee, salt and *Aframomum korarimao),* 'zilch' (Roasted or boiled maize green seeds are mixed with freshly made traditional ghee, salt and served hot and fresh), 'quince' (Traditional snack made from boiled grinded wheat, barley or oat seeds and mixed with traditional ghee; onions carrots and other vegetables can also be fried and served with 'qinche') and 'anababro' in Amharic or 'bidden walitti gombifamee'. This type of local food refers to traditional Ethiopian flat bread made from unleavened red *Eragrositis tef* dough. Spiced butter, red hot paper or green ground pepper and salt are mixed with ghee and smeared on the flat bread and served (Alganesh and Tola, 2017). Some of these traditionally prepared foods are unique to the study areas. The respondents stated that the trend of use of butter to prepare the above mentioned traditional foods had declined due to shortage of butter and consequent increased cost of butter. Up to 55% of the respondents reported that butter was also produced and sold for income generation. Income from butter sales was used to purchase other inputs for family members. A lower proportion of respondents in the three districts indicated the use of butter for cosmetic purposes.

Eyasu and Asaminew (2014) also reported that butter is used for cooking, income generation and hair dressing mainly by the female members of household in north-western Ethiopia. Zelalem et al. (2011) also showed that according to the respondents, butter is used for home consumption (87%), income generation (10%) and other purposes (3%) in Ethiopia. Some respondents from Wolmera district also indicated that butter was added to coffee or tea and drunk to get relief from common cold and coughs. Fresh butter is fed to children of weaning age and the elderly for its laxative effects. This practice was also reported from Borena areas of Ethiopia by Yonad (2009) freshly made butter that is packed in leaves is sold in very small quantities for cosmetic purposes and often used for hair dressing. Butter was used for hair dressing by children and women and seldom by men as a headache treatment in the study areas. The respondents indicated that they believed that butter for hair dressing promotes hair growth and relieves headaches. This aligns with reports of Zelalem et al. (2011) and Abebe et al. (2014). In the current report the respondents also indicated that butter is also used as ointment on skins and for treatment of wounds. Ghee that is stored for long time is used to treat chronic coughs.

Table 2. Hygienic practices of vessels used for fermentation of milk and churners and purposes of butter

Variable	Kersa N= 118	Mena N= 114 (%)	Wolmera N= 298	
Do you clean vessels used for milk fermentation and churners using hot/cold water, detergents and smoke using chips of woods?				
Washing with hot water, smoking and rubbing with aromatic herbs				X2 (p)
Yes	77 (65)	61 (54)	21 (71)	21.64(*)
No	41 (35)	53 (46)	86 (29)	
Washing with hot water, detergents and smoking with chips of woods				160.86 (NS)
Yes	24 (20)	17(15)	38 (13)	
No	94 (80)	97(85)	260 (87)	
Washing with cold water and smoking with chips of wood				
Yes	18 (15)	35 (31)	23 (8)	189.36(NS)
No	100	79 (69)	275 (92)	
Purposes of butter (%)				
Flavouring of locally made stews	31(26)	26(23)	83(28)	
Flavouring of locally made snacks	14(12)	22(19)	83(28)	
Income generation	65(55)	57(50)	119(40)	
Hair dressing	8(7)	9(8)	13(4)	

Percentages in parentheses; N= Total number of respondents, X2 (p) represents chi square and p values, respectively. N (%) represents number of respondents and their percentages across columns, p values were declared significant (*) at 95 % confidence interval, NS=non-significant difference

Types of churners used for making butter

In Kersa district, 37% of the respondents indicated that clay pot churners were used for butter making. While more than 60% of them indicated that gourd (Lagenaria siceraria) churners were used for the same purpose (Fig. 2). In Wolmera, 96% of the respondents reported that clay pot churners were used for butter making while only 4% of the respondents indicated that they used electrical and improved manual churners. In Mena, all respondents reported that gourd churners were used for making butter. Different types of local churners are used across the country. Abebe et al. (2013); Debela et al.(2016) and Yayeh et al.(2017) reported that clay pots are used for storage and fermentation of milk until desired volume is collected for processing. Respondents indicated that clay pots were more suitable than bottle gourds for rocking (shaking) on the floor for churning. Tseday and Bereket (2016) also confirmed that 40% and 4.2% of smallholders in southern Ethiopia used clay pots and gourds for churning, respectively. While, in Gurage zone only clay pots were used for churning (Abebe et al., 2013). Traditional churning method is generally time consuming, labour intensive and results in loss of high fat in butter milk (Abebe et al., 2018). Besides, local churners are not easy to clean and sanitize, they form biofilms and easily harbour microorganisms (microorganisms affects the safety and quality of dairy products), and they are delicate and mostly operated by women thus increasing the work burden of women. The current result implies that there is a need for introduction of improved churners in the study areas.

Processing of milk in to butter, costs of butter used for different reasons and reasons for making butter at household level

The results of processing of milk into estimated costs butter, purposes of butter used for different purposes and reasons for making butter at household level are presented in Table 3. In Kersa (7.53 ± 2.49 litres), Mena (6.39 ± 1.96 litres) and Wolmera (7.56 ± 2.83 litres) areas there was significant differences ($p < 0.05$) in the volume of fermented milk used for butter making. There was also significant difference ($p < 0.05$) in the fermentation time of whole milk (days) in Wolmera. While, the fermentation time of whole milk in Kersa and Mena did not differ significantly ($p < 0.05$) between the sites. The average fermentation times of whole milk in Kersa, Mena and Wolmera were 3.71 ± 0.71, 3.49 ± 0.54 and 4.56 ± 0.89 days, respectively. The duration of churning was differ significantly ($p < 0.05$) among the study sites. Churning time in Kersa (2.00 ± 0.187 hours) and Mena (1.48 ± 0.191 hours) were not significantly different ($P < 0.05$) from each other except for that of Wolmera (2.891 ± 0.249 hours).

A report by Belete (2006) from Fogera area aligns with the average fermentation time reported in the current study. In Jimma town, 86% of respondents indicated that the average time for fermentation of milk was three days and one week according to few respondents, respectively (Belay and Janssen, 2014). The duration of spontaneous milk fermentation depends on the quantity of back slop used, temperature of milk storage and season of the year. Fermentation time becomes longer during the rainy season compared to dry season.

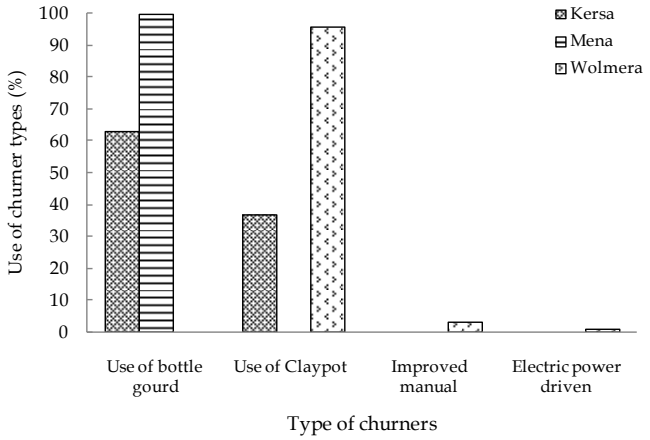

Figure 2. Types of churners used to produce butter by smallholder producers

Churning time of fermented milk in the current study coincides with a report of Mekdes (2008) in the southern Ethiopia (91.8 ± 4. 6 minutes and 69.9 ± 2.3 minutes, respectively) and Sale et al.(2018) (1.9 ± 0.04 hours). Churning time depends on the volume of milk churned and temperature during churning. If it is too cold, butter formation is delayed and butter grains become small and difficult to handle. If the temperature is too high, the yield of butter is reduced because a large proportion of the fat remains in the buttermilk and the butter becomes spongy and of poor quality (O'Connor, 1995). Sour milk should be churned between 10 and 12°C and 14 and 17°C in the hot and cold seasons, respectively (Gebremedhin et al., 2014). Churning duration also depends on the level of acidity of milk to be churned. The shorter churning time reported in the south-western midlands might be due to warmer temperature in Kersa and Mena areas compared to the cooler temperature in Wolmera district.

There was significant difference between the amounts of butter produced in the three districts ($p < 0.05$). In Kersa, 0.338 ±0.10 kg of butter was produced from 7.530 ± 2.49 litres of fermented milk. In Mena, 0.290 ± 0.010 kg of butter was produced from 6.390 ±1.96 litres of fermented milk and in Wolmera district 0.423 ± 0.134 kg of butter was produced from 7.56 ± 2.83 litres of fermented milk. There was significant difference ($p < 0.05$) in the quantity of butter sold for income generation between Wolmera (0.672 ± 0.019 kg/ week), Kersa (0.421 ± 0.014 kg / week) and Mena, (0.391 ± 0.014 kg / week). But the quantities of butter sold in Kersa and Mena did not differ significantly ($P<0.05$). The estimated price of butter sold in the three districts significantly differed from each other (63.114 ± 2.290, 62.526 ± 2.330 and 108.507 ± 3.040 Ethiopia Birr/week in Kersa, Mena and Wolmera, respectively). There was also significant difference ($P < 0.05$) between the total costs of butter produced and used for different purposes in Kersa (115.93 ± 3.94 ETB), Mena (107.93 ± 4.01 ETB) and Wolmera districts (256.92 ± 5.23 ETB). These results agree with Sintayehu et al. (2008).

The quantity of butter sold for income generation in Wolmera was higher than that of the two districts. This might be due to the proximity of Wolmera to the central market as compared to Kersa and Mena which are located far away from the central market. The income from sales of butter in Wolmera was nearly double of that in Kersa and Mena districts. This might be due to the proximity of Wolmera to the central market where there are more consumers. The current study found that a higher quantity of butter was used for home consumption than that sold for income generation. Asfaw (2009) showed that in Arsi zone, the average monthly per capita consumption of butter/ household and per capita utilization of butter for hair dressing was 0.44 kg. An average of 0.11 kg of butter was consumed/household/ week in southern Ethiopia (Tseday and Bereket, 2016). While, the average quantity of butter produced /household/ week in Ambo zone was 0.44 kg, of which 34.1% was consumed at home and 65.9% was sold (Debela et al., 2016).

Butter making is based on traditional practices. The average volume of batch of fermented milk for butter making in the current study was slightly less than quantities reported by Tegegne et al.(2013); Gebremedhin et al.(2014) and Debela et al.(2016) which were 9.05 ± 0.31, 10 and 7-10 litres, respectively. The volume of a batch of fermented milk depends on the quantity of fresh milk accumulated which is affected by number and genetics of milking cows, availability of feed and quantity of milk consumed and sold.

Smallholder farmers in the central highlands process fresh milk in to butter and other products. This is supported by Zegeye (2003); Gebremedhin et al. (2014) that revealed that in rural areas fresh milk is mostly processed into butter. The amount of butter produced/batch in Wolmera was almost three-fold of that produced in the two districts. The quantity of butter produced in the current study parallels with Debela et al. (2016) of 0.44 ± 0.01 kg of butter produced in western Shewa. Butterfat recovery as butter also depends on milk acidity, churning temperature, degree of agitation and extent of filling of the churn (O'Connor, 1995).

Reasons for butter production

The result of chi-square test of reasons for butter production showed significant difference (P<0.05) between the three study sites (Table 3). But, there was no significant difference (P<0.05) in the chi-square results of butter production for product diversification at the smallholder producers level in the three sites. Milk was processed in to butter and other products due to absence of market for fluid milk according to the respondents from Kersa (60%), Mena (59%) and Wolmera (27%) districts. More than 15% of the respondents in all sites indicated that milk was processed in to butter for the purpose of product diversification. Fifty three percent of the respondents from Kersa, Mena (46%), and Wolmera (71%) indicated that milk is processed in to butter and other products in order to use the by-products such as cottage cheese and whey for household consumption and to sell butter for buying household expenditure. The proportion of respondents from Wolmera that produced butter was lower than that in the other two districts. This might be due to the proximity of Wolmera to the central market which enabled the producers to rapidly sell fresh milk. This aligns with Tsegay and Gebre-egziabher (2015) that showed that butter was made for purposes of increased shelf life, value addition and product diversification in Wolaita zone. In East Gojam, 24% and 76% of respondents processed milk to increase its shelf life and for product diversification, respectively (Sale et al., 2018). In the current study, the major reasons for milk processing in Kersa and Mena were absence of market for fresh milk, income generation and production of cottage cheese and whey for household consumption. Product diversification and lack of market for perishable dairy products in rural areas signals a need for dairy processing technologies and dependable marketing systems in peri-urban and rural areas.

Methods of butter preservation, spices used for ghee making and shelf life of local butter preserved using different methods

Butter preservation in the form of ghee is a common practice in different parts of the countery. Different type of spices are used with heat treatment to preserve and extend shelf life of butter. In the study areas respondants use of different types of spices to preserve local butter and improve the flavour of ghee (Table 4). The result of chi-square tests of use of local preservatives for butter preservation showed significant difference (P<0.05) between different study sites. One third of the respondents in Kersa and Mena and over 50% of the respondents in Wolmera indicated that butter was traditionally preserved using different methods. The shelf life of traditionally preserved butter was significantly different (P ≤ 0.05) along the study sites. In Wolmera smallholders indicated that spiced butter and traditional ghee had shelf life of 2.09 ± 1.12 and 2.0 months, respectively. Consumers indicated that spiced butter and traditional ghee had shelf life of 3.06 ± 2.43 and 2.07 ± 1.12 months, respectively. In the south-western midlands, producers indicated that salted butter had shelf life of 2.67 ± 0.22 and 1.21 ± 0.08 months, respectively. Producers indicated that spiced butter has shelf life of 4.15 ± 0.11 and 2.01 ± 0.06 months, respectively, and traditional ghee has a shelf life of 8.53 ± 0.25 and 5.09 ± 0.13 months, respectively. In Kersa (38%), Mena (27%) and Wolmera (58%), respondents reported that local preservatives were used to extend shelf life of butter. The salt and spices used to preserve butter should be clean and of best quality to reduce the risks of contamination of butter. For instance, a report by Alganesh et al. (2018) showed a mean total coliform count of salted and spiced butter of 6.96±0.11 and 6.54±0.05 log CFU/gram of butter, respectively. The same study also showed mean yeast and mild counts of salted and spiced butter of 6.78±0.05and 6.37±0.06 log CFU/gram of butter, respectively. But according to the Ethiopian standard total coliforms should be absent in edible butter and yeast and mold counts should be less or equal to 1 log CFU/gram of butter (ES, 2009).

Traditional ghee making was an important method of butter preservation in the study areas. The respondents indicated that Ocimum hardiense, Aframomum angustifolium, Nigella sativa, Allium sativum, Trachyspermum ammi, Elettaria cardamomum, 'Hagugata', Trigonella foenum and Ocimum spp. were commonly used for flavouring and seasoning during traditional ghee making. Retailers in the central highlands reported that they do not preserve butter that is destined for marketing purpose. In the south-western midlands, smallholders preserved butter used for home consumption by salting, spicing and traditional ghee making. According to the respondents, another means of refreshing butter was to sprinkle water on butter at certain intervals, mixing the butter at the surface with the one at the middle and bottom to avoid surface discoloration.

Previous studies by Yitaye et al.(2009), Eyassu and Asaminew (2014) and Debela et al.(2016) reported shelf life of butter preserved by spicing, salting and traditional ghee making to be 3-18, 3.7 months and 11.1-29 months, respectively. Alganesh et al. (2018) noted that spices, herbs and salt used to preserve butter should be clean to reduce contamination. Mekdes (2008) and Eyassu and Asaminew (2014) also showed that smallholders use traditional preservatives to extend the shelf life of local butter.

The shelf life of butter in the present study is lower than that of previous reports, possibly due to differences in ambient temperature, type and hygiene of packaging materials and hygiene of cleanliness of spices used for butter preservation.

Spices used for traditional ghee making

In Wolmera, *Trigonella foenum (82%), Ocimum* spp. (72 %) and *Ocimum hardiense (63%)* are major spices used for traditional ghee making. While, only some respondents reported that *Aframomum angustifolium and Nigella sativa* are spices used for traditional ghee making. In the same district, very few respondents

indicated that *Allium sativum, Trachyspermum ammi and Elettaria cardamomum* are used for seasoning in traditional ghee making (Table 4). In Kersa and Mena *Elettaria cardamomum, Ocimum hardiense, Aframomum angustifolium, Nigella sativa,* and 'Hagugata' (unidentified) were reported to be commonly used in the traditional ghee making. While, *Trigonella foenum* and *Ocimum* spp. were reported by very little proportions of respondents. The uses of different types of spices are in agreement with previous reports from different parts of the country (Yitaye *et al*., 2009; Debela et al., 2016; Tseday (2018). Traditional ghee is made by boiling locally made butter after which powders of spices, chopped tubers of spices and herbs are added and boiled until foaming is ceased. It is believed that the spices are used to increase the shelf life and impart desired aroma and flavour into the traditional ghee.

Frequency of butter making by smallholder producers

Frequency of local butter production in the study areas depends upon volume of milk accumulated per week and extent of fermentation condition. Frequency of the production varied from one to three time per week (Fig. 3). More than 30% of the respondents indicated that butter was made once, twice and three times a week. In Kersa, 80% and 20% of the respondents indicated that butter was produced twice and three times a week, respectively. In Mena, butter was made twice and three times/week according to 40 % and 60% of the respondents, respectively. The current result aligns with Yitaye et al., 2009; Tsegay and Gebre-egziabher (2015) which indicated that 100% of households produced butter 2-3 times a week. Mekdes (2008) also indicated that 33% and 36% of respondents in southern Ethiopia made butter every day and four times a week, respectively. Sale et al. (2018) from Amhara region showed that 47% of respondents made butter twice a week. The current finding is also in line with Tseday (2018) that indicated that the frequency of butter making mainly depends on the temperature of an area and souring time of milk. In the lowland and midland areas, butter is produced twice a week. In the study areas, frequency of butter making varies across agro-ecological zones. The frequency of butter production depends on the quantity of daily collection of milk, reasons for milk processing, presence or absence of market for fresh milk, quantity of fresh and fermented milk consumed by the farm households and the ambient temperature at which spontaneous fermentation occurs. Besides, the frequency of butter making by smallholder producers depends on the size of production or number of milking cows.

Post-harvest losses of local butter

Postharvest loss of butter can happen in the supply chain from collection of butter to consumpition. The loss can be caused by different factors. Awarness of respondents for presence of the loss and possible reasons for the loss are indicated in Table 5. In study sites, 82.3% of respondents were aware of post-harvest losses (PHL) of butter during production, handling and marketing. While, the remaining proportions of the study population indicated that they are not aware about post-harvest losses of butter. The main reasons for post-harvest losses were discarding portions of butter during storage due to mould growth and discolouration (29.9%) and melting and spillage of butter that is stored at ambient temperature (63.9%). Other reasons of the post-harvest losses includes porosity of local packaging materials (17.7%) (The packaging materials such as 'woficho', gourd and other leaves are porous and absorbs butter, butter can leak and be spilled out from the packages, etc., butter sticking to local churners during churning (33.3%) and inefficient churning resulting in the loss of butter into buttermilk (31.3%). The smallholders minimized post-harvest losses by using umbrellas to shield the butter from direct sunlight and heat during transport and sale in the local markets. Overnight storage of butter in buckets of cold water before transporting butter to local markets was another method used to minimize post-harvest losses. But, this might expose butter to further microbial deterioration from the water. There is need for improved cooling mechanisms for butter to maintain its quality and safety. Improved processing and handling techniques should be used to minimize loss and deterioration of butter.

Table 3. Processing of milk in to butter, purposes of butter and reasons for making butter at household level

Variable	Kersa N = 118	Mena N = 114	Wolmera N = 297	Overall mean
Amount of raw milk fermented for butter making at a time (litres)	7.530 ± 2.49a	6.390 ± 1.96b	7.56 ± 2.83c	7.16 ± 2.427
Fermentation time of whole milk(days)	3.710 ± 0.71a	3.490 ± 0.54a	4.56 ± 0.89b	3.92 ± 0.713
Churning time (hours)	2 ± 0.187a	1.478 ± 0.191a	2.891 ± 0.249b	2.123 ± 0.209
Quantity of butter produced at a time (kg)	0.338 ± 0.01a	0.290 ± 0.01b	0.423 ± 0.134c	0.491 ± 0.011
Quantity of butter sold for income generation (kg/week)	0.421 ± 0.014a	0.391 ± 0.014a	0.672 ± 0.019b	0.494 ± 0.016
Average income from butter sold per week (ETB)	63.114 ± 2.29a	62.526 ± 2.33a	108.507 ±3.04b	78.049 ± 2.553
Quantity of butter used for flavouring stews (kg/week)	0.122 ± 0.054a	0.280 ± 0.055a	0.446 ± 0.071b	0.283 ± 0.06
Cost of butter used for flavouring stews (ETB/week)	10.864 ± 8.611a	45.122 ±8.761b	66.356 ± 11.427b	40.498 ± 9.539
Quantity of butter used for food preparation (kg/week)	0.025 ± 0.008a	0.019 ± 0.008a	0.383 ± 0.011b	0.142 ± 0.009
Cost of butter used for food preparation (ETB/week)	4.258 ± 1.153a	3.087 ± 1.173a	52.75 ± 1.530b	20.032 ± 1.286
Quantity of butter used for hair dressing (kg/week)	0.180 ± 0.015a	0.144 ± 0.015a	0.327 ± 0.02b	0.217 ± 0.017
Estimated cost of butter produced and used/household/week (ETB)	115.932 ± 3.941a	107.930 ± 4.009a	256.918 ± 5.229b	160.260 ± 4.393
Reasons for making butter	Kersa N = 118	Mena N = 114	Wolmera N = 295	X2 (p)
Why do you prefer to process milk in to butter?				
Absence of market for whole milk				5.62(*)
Yes	71 (60)	67 (59)	80 (27)	
No	47 (40)	47 (41)	215 (73)	
Product diversification				131.5(NS)
Yes	29 (25)	31 (27)	46 (16)	
No	89 (75)	83 (73)	249 (84)	
To use the by products for household consumption and sell butter				12.48(*)
Yes	63 (53)	53 (46)	210 (71)	
No	55 (47)	61 (54)	85 (29)	

Means with different superscripts in a row are significantly different (P < 0.05), In July 2019, 1 United States dollar = 28.70 Ethiopian Birr (ETB), Percentages in parentheses; N = Total number of respondents, X2 (p) represents chi square and p values, N (%) represents yes responses and their percentages across columns, p values were declared significant (*) at 95 % confidence interval, NS=non-significant difference

Table 4. Local butter preservatives, preservation methods and spices used for traditional ghee making

Do you use any local butter preservation method?	**Kersa N= 118**	**Mena N = 114**	**Wolmera N= 252**	**X2 (p)**
Yes	45 (38)	31 (27)	145 (58)	13(*)
No	73 (□2)	83 (73)	107 (42)	
Local butter preservation techniques				
Sites/supply chains	Salting	Spicing (Kneading butter with powders of spices)	Local ghee making	
Wolmera				
Producers	0	2.09 ± 1.12a	2.00 ± 0.00 a	
Consumers	0	3.06 ± 2.43b	2.07 ± 1.12 a	
South-western midlands				
Producers	2.67 ± 0.22a	4.15 ± 0.11c	8.53 ± 0.25b	
consumers	1.21 ± 0.08b	2.01 ± 0.06a	5.09 ± 0.13c	

Percentages in parentheses; N = Total number of respondents, Means with different superscript in a row are significantly different ($p \leq 0.05$), X2 (p) represents chi square and p values, N (%) represents yes responses and their percentages across columns, p values were declared significant (*) at 95 % confidence interval

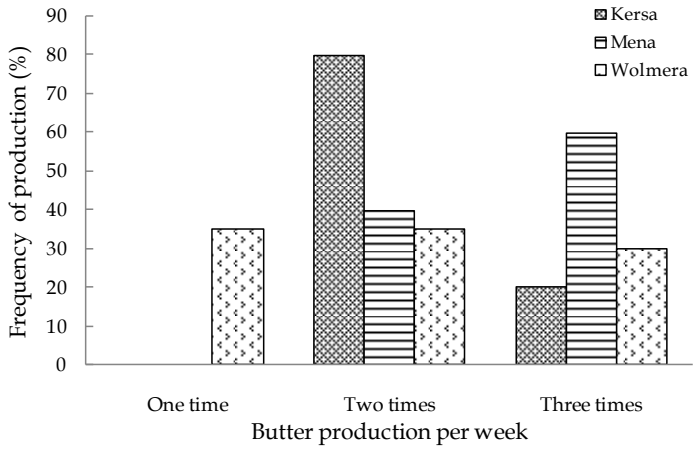

Figure 3. Frequency of butter production per week by smallholder farmers in the three study districts

Gender roles in butter production, processing and handling

In developing countries the roles of gender in production, handling, and marketing of dairy products is significant. According to respondents house wives in a family plays the major role in processing, production and marketing of nutter (Fig. 4). Over 90% of the respondents in all districts reported that production, handling and processing of butter were the responsibility of women. A report by Amistu et al. (2016) aligns with the current finding in that women in Ethiopia are usually responsible for handling and maintaining the quality of dairy products. Yonad (2009) also reported that activities related to dairy products handling are mainly managed by women in Borena areas. In Anderta area of Tigray, wives and daughters play major roles in milk handling and processing (Tsadikan, 2012; Betela, 2015). Sintayehu et al. (2008) also showed that 76.3% of women in mixed crop–livestock production systems were involved in churning and marketing of dairy products.

CONCLUSION

Butter production, handling and processing in the study areas is based on traditional practices. More than 90% of the activities related to butter production and handling are performed by female household members. Butter is mainly produced for income generation, flavouring of traditional stews and foods, and hair dressing. Clay pots and gourds are local churners used for milk fermentation, butter making and storage purposes. Most of the study populations use cold water, detergents such as 'hyjaks' for washing milk and butter vessels and use chips of woods for smoking purposes. Milk is processed in to butter mainly for product diversification and due to the absence of market for fresh milk Traditional methods of butter preservation in the study areas are ghee making, salting and spicing. The respondents indicated that there are significant post-harvest losses of butter in the study areas. Local copying mechanisms such as cooling butter in cold water for overnight before taking to local markets, using umbrella to protect butter from direct sunlight while trekking to and in the local market places are used for

mitigations of PHL. Generally, processing, storage and packaging facilities (clay pots, gourds) and preservation methods were not optimized. Cost-effective strategies can be applied to optimize these practices to supply adequate, better quality and safe butter. The findings implied that there is a need of dairy processing technologies and dependable marketing systems in rural areas. It is also vital to assure the safe production, handling and delivery of local butter by creating awareness to the smallholder butter producers.

Table 5. Post-harvest losses of butter and their reasons according to smallholders

Post-harvest loss of butter	**N = 294**	**X2 (p)**
Is there any quantitative loss of butter during production, handling and marketing?		
Yes	242 (82.3)	68.65(*)
No	52 (17.7)	
Reasons for losses		
Mould growth or discolouration	10 (3.4)	25.03 (NS)
Melting and spillage of butter at ambient temperature	147 (50)	22.68(*)
Butter sticking to local churners during churning	8 (2.72)	10.14 (NS)
Butter sticking to containers and leaves during storage and marketing	119 (40.5)	0.21(*)
Loss of butter into buttermilk during churning	10 (3.4)	3.21(NS)

Percentages in parentheses; N= Total number of respondents, X2 (p) represents chi square and p values, N (%) represents yes responses and their percentages across columns, p values were declared significant (*) at 95 % confidence interval, NS=non-significant difference.

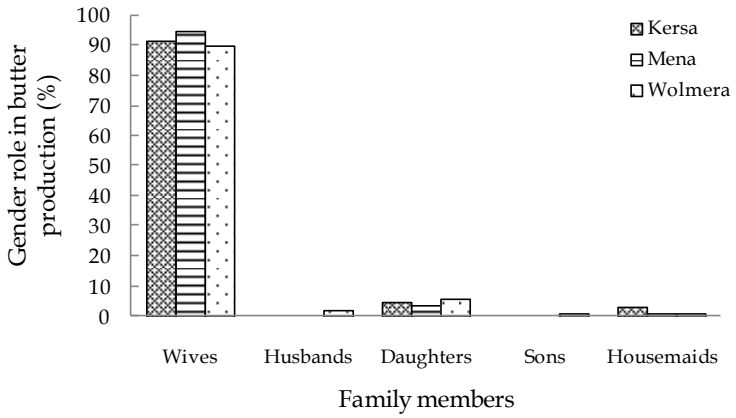

Figure 4. Gender roles in butter production, processing and handling

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