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ASSESSMENT OF RISK FACTORS OF FOOD SAFETY IN LOCAL BUTTER MARKETING IN KERSA, MANA AND WELMERA DISTRICTS OF OROMIA, ETHIOPIA

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ABSTRACT

Risk factors pre-disposing local butter to food safety hazards in the informal marketing system along the supply chain of the central highlands and south-west midlands of Ethiopia were assessed. Purposive random sampling technique was used to select 1101 respondents from the local butter supply chain (532 producers, 107 retailers and 462 consumers). Data were collected using a semi-structured questionnaire developed separately for each category of respondents. Ninety- nine percent of the respondents indicated that butter was stored and marketed at ambient temperature with no cold chain management. Common butter storage materials included high-density polyethylene containers (51%), low-density polyethylene plastic bags (29%) and clay pots (73%). The respondents packed and marketed butter using castor leaves, plastic cups and false banana leaves and lints. Stream, river and borehole water sources were used to wash vessels, churners and fresh butter. However, only 23% of the respondents used tap water for the same purposes. The majority of the respondents trekked on their foot to take butter to local market places followed by the use of horse carts (11%) and three-wheel drives (10%). Itinerant traders and retailers played key roles in the informal supply chain of butter. Overall, there are no standard operating procedures and infrastructures along the supply chain. Thus, local butter supplied to consumers is liable to sensorial, physico-chemical and microbial deterioration and is exposed to risks of food-borne pathogens. The practices endanger the safety and quality of local butter unless stringent quality control measures are taken by concerned regulatory bodies. The objective of the study was to identify risk factors and design intervention to minimize the food safety hazards in butter.

Key words: Food safety hazards, informal market, local butter, risk factors, supply chain

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INTRODUCTION

Butter is a dairy product consumed directly or with other ingredients [1]. It is widely used as a seasoning in cooking, suggesting that it plays an important role in the formation of flavors during heating [2, 3]. In Ethiopia, locally produced butter is also used to treat chronic coughs and as a hair cosmetic. In hair cosmetic products, the local butter serves dual functions of hairdressing and curing headaches [4].

In Ethiopia, butter production accounts for 62% of the total milk production and is mainly produced on small scale farms in rural areas either for family consumption or income generation [7]. Eighty-four percent (84%) of the farm households sell butter for income generation whilst 95 % of marketed dairy products are channeled through an informal trading system. In this system, dairy products may directly pass from producers to consumers or through one or more market agents. The local vendors collect butter from local markets, transport it and sell it to retailers in urban centers [8]. The informal local market system indirectly exposes the butter to food safety risks along the supply chain.

To produce local butter, fresh milk is added in batches into local vessels with partially fermented milk. The milk accumulated over several days is kept at ambient temperature and left for spontaneous (natural) fermentation for up to 3 - 5 days [4, 5]. The naturally fermented milk is thoroughly mixed and churned using traditional churners to separate the butter from buttermilk [6].

Unfortunately, in Ethiopia, the production of local butter is highly dominated by traditional practices under unhygienic conditions. There is no cold chain management during the handling, storage and marketing of the butter. Market places are open, dusty or muddy fields with crowds of people, increasing the risks of cross-contamination by microorganisms. Furthermore, butter markets are constrained by cultural taboos such as abstaining from sales and consumption of dairy products on some days of the week and the short shelf life of the product increases the susceptibility of the butter to deterioration [9]. The informal markets are also characterized by no license to operate, low cost of operation, no regulation of operations, direct delivery of milk products by producers to consumers in the immediate neighborhood and sale to retailers, itinerant traders, and/ or consumers in the nearby towns [7, 10].

Although butter is the most common marketable dairy product in Ethiopia [10, 11], the prices of butter keep increasing, and this subjects the product to different forms of adulteration with foreign materials. In the local market places, buyers use color,

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firmness, absence of adulterants, odor, hygiene, melting quality, texture and consistency of butter to set prices.

In addition to the adulteration, the unhygienic conditions employed during production, handling and marketing could increase the health risk of consuming locally produced better in Ethiopia. Unfortunately, limited research exists on identifying the health risk factors associated with the consumption of local butter in the informal supply chains. Therefore, it is necessary to know the main factors that pre-dispose local butter to contamination by pathogenic and spoilage microorganisms and find effective ways to minimize pre-disposing factors that could cause the deterioration of milk products including butter. Therefore, this study assessed the risk factors associated with the safety of informally marketed local butter along the supply chain and to design possible interventions to address the constraints.

MATERIALS AND METHODS

Description of the study areas

A baseline survey was conducted in the Wolmera district of the central highlands and also Kersa and Mana districts of the southwest-midlands of Addis Ababa (Figure 1). The locations are dairy potential areas supplying butter to central and southwest midland markets, respectively.

Wolmera District: The Wolmera is situated at $8^0$74'34"North latitude and $38^0$97'12"East longitude. The annual temperature and rainfall range from 18°C - 24°C and 1000 - 1100 mm, respectively [12].

Kersa district: The Kersa district is found in the Jimma zone of Oromia region and located at 355 km to the southwest of Addis Ababa. The mean annual rainfall and a temperature range between 1200-2500 mm and 11^0C- 22.5^0C, respectively [13].

Mana district: The mana district lies between 1,470 - 2,610 meters above sea level. The mean annual temperature and rainfall of the district range between 13^0C and 24.8^0C and 1,467mm, respectively [14].

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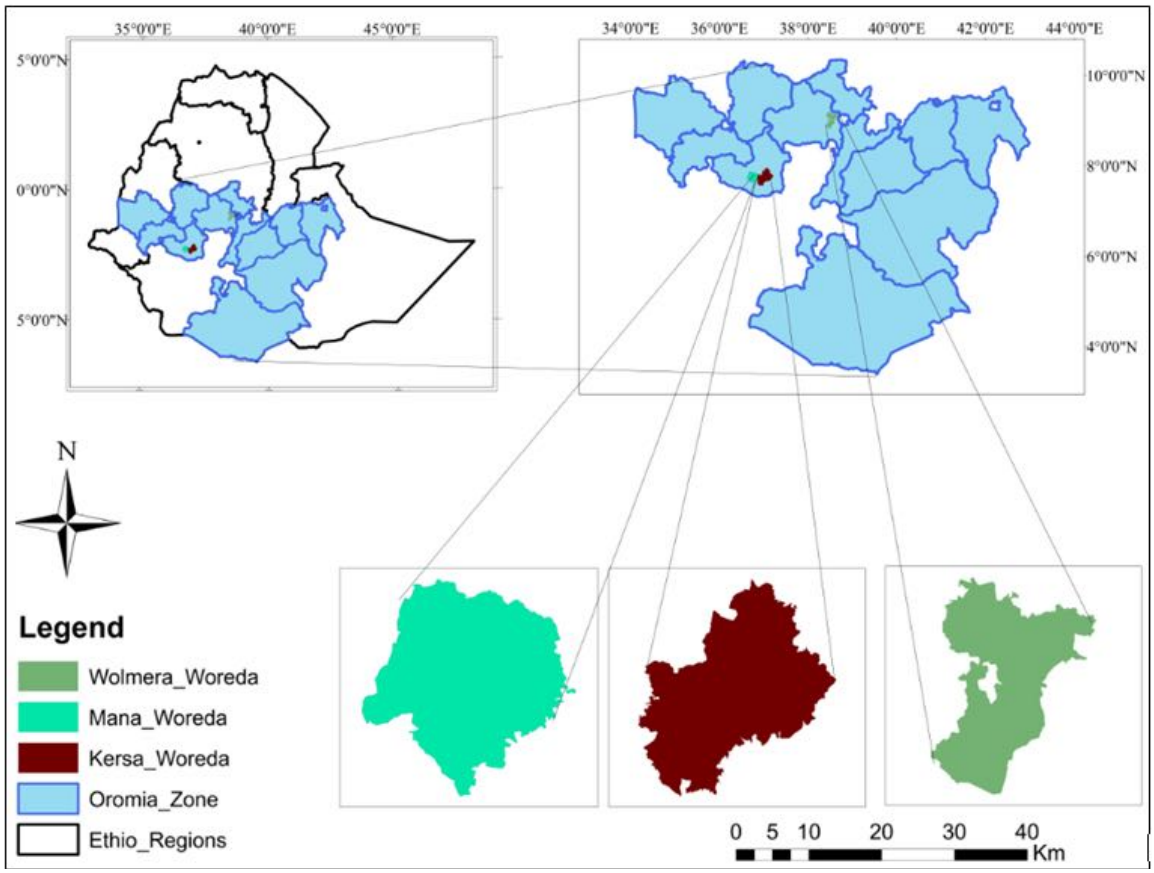

Figure 1: Diagrammatic sketch of the study sites (Drawn by informal communication with EIAR staff)
'Woreda'= District

Sampling Method

A semi-structured questionnaire was used to collect qualitative and quantitative data using a mixed methods research design [15]. The questionnaire was pre-tested during the pilot phase. Purposive random sampling technique was used to identify high-potential 'kebeles' (lowest political administration structure in Ethiopia) and select female smallholder producers and obtain their names from each district and respective 'kebeles'. The required number was obtained by randomly drawing the names of each respondent from the population using a lottery system. The reason for selecting women for the face-to-face interviews was because women are usually engaged in dairy production, handling and marketing activities.

In Wolmera, four 'kebeles' were selected out of 26. A total of 75 households/ 'kebele' owning at least one milking cow, producing and marketing butter were randomly selected and interviewed. In Mana and Kersa, three 'kebeles' each and an average of 39 households/'kebele' were randomly selected and interviewed.

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The sample size was determined by considering the expected prevalence of food safety risks associated with handling and informal marketing of butter along the supply chain and the confidence level to be achieved to meaningfully interpret the estimates. Accordingly, the formula used was

$$no = \frac{z^2 * p * q}{d^2}$$

where, n_0 = desired sample size,
z = standard normal deviation (1.96 for 95% confidence level),
p=0.5 (proportion of population to be included in the sampling),
q = 1-p = 0.5,
d= desired degree of accuracy level of precision (0.05).

The proportions of the population to be sampled were considered to be 50 % because limited research was previously undertaken on risk factors pre-disposing local butter that is informally marketed along the supply chain in the sites. It was assumed that there was a large population, but the variability in the proportion of the population that produces and markets butter in the sites was unknown. Therefore, maximum variability was considered. The number of respondents was proportionally taken from each 'kebele' and calculated for each site [16]. The calculated number of respondents per site was 384. There were a few non-responses due to unwillingness to participate in the interview; and this was compensated by the supply chain approach.

A total of 532 butter producers were selected from Wolmera (300), Kersa (118), and Mana (114) districts for the interview the. Identical sample size determination formula and technique were used to select 107 retailers and 462 consumers from the three sites. The questionnaire focused on the assessment of butter storage conditions, packaging materials, sources of water for washing vessels and fresh butter, supply chains, modes of butter transportation and major market actors. The respondents were also asked to characterize the properties of rancid or aged butter based on their knowledge and attitudes. The properties of aged or rancid butter were characterized by changes such as alteration in odor, color and growth of molds on butter surfaces.

Statistical analysis

The data were analyzed using the SPSS (2016) (statistical package for social sciences). Descriptive statistics were used to calculate percentages and frequencies [17].

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RESULTS AND DISCUSSION

Figure 2 shows data on the sources of water used for washing utensils and fresh butter. More than 60% of respondents in Kersa and Mana and 10% in Wolmera used stream water for washing butter vessels and fresh butter, respectively. Only an average of 23% of respondents from all sites used tap water for the same purpose. In the study sites, most of water used for butter production and washing fresh butter was not hygienic. Wolde *et al.* (2020) indicated that 6% of all tap water bacteriological samples from Addis Ababa were positive for total coliforms (4%) and fecal coliforms (2%). About 35% of respondents from Wolmera stated that bore whole water was used for washing fresh butter and vessels. The same study confirmed that drinking water collected from service reservoirs was positive for 5% total coliforms and 1% fecal coliforms [18].

Small proportions of 5 % and 13 % of respondents, respectively showed rain and river water as the sources of water used for washing fresh butter and vessels. Drinking water collected from springs and wells was positive for 15 and 15 % total coliforms and 9 and 6 % fecal coliforms, respectively [18]. In Jimma, only 25% of the water samples were acceptable with a recommendation of a regular check-up and 75% were either unacceptable or glossily polluted and the presence-absence test also revealed the presence of coliform bacteria in tap water [19]. The WHO indicated that in standard drinking water, total coliform bacteria must not be detectable in any 100 ml of water [20]. The community usually disposes of household wastes and defecates in open fields which can be washed into the collecting chamber or open wells. This practice can cause contamination of water sources and water-related diseases [19].

In the present study, most of the water sources used for washing vessels and fresh butter were not potable and/ not at least treated by boiling. Subsequently, the vessels can be suitable for the multiplication and harboring of microorganisms. Studies suggested various outbreaks of bacterial spoilage in butter have been controlled by the treatment of water used for washing fresh butter. Abebe (2018) showed that in central Ethiopia tap, river, spring and borehole water were used for butter production and handling [9].

In West Shewa, smallholders practiced substandard sanitary procedures during processing and handling which leads to quality deterioration and shortened shelf life of dairy products [5]. Zelalem *et al.* (2011) confirmed that in the central high land of Ethiopia water used for cleaning milk vessels is not clean and can be a

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potential source for contamination of dairy products and can be a threat to public health [4].

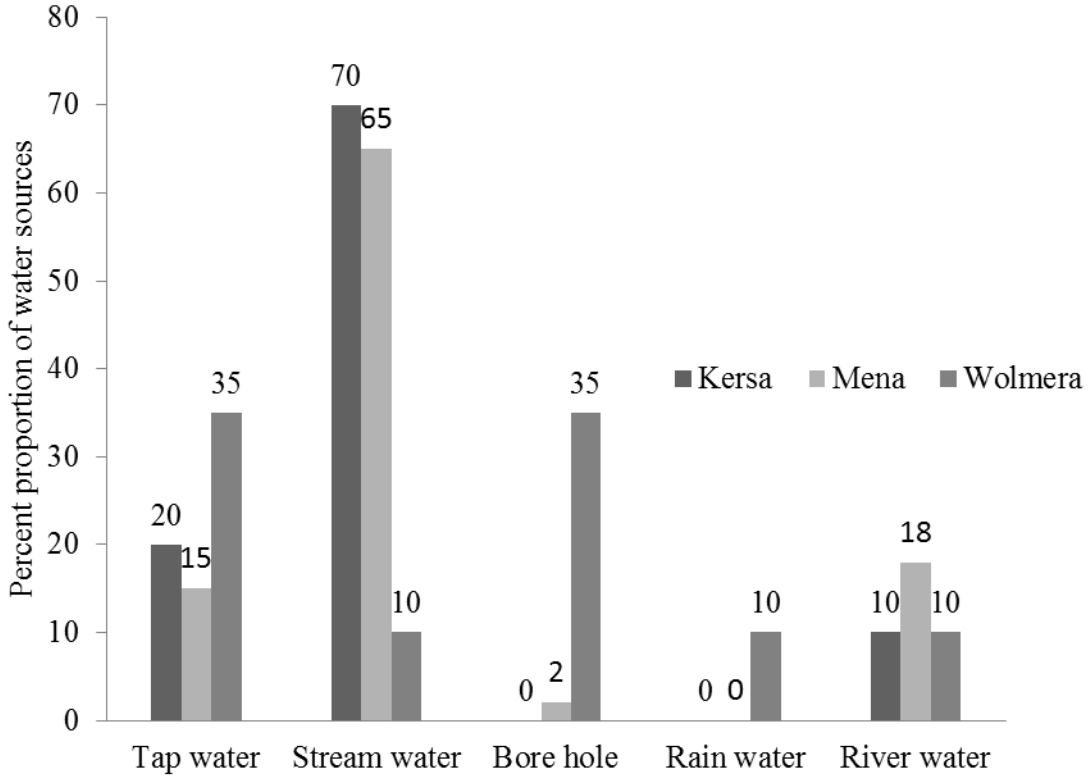

Figure 2: Sources of water used for washing vessels and fresh butter (%)

Storage temperature, practices of adulteration, and local packaging materials used for butter storage

The results of storage temperature of local adulteration, packaging materials during storage and practices of adulteration of butter are shown in Table 1. An average of 46.67 % of respondents indicated adulteration as a possible source of butter spoilage. This is in agreement with reports from Southern Ethiopia and the central highlands that butter that is exposed to any form of adulteration can be exposed to cross-contamination and presents a threat to public health [22, 23].

More than 99% of the respondents in Kersa, Mana and Wolmera, indicated that they stored butter at average annual minimum and maximum room temperatures of 9^0C to 23^0C, respectively. A report from selected areas of central Ethiopia also indicated that 68 % and 30% of respondents stored butter at room temperature and in cold water, respectively [9]. At room temperature, butter can be exposed to the action of different microorganisms which include *Pseudomonas spp., Bacillus spp., Brucella spp., Staphylococcus aureus, Streptococcus agalactiae,*

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Mycobacterium tuberculosis, Enterobacteraceae spp., Listera Monocytogens, Salmonella spp. and mycotoxins [24]. For instance, in Addis Ababa retail butter shops, the presence of Salmonella spp. in butter was confirmed [25].
Storage of butter at room temperature can also be associated with discoloration, off-flavor development and growth of mold on the surfaces. The conditions favor the growth of molds as the packaging materials are porous and there is presence of oxygen. Moreover, when butter is stored at room temperature without cooling, spoilage microorganisms can easily cause deterioration.

High (51%) and low (10%) density polyethylene plastic containers were used for packaging and storage of butter. Only three percent of Wolmera smallholder producers used stainless steel for packing butter. More than 34 and eight percent of respondents used clay pots and thatched woven grass containers, respectively to store butter. The result indicates that almost all respondents used substandard non-food grade materials for packaging of butter. Eighty eight percent of producers in Central and North- West Ethiopia use plastic materials and bottle gourds for butter storage and churning, respectively [22, 26].

Butter that is taken to local markets is packed in castor leaves rinsed using surface water from rivers, springs or rainwater according to more than 64% of respondents. While in Wolmera, an average of more than 23 and 27 % of the respondents described that plastic cups, false banana leaves *(Ensete ventricosum)* and lints are used to pack butter that is taken to local market places. These local materials are cleaned using surface water from rivers or springs or rain water. After packing butter in the substandard local materials, it is carried by hand and taken over long distances to local markets. The local packaging materials are not air proof; they are porous and cannot easily be cleaned and sanitized and can form and harbor biofilms which can contaminate butter.

Butter can easily spill out, especially on hot sunny days and this undoubtedly increases post-harvest losses of butter. The local packaging materials used in the informal systems can also expose butter to cross-contamination with foodborne pathogens which may threaten public health. The current result is in agreement with previous reports that indicated handling, packaging and preservation facilities used for dairy products from farm to fork as traditional and substandard, and can cause spoilage in dairy products [6, 22].

Properties commonly used to identify aged butter along the supply chain
Figure 3 represents the result of properties commonly used to identify aged butter. Change in smell, mold growth, presence of worms in butter and color changes

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were used to rate rancid butter. Forty percent (40 %) of consumers and about 30 % of producers and retailers indicated that rancid butter exhibits a change in smell. An average of 27 % of respondents along the supply chain characterized mold growth on the surface of butter as an indication of rancidity while 50 % of retailers, 24% of producers, and 8% consumers rated change in color of the butter as a sign of rancidity or to rate aged butter. Only about ten percent of consumers indicated the presence of worms as a sign of spoilage and rancidity. Study respondents indicated that when color of butter changes from light yellow/white to darker color, it is a sign of high level of fermentation (age of butter).

Growth of molds on butter surface and color changes might result due to the growth of spoilage microbes; and microbial rancidity is an oxidative process of fatty acids. Similarly, the aroma of butter changes from a fresh pleasant to a stringent odor when it is stored at ambient temperature. The exact causes of color and odor changes of traditional butter during storage at ambient temperature needs to be confirmed with laboratory analysis.

A portion of food can develop an off-flavor by coming in contact with the sources of off-flavors during processing or storage. Such off-flavours include moldy (mildew), yeasty (earthy), musty (swampy), malty, putrid, rancid, unclean, astringent and other types of off-flavors. Many of the off-flavors in butter can develop during microbial and oxidative rancidity [2, 11]. Protease enzymes are also responsible for spoilage of dairy products [27]. Lipase enzymes are the major future problems and may be of great concern in the developing world where the production of dairy products is taking place under unhygienic conditions [28]. The normal ranges of (free fatty acids = FFA) butter are involved in flavor impartation properties to dairy products. However, the reduction in butter quality is caused by rancidity and bitterness that are related to high levels of FFA and the breakdown of proteins [29].

The level of acidity shows the exposure of fat to oxidation. Highly acidic butter shows faster oxidation, and thus, has poor keeping quality and a decrease in consumer acceptability [30]. Findings from this study, however, showed that producers in the community described rancid butter as ‘aged butter’ rather than considering it as a defective product. The consumers preferred to use aged butter for flavoring stews at the household level, in hotels, restaurants, and for seasoning special traditional stews. The respondents showed that rancid butter can be kept at room temperature and stored for a longer period of time by periodical remixing.

In the traditional Algerian dairy products, fermented dairy products have been the pride of culinary tradition [31]. In northern Ethiopia, the FFA of local butter collected

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from producers and traders were 2.06 and 3.40 %, respectively. The standard FFA is about 0.3%. The reason for high FFA might be due to poor conditions during milk and butter production and handling, adulteration practices by cheaper hydrogenated oils, their oxidation products and potential exposure of butter to high lipases production by psychotropic bacteria [32].

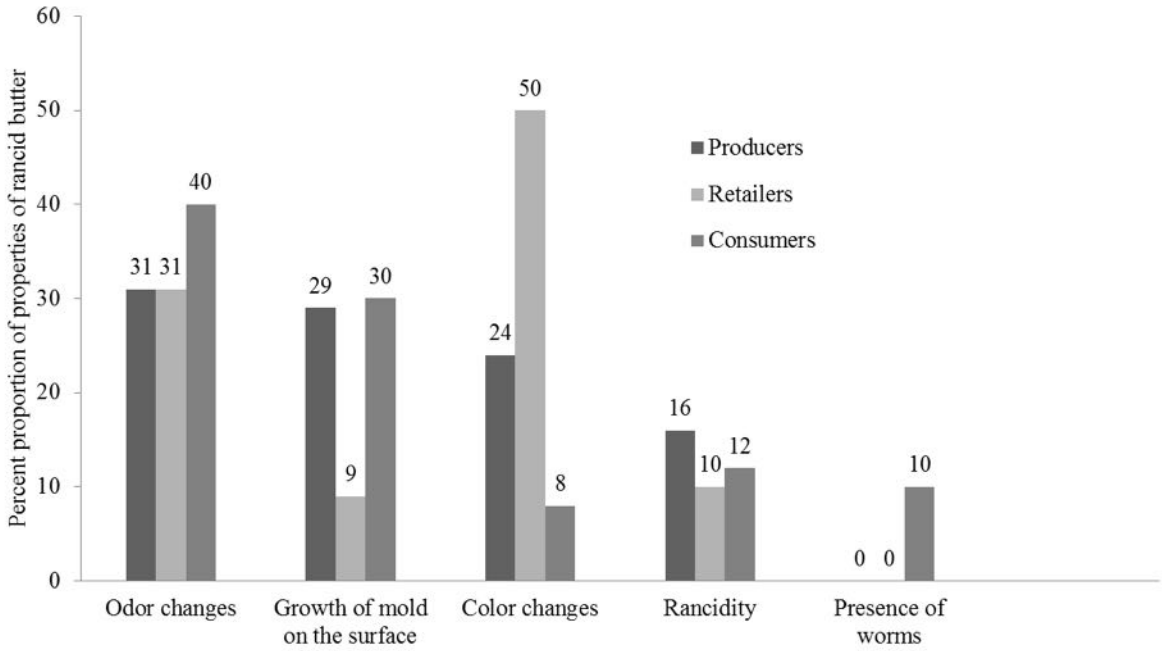

Figure 3: Properties used to identify aged butter according to responses

Informal butter market supply chains and their contribution to butter contamination
The result of the flow diagram of the informal local market butter supply chains is presented in Figure 4. A supply chain refers to a system of activities and resources involved in supplying a product or service to the consumers. The actors in the butter supply chain include retailers, itinerant traders, milk and milk products vendors, supermarkets, and consumers. Informal butter marketing involves the supply of butter either directly from the producers to consumers through itinerant traders or retailers or milk and milk product vendors. Smallholder producers sell butter mostly to itinerant traders and retailers and only some proportion of butter is sold directly to the consumers. The respondents described that itinerant traders pack butter into plastic containers and travel long distances to sell it to other retailers in towns and peri-urban areas.

The retailers in the urban centers pack and store butter purchased from smallholders and itinerant traders. The butter is packed and stored in fertilizer sacks and plastic bowels and stored at ambient temperature. Some retailers in the

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central market also indicated that butter in the retail shops is stored in cement sinks on the troughs. The heaped butter is covered with plastic sheets, false banana lints, and stored at ambient temperature. The heap of butter is periodically mixed; with the intention of refreshing the butter by mixing the one on the surface with that of the bottom of the cement sink.

The retailers indicated that some portions of the heaps of butter were removed and sold to consumers and hotels and restaurants as rancid butter, semi-rancid and freshly purchased butter with variable prices depending on the time the butter was purchased. The consumers mentioned that most itinerant traders did not have specific addresses, trade licenses and as a result, they sold their butter at lower prices. The respondents also described that butter sold by itinerant traders was of low quality and was usually suspected of adulteration by cheaper materials. The itinerant traders gathered butter from rural areas and took it to the regional and central markets. Similar reports showed that butter sold in local markets is mostly adulterated at retail levels with hydrogenated vegetable oils, water, buttermilk and banana pulps [33, 34].

The respondents indicated that the newly emerged milk and milk products vendors purchased butter from itinerant traders, stored it in refrigerators to sell it to consumers. Food systems in Africa are frequently uncoordinated and poorly regulated, resulting in compromised food safety and protection of public health from foodborne illnesses [35]. A report from producers in Menz district of Northern Ethiopia confirmed high microbial loads of 1.59, 10.43, and 10.26 log cfu/gram of butter for total bacterial counts, total coliforms and yeast and molds, respectively. In that order, traders' butter showed high loads of total bacteria, coliforms and yeast and molds counts of 13.56, 10.50 and 10.80 log cfu/gram of butter, respectively [32]. The same study concluded that the presence of mold contamination in butter indicates contamination by water or air. However, the presence of microorganisms in dairy products in large numbers of which some strains may be pathogenic is an indication that the products are potentially hazardous to the consumers' health [36, 37].

The informal marketing system has no standard operating procedures to maintain the safety and quality of local butter when it is moved along the supply chain through informal routes. In the informal market channel, the sensorial, physicochemical and microbial properties of butter is worsened as it moves along the supply chain. Consequently, the safety of butter becomes hazardous when it reaches the consumers. Thus, most of the dairy products including butter that is

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marketed through the informal chain can pose high public health risks of food-borne pathogens.

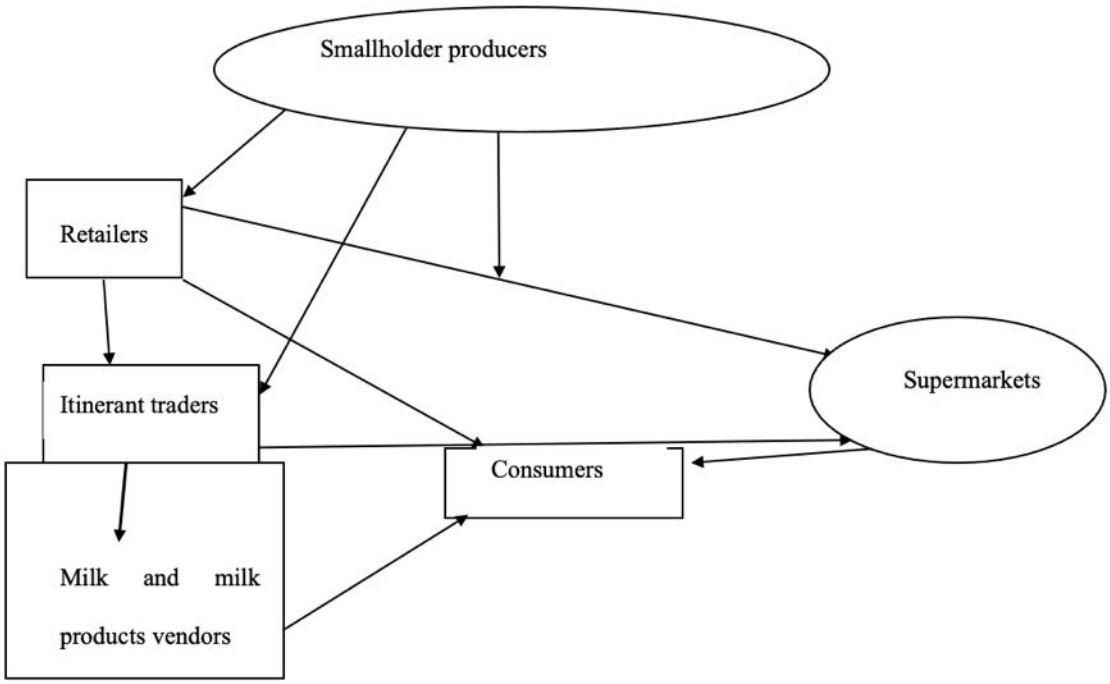

Figure 4: Flow diagram of the informal local market butter supply chain

Modes of transport to local markets

Figure 5 represents results of the modes of transport of butter to local markets in the study areas. Trekking on foot was the major mode of transporting butter to local markets according to 86, 100, and 50 % of respondents from Kersa, Mana and Wolmera, respectively. The use of horse carts to transport butter to local markets was reported by Kersa (14%) and Wolmera (30%) respondents. In Wolmera, the use of a three-wheel drive vehicle for taking butter to local markets was described by 20% of respondents. More than 50% of producers trek for more than an hour to deliver butter to local markets [7]. While walking to the local markets butter is exposed to direct sunlight and it can easily melt and cause significant post-harvest losses. Additionally, oxidation can take place which potentially leads to deterioration of the butter.

The mode of transport coupled with the poor packaging materials and exposure of butter to sunlight and oxidation exposes the butter to physico-chemical and microbial deterioration. Therefore, the consumption of such dairy products can pose potential health risks to the public. Evidence from literature shows that

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consumption of raw milk and raw milk products including cheese, cream, butter and yoghurt is common in sub-Saharan Africa including Ethiopia [23, 38].

In Ethiopia, production and consumption of raw milk and various dairy products often takes place under unsatisfactory hygiene conditions [39]. As a result, the possibility of contamination by pathogenic microorganisms such as Staphylococcal food poisoning due to the consumption of dairy products is very high [40]. Occurrence of S. aureus in milk and other dairy products at various points of the value chain are attributable to cross-contamination from contaminated milk from infected farms, poor handling practices, and use of unhygienic equipment [40].

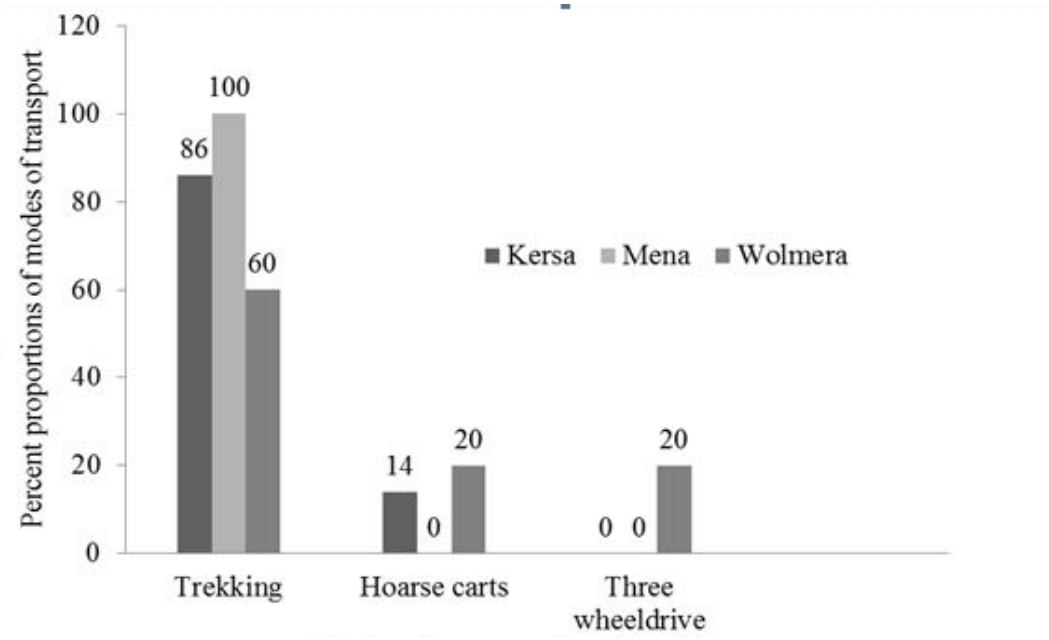

Figure 5: Modes of transport of butter to local markets

CONCLUSION

Assessment of factors pre-disposing local butter to food safety hazards along the supply chain was conducted. The result of the study indicated that the informal butter marketing system in the central high lands and south western mid lands of Ethiopia is not regulated; there are no quality assurance mechanisms. These practices pre-dispose local butter that is supplied along the supply chain to risks of foodborne pathogens that can pose health risks to the consumers.

The informal butter supply chain cannot address the safety and quality of local butter. Moreover, the awareness of the supply chain actors about the factors that pre-dispose local butter to food safety hazards is very low. Therefore, there is a

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need to set stringent quality control measures by concerned regulatory bodies. Further, the regulatory bodies should set critical control points at production, processing, water supply, packaging materials and butter transport and marketing.

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COMPETING INTERESTS

The authors do not have any conflicts of interest.

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Table 1: Causes of spoilage of butter, according to respondents N (%)

Storage temperature	Study sites			
	Kersa (N=118) N (%)	Mana (N=114) N (%)	Wolmera (N=295) N (%)	Average
Room temperature (9^{0}C - 23^{0}C)	118 (100)	114(100)	288(98)	98.00
Refrigerator (4^{0}C)	0 (0)	0(0)	7 (2)	2
Packaging materials used during storage				
HDPPC	57 (48)	61(54)	153(52)	51.33
LDPPC	14(12)	8(7)	34(11.81)	10.27
Stainless steel	0 (0)	0(0)	8(2.77)	2.77
Clay pot	47 (40)	45(39)	72(25)	34.67
TWGC	0 (0)	0(0)	22(8)	8.00
Packaging materials				
Castor leaves	103(87.29)	96(84)	68(23.32)	64.87
Plastic cups	-	-	68(23.32)	23.32
False banana leaves and lints	15(12.71)	18(16)	159(53.36)	27.36
Practice of adulteration	40	50 (57)	50 (148)	46.67

N= number of respondents, HDPPC =High density polyethylene plastic containers, LDPPC = Low-density polyethylene plastic containers, TWGC= Thatched woven grass containers

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