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Handling, Processing and Utilization of Milk and Milk Products in Ethiopia: A Review

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Abstract: Milk and milk products play an important role in human nutrition throughout the country. Milk is also used for rearing calves and whatever is obtained over and above producer household requirement is soured for beverage (*Ergo*) and/or butter (*kibe*) making. The aim of this review was to synthesize earlier work on handling, utilization and processing of milk and milk products in Ethiopia. The hygienic conditions are different according to the production system, adapted practices, level awareness and availability of resources. In most cases, the practices for limiting spoilage of milk in Ethiopia are very few. These include immediate boiling of milk after its production, the use of lactose fermentation by lactic acid bacteria and sanitizing methods, which include smoking of the vessels used for processing or storage of milk and milk products. This indicates that the health of the dairy consuming community is not secured. Therefore, Milk of good hygienic quality is necessary to produce milk products of good quality and adequate shelf life in order to provide a safe, wholesome food for the consumer.

Key words: Handling Practices · Utilization · Processing

INTRODUCTION

Demand for milk and dairy products has increased in the tropical areas where people's incomes have been growing. However, despite milk's contribution to gross domestic products and its value as a food, sub-Saharan Africa in general and Ethiopia in particular has failed to attain self-sufficiency in dairy production. Dairy processing plants are few in numbers, much of the milk produced by rural small holders is processed on farm using traditional technologies and milk processing is based on sour milk [1]. This is due to high ambient temperature, small daily quantities of milk produced, consumer preference, the better shelf life of fermented milk as well as the type and capacity of the locally available processing materials and methods used. Ethiopians, like other countries, have been using milk as part of their diet for centuries. Milk is used for rearing calves and children, and the surplus is soured for *Ergo* (Ethiopian naturally fermented milk) and/or butter and *Ayib* (Ethiopian cottage cheese)-making. *Arrera* (defatted sour milk) is used for human consumption or for *Ayib-making* [2].

In Ethiopia, there is no standard hygienic condition followed by producers during milk production. The hygienic conditions are different according to the production system. In most of the cases under smallholder condition, the common hygienic measures taken during milk production especially during milking are limited to letting the calf to suckle for few minutes and/or washing the udder before milking. The quality of the water used for cleaning purpose (washing the udder, milk equipment, hands), however, is not secured [3]. Milk production under Ethiopian smallholder condition can therefore generally be characterized as unhygienic.

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In Ethiopia very limited comprehensive review works were synthesized at national level and in a well coordinated manner or to compile relevant endeavors effected on production to consumption of dairy product so far. However, the works done by MSc or PhD students as a part of their studies and few researchers were worth mentioning. Hence, for effective interventions to be designed information is needed from the existing handling, processing and utilization of milk in the country. Therefore, the objective of this paper is to synthesize the earlier works on handling, processing and utilization of milk and milk in Ethiopia.

Milk Production in Ethiopia: In Ethiopia milk is considered one of the oldest kind of food and so many people depend on its products. Milk production depends mainly on indigenous livestock genetic resources dominated by small holder farmer; more specifically on cattle, goats, camels and sheep. The indigenous breeds accounted for 99.19 percent, while the hybrids and pure exotic breeds were represented by 0.72 and 0.09 percent, respectively [2]. Cattle has the largest contribution (81.2%) of the total national annual milk output, followed by goats (7.9%), camels (6.3%) and sheep (4.6%) [4]. the number of milk cows at national level varied during the 15 years reference period (1996 to 2010). Generally, this number tended to increase from about 8.8 million in 1996 to 11 million in 2001 and sharply decreased to roughly 7.9 million in 2003 then increased to 9.6 million in 2010 [2]. Despite its potential for dairy development, productivity of indigenous livestock genetic resources in general is low, and the direct contribution it makes to the national economy is limited. For example in 2010, a total annual milk production of 3. 2 billion liters, of which contribution from 9.6 million cows at national level, estimated 2.7 billion liters [2].

In the same year, the average daily milk production was only 1.69 liters with average lactation length of about 180 days and mean annual milk yield per cow of 305 liters [2]. MoA [5] also reported some improvement in per capita consumption of milk and estimated it at 19.2 kg when compared with 2009, 16 kg/year, which is much lower than African and world per capita averages of 27 kg/year and 100 kg/year, respectively [6] . The annual growth rate in milk production of 1.2 percent falls behind the annual human population growth estimated at 3 percent [7]. About 4% increment in total milk production is required per annum to feed the increasing human population and narrow the gap in milk supply and demand [8]. Thus, the country has been spending foreign currency to import dairy products from abroad to meet domestic demand. For instance, in five reference years, 2005–2009, export values increased from about 73 000 USD to 123 000 USD, while import values increased from about 5.6 million USD to 10.3 million USD during the same period. Milk production, however, increased steadily from about 927 million liters in 1996 to 2.9 billion liters in 2010 (31.5 percent increase).

Handling Practices of Milk and Milk Products in Ethiopia: Milk is a major component in human diet all over the world. Though, milk is the most easily contaminated and perishable product of animal origin. This is mainly due to its high nutritional value creating an ideal medium for the growth of spoilage as well as pathogenic microorganisms. The handling and safety of milk and milk products is of great concern around the world. This is especially true in developing countries where production of milk and various dairy products takes place under rather unsanitary conditions and poor production practices. Thus, farmers and all who handle milk before sale must consider the health of consumer [9].

Also, all cases of dairy illness continued to be of bacterial pathogens that have involved in communicable diseases associated with the consumption of milk include *Salmonella* spp, *Listeria monocytogenes*, *Staphylococcus aureus*, *Campylobacter* spp, *Yersinia, Escherichia coli* and *Clostridium botulinum* [10]. This problem can be severe in countries like Ethiopia, where most of the milk produced is marketed to consumers without being pasteurized and where there is no functional official quality control standard [11]. The hygienic production of milk is critically important to dairy product manufacture from two perspectives: efficiency of manufacture and quality of product; for example, poor hygiene leads to high counts of somatic cells and bacteria, which enhance undesirable protein hydrolysis and loss of yield.

In most cases, the practices for limiting spoilage of milk in Ethiopia are limited to certain treatments that include immediate boiling of milk after its production, the use of lactose fermentation by lactic acid bacteria and sanitizing methods, which include smoking of the vessels used for processing or storage of milk and milk products. This practice of smoking the vessel by burning wood chips of specific trees and shrubs has an advantage of imparting a special taste and odor to the product, and disinfect the vessels, thus reducing the numbers of micro-organisms and thereby extending the shelf life of the product [12]. The most apparent plants reported by earlier studies that were used for smoking of the milk

utensils in an attempt to improved the product quality shelf life in different part of the country were *Olea africana, Acacia busia, Ocimum hardiense*, Eucalyptus *globules, Ocimum hardiense, Sida tenuicarpa vollesen* [12- 17]. Smallholders also add spices to butter as a preservative and/or to enhance its flavor for cooking [18].

Moreover, Ethiopian farmers particularly women have their own practices to improve the keeping quality of locally produced dairy products through sanitation of milk and milk handling equipments as well as by applying locally evolved processing knowledge. For instance worth mentioning in Dawuro zones, a number of farmers' were used two cheese preservation methods namely whey immersion and ghee waxing [19]. The former involve keeping of cottage cheese together with whey while the latter procedure involve covering of the outer surface of freshly made cottage cheese with traditionally produced ghee.

Generally, the highly perishable nature of milk coupled with mishandling practices from production up to the consumption stage, the amount produced is subject to high post harvest losses. The estimated post harvest losses of up to 40 percent of milk and its derivatives in Ethiopia have been reported from milking to consumption [1]. According to FAO [20], the value of annual milk and milk product losses due mainly to mishandling across five African and the Middle East countries (Kenya, Tanzania, Uganda, Ethiopia and Syria) was over US $ 90 million. Post harvest losses and quality deterioration are mainly attributed to mishandling in the dairy chain from farm to fork. These include: contamination during milking and further handling coupled with storage time and temperature before consumption; deliberate adulteration of milk; absence substandard handling, transportation and distribution systems; inefficient processing technologies; inadequate fresh milk outlet and spillage losses during milking [2]. Reducing such losses and improving quality are effective ways of making more and safer milk available. This helps to improve the welfare of resource-poor dairy producers and low income consumers through increased supply in terms of volume and geographical distribution and marketing of safe and better quality milk and milk products.

Milk Processing in Ethiopia: In Ethiopia, milk processing is generally based on *Ergo* (Ethiopia naturally fermented milk), without any defined starter culture. This is due to a number of reasons including high ambient temperatures, small daily quantities of milk, consumer preference and increased keeping quality of sour milk [21]. Cows are the main source of milk, and which is the focus of processing in Ethiopia. Milk processing is an important measure for the preservation of food constituents as sources of nutrients and cash for many people in the world [22]. As has been indicated earlier, fermented milk for instance can be stored up to 20 days compared with less than a day for fresh milk [21].

Milk as a food is an ideal medium for the growth of bacteria and if kept at above 16°C the bacteria will multiply rapidly thereby causing deterioration in quality [21]. Therefore, surplus milk needs to be processed to preserve its valuable constituents for a long time. Processing alone cannot eliminate milk quality problems originated on the farm [23]. It is therefore important that appropriate processing and storage materials are used and the required care is taken while handling milk and milk products. Although various traditional milk processing and storage equipment are used in different parts of Ethiopia, clay pot is the most commonly available and used. Traditional churning methods are reported to be time consuming and labor intensive and result in considerable loss of fat in the *Arera* (sour skim milk). These traditional churning methods are generally inadequate to cope with the present trend of substantial increase in milk supply [18]. Rahel [13], also stressed the importance of improving traditional methods of milk processing to reduce the time elapsed in the processing and increase recovery of final products per unit of raw materials used.

In Ethiopia, milk is traditionally preserved into different products like ghee, butter and cheese. Since, milk products are more stable than fresh milk because they are more acidic and/or contain less moisture. Among the traditional fermented milk products, butter, *Ayib* (Ethiopian cottage cheese), and *Ergo* (Ethiopian fermented milk) represent the most marketed products next to whole milk. It is therefore important to look into their processes in relation to hygienic conditions practiced during handling [15]. Milk processing is usually designed to remove water from milk or reduce the moisture content of the product. Generally, milk processing is not well developed in Ethiopia [24]. It is important, therefore, to consider these processes and look to possible technological interventions at this level when considering dairy development in the rural areas [21].

Ergo (Ethiopian Naturally Fermented Milk): *Ergo* is one of the most common traditionally made fermented milk products in Ethiopia. As indicated by Desalegn [25], *Ergo* is made by natural fermentation of milk under ambient

temperature, without the addition of starter cultures using traditional utensils under non-hygienic environment. Fresh batches of milk may be added to the fermented product each day with or without previous removal of whey, until the container is full. In countries with a developed dairy industry milk is heated to sterilization temperature of above 100°C for 15 to 40 minutes followed by cooling and inoculation with bacteria (starter cultures) to achieve a controlled fermentation [21]. *Ergo* is the most 'natural' milk preservation originated from the inability of the livestock owner to control the keeping quality of the milk [26]. Microbial fermentation provide a way to preserve food products, to enhance nutritive value, to destroy undesirable factors, to make a product safe, to improve the appearance and test of some foods, and to reduce the energy required for cooking [27].

In Ethiopia, *Ergo* makes the basis of further processing of milk into more stable fermented milk products. The relatively low pH of *Ergo*, ranging from 4.3 to 4.5 retards the growth of pathogens and spoilage bacteria enabling its further storage [28]. Average acidity and temperature of sour milk on smallholder farms of the central Ethiopian highlands is 0.86% and 18.4°C, respectively, and adequate fermentation was achieved in about 62 hrs [18]. *Ergo* is the major fermented dairy product that is popular and consumed in all parts of the country and by every member of the family. It is thick, smooth and of uniform appearance and usually has a white milk colour when prepared carefully. The product is semi-solid and has a pleasant odour and taste. *Ergo* is produced from raw milk of cattle in all parts of Ethiopia by smallholder farmers. It is also made from milk of goats and camels in the lowland regions in relatively small amounts. It constitutes a primary sour milk product from which other products may be processed. Products such as butter, ghee, buttermilk, cottage cheeses and whey are made from fermented milk.

***Kibe* (Traditional Butter):** In Ethiopia, there are three types of butter exist, *Lega, Mekakelegna* and *Besal,* which refer to fresh, semi-rancid and rancid, respectively, based on the degree of lipolysis it has undergone due to the age of the product. Traditionally, Smallholder butter making is based on sour milk. Souring milk has a number of advantages. It retards the growth of undesirable microorganism, such as pathogens and putrefactive bacteria and makes the milk easier to churn. Milk for churning is accumulated over several days by adding fresh milk to the milk already accumulated [21]. Since butter is always made from fermented milk, there is no tradition of using cream. This traditional butter processed and sold by women in every community [29]. *Kibe* has an attractive appearance with a white to light yellow color. Like factory processes butter, it is semi-solid at room temperature. It has a pleasant taste and odor when fresh but with increased storage, change occur in odor and taste, unless refrigerated or further processed in *Niter Kibe* (traditional ghee) by boiling spices. The storage stability of butter still makes preferable to other dairy products. This gives butter a distinct advantage over fresh milk in terms of more temporal flexibility for household use and marketing. Butter is cooked at around 100°C until the moisture content is almost completely evaporated as a means to prolong its shelf-life. During the process, spices such as garlic and ginger are added to improve its flavor. The resultant product - *Niter Kibe* (melted butter or ghee) can be stored for quite a long time at ambient temperature. Butter has additional functions besides its nutritional value. Women use butter as hair oil, which is assumed to have dual functions for hairdressing and to cure headaches. Ghee is added to a variety of Ethiopian traditional dishes such as: *Kitifo* (minced beef served raw or half cooked) and a variety of cereal, pulse and meat based sauces. Ghee is also consumed with coffee and tea especially when important guests are received in a home and during major holidays.

The churn is then stoppered with a plug, a false banana leaf, a piece of skin or leather or other similar materials stretched over the opening and securely tied. Then after the churn is vigorously agitated or churned in such a way that air is incorporated in the liquid [26]. Although different materials can serve as a churn for butter-making, clay pot and bottle gourd are the most commonly used ones [29]. The break point, that is the point when butter starts to form, can be detected by a change in the sound of the milk up on agitation. After butter granules have coalesced into large grains, the churn is rotated on its base. This collects the grains in the centre and forms lumps for butter. The butter is then skimmed off, kneaded in cold water and washed to remove visible residual buttermilk [30].

According to Zelalem and Inger [18], 21 liters of whole milk is needed to produce a kilogram of butter, which has 83% total solids. The average churning time was 222 minutes for traditional method of churning whereas it was reported to be on average 80 minutes when using an improved type of churn developed by ILCA called ILCA Internal Agitator.

***Arera* (Defatted Buttermilk):** Defatted buttermilk is a semi liquid product that remains after butter making. *Arera* is a local name for defatted Buttermilk in Ethiopia. It has a thin consistency and basically contains the casein portion of milk. Its taste and odor are similar to those of *ergo*. It is either consumed in that form or cooked to produce *Ayib*. The consumption of defatted buttermilk depends on the standard of living of the family. In contrast to other traditional dairy products, *Arera* comprises 91.5% moisture, 3.1% protein, 1.4% fat, 3.4% carbohydrate, and 0.6% ash. A hundred grams of *Arera* give 95 mg calcium, 84 mg phosphorus, 1.0 mg iron, 0.03 mg thiamine, 0.21 mg riboflavin and 0.10 mg niacin [31]. It is, thus, used to supplement the diets of children and the elderly in rural areas. According to Zelalem and Inger [18], buttermilk is either directly consumed with in the family or converted to cottage type of soft cheese (*Ayib*). The consumption of buttermilk depends on the standard of living of the family. Surpluses are also given to calves, lactating cows and dogs [9].

***Ayib* (Ethiopian Traditional Cottage Cheese):** *Ayib* (Ethiopian traditional cottage cheese) is a white, soft curd-type cheese typical of many regions in the country. It is made from buttermilk obtained after churning of sour whole milk [32]. For the production of this traditional Ethiopian cottage cheese called '*Ayib'* buttermilk is heated in a clay pot on a low fire to about 50°C [33]. When the curd and whey separate, the heating is stopped and the contents of the pot are allowed to cool. Once cold, straw or fiber from false banana is introduced in the milk pot to serve as a sieve. The whey is drained off and the cheese curd is kept in a clean bowl or pot [30]. It is a crumbly product, which is eaten with many national dishes by various ethnic groups in the country. It can be consumed as side dish as such, or it may be spiced with various herbs and spices peculiar and/or common to each ethnic group in the country. As reported by FAO [30], an average of 8 liters of *Arera* are needed to produce a kilogram of *Ayib* having on an average 2.25% fat, 1.23% ash, 20.42% total solid, the average moisture percentage being 79.58%.

Efforts were done by different scholar in different parts in the sector on documenting traditional *Ayib* processing and quality [9, 11, 19, 34]. Production of relatively stable milk products is an essential part of milk processing. There appears to be no standards on the production and quality of cottage cheese and other milk products in Ethiopia owing to the main fact that the data set to install such standards and quality control is minimal. The Ethiopian cottage cheese has a short keeping quality because of its high moisture. It is very acidic with an average pH of 3.7 but still has a short keeping quality of 2-3 days [9] at high ambient temperature while at 4°C it stayed for about 7 days. The keeping quality can be increased by adding salt, reducing the moisture content of the cheese or by storing the product in an airtight container [21] . Higher cooking temperatures also enhance its shelf-life [35].

Aguat (Whey): *Aguat* is Amharic name for whey. It is the liquid that remains after most of the fat and protein in the milk are removed during cheese making [33]. Whey should be fed to animals; calves, cows and dogs or consumed by humans. *Aguat* contains valuable nutrients, i.e. whey proteins, carbohydrate and minerals. The protein content of *Augat* is estimated at about 0.75% [36]. The whey from cheese making vary according to the type of cheese made and, therefore, the content of protein, salts and lactose also vary. There are many uses for whey and its constituents. Where cheese is made on a small or farmhouse scale the quantity of whey available does not justify the manufacture of the more exotic or sophisticated products where large quantities of whey are required along with expensive, large scale equipment. Whey proteins extracted from whey by ultrafiltration have also found many uses in the food industry [33].

Utilization of Milk and Milk Products in Ethiopia: Milk and milk products form part of the diet of many Ethiopians. The importance of milk in the diet of Ethiopians differs according to the farming systems and the socio-cultural setups. In the lowlands, especially where livestock keeping is the main occupation, milk is consumed by all groups of the society. In the highlands, the rural people are sedentary farmers raising both livestock and crops, with their diet consisting mainly of cereals [2]. Moreover, the consumption pattern of milk and milk products produced at home varies depending upon the amount of milk produced per household, dairy production system and market access, season of the year, and fasting period (particularly for the followers of Orthodox Christian) [37]. Fresh milk, *Ergo*, whey, Ethiopian cottage cheese (*Ayib*) and traditional butter are the most common milk products produced and consumed by different part of the country.

Table 1: Utilization of milk at regional level (2009/10)

	Utilization (%)				
Region	Household consumption	Sale	Wage in kind	Others	Total
Tigray	91.8	1.34	0.42	6.43	100
Afar	87.29	4.69	0.3	7.72	100
Amhara	92.62	0.38	0.24	6.76	100
Oromia	86.36	6.31	0.29	7.05	100
Somalia	67.79	29.68	0.17	2.36	100
Benshangule-Gumuz	63.89	0.89	0.12	35.1	100
SNNP	88.63	2.29	0.36	8.73	100
Gambella	85.13	11.15	0.44	3.28	100
Harari	47.47	47.21	-	5.32	100
Dire Dawa	63.65	35.65	0.29	0.24	100
Ethiopia	85.23	6.86	0.29	7.62	100

Adapted from (2).

Table 2: tilization of butter at regional level (2009/10)

	Utilization (%)				
Region	Household consumption	Sale	Wage in kind	Others	Total
Tigray	96.95	0.31	0.38	2.36	100
Afar	88	1.25	-	10.75	100
Amhara	98.22	0.41	0.01	1.36	100
Oromia	87.65	7.58	0.06	4.71	100
Somalia	100	-	-	-	100
Benshangule-Gumuz	95.37	11	0.01	3.51	100
SNNP	66.95	31.43	0.34	1.28	100
Gambella	91.68	5.74	0.55	2.03	100
Harari	-	-	-	-	-
Dire Dawa	-	-	-	-	-
Total	87.13	10.07	0.17	2.63	100

Adapted from (2).

Table 3: Utilization of defatted sour milk (*Arera*) at regional level (2009/10)

	Utilization (%)				
Region	Household consumption	Sale	Wage in kind	Others	Total
Tigray	90.91	-	-	9.09	100
Afar	88.21	0.43	0.34	11.02	100
Amhara	98	0.47	0.05	1.48	100
Oromia	92.49	4.54	0.01	2.96	100
Somalia	92.17	7.83	-	-	100
Benshangule-Gumuz	96.64	-	-	3.36	100
SNNP	87.32	7.4	0.53	4.75	100
Gambella	98.44	0.28	1.11	0.17	100
Harari	100	-	-	-	100
Dire Dawa	-	-	-	-	-
Total	90.9	4.81	0.3	3.99	100

Adapted from (2).

Milk is used for rearing calves and children, while the surplus is processed into a few shelf stable fermented milk products or sold in the local markets. *Ergo* (naturally fermented milk) can be consumed directly and also makes the basis of traditional milk processing. The two major marketed fermented milk products are traditional butter and *Ayib*. In Ethiopia, fresh butter has also cosmetic value where women use butter for hairdressing. Butter is also cooked at boiling temperature until almost all its moisture content is evaporated with spices such as garlic and ginger being added to improve its flavor. The Amharic term for the resultant product is *Niter Kibe* (for clarified melted butter or ghee) that can be stored for quite a long time at ambient temperature. It is also consumed with coffee and tea. Buttermilk is either directly consumed with in the family or converted to cottage type of soft cheese (*Ayib*). Generally, milk consumption in rural areas can be considered as a function of wealth or availability to a given household, while in urban areas it can be determined by the purchasing power of the household, the level of awareness on its nutritive value and availability [2].

According to CSA (38), of the total annual milk production at national level in 2009/10, 85 percent was used for household consumption, 7 percent sold, 0.3 percent used to pay wages in kind and the remaining eight percent was used for other purposes such as the production of butter and *Ayib* (Ethiopian cottage cheese). The proportion of milk used on one hand for household consumption was highest in the Amhara Region (92.6 percent) followed by Tigray (91.8 percent) and SNNP (88.6 percent) with Harari (47.5 percent).

The quantity of milk sold, on the other hand, was highest in Harari (47.2 percent) followed by Dire Dawa (35.7 percent) and Somali (29.7 percent) (Table 1). Generally, more milk products especially butter (36.4 percent) and *Ayib* (10.1 percent) were sold as compared to milk (6.9 percent) (Tables 2 and 3). About 91 percent of the *Arera* produced at national level was consumed within the household with 4.8 percent being marketed (Table 3).

Summary: Milk and milk products form part of the diet for many Ethiopians. Dairy production, processing and utilization in Ethiopia are mostly traditional. Apart from consumption of whole fresh milk, dairy products are widely used and are considered as traditional recipe in the form of Butter/ghee, *Ayib* and *Ergo* to name the few. The milk production conditions in the Ethiopia are not likely to ensure the quality of products. The common hygienic measures taken during milk production, especially during milking, are limited to letting the calf to suckle for few minutes and/or washing the udder before milking.

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