Traditional Fermented Dairy Products of Ethiopia: A Review

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Abstract: Fermented foods play an important role in human nutrition and protecting against infectious diseases. Understanding the properties of traditionally fermented dairy products as well as a proper analysis of the indigenous processing steps are important in order to recommend appropriate manufacturing protocol and procedures for commercialization. Little information is available on the general characteristics and processing practices of traditional dairy products of Ethiopia. Therefore, the objective of this review was to critically assess and summarize information on indigenous fermented dairy products of the country. The traditional dairy products included in this review are *ergo* (spontaneously fermented milk), *ititu* (spontaneously fermented milk curd), *kibe* (traditional butter), *neter kibe* (ghee), *dhanaan* (Ethiopian fermented camel milk), *ayib* (Ethiopian cottage cheese), *hazo* (spiced fermented buttermilk), *arera* (defatted sour milk) and *aguat* (acid whey). The indigenous dairy products have good nutritional and functional potential to scale up to commercial production. However, detailed investigation on the characterization of the products and standardization of the manufacturing steps should be undertaken. The huge potential of microbial biodiversity related with the long storage stability of the traditional dairy products especially *dhanaan* and *ititu* shows promising potential for development of technologically important indigenous starter cultures.

Keywords: *Ayib*; *Dhanaan*; *Ergo*; Ethiopian dairy products; *Ititu*.

1. Introduction

Ethiopia has the largest livestock population in Africa and amongst the top 10 in the world. According to the Livestock State Ministry report (LSM, 2014), the number of cattle, camel, sheep and goat population of Ethiopia was estimated to be 56.5, 4.5, 34.5, 32.5 million heads, respectively. Population growth, urbanization and income growth in the country are the driving force for massive increase in demand for foods of animal origin. Although Ethiopia has favorable agro-ecological conditions for milk production, especially in the highland regions, per capita milk production is relatively small.

Currently, the demand and consumption of dairy products in the urban areas is increasing as a result of emerging new market opportunities. To a large extent these opportunities are driven by the rise of dairy supply chains, linking rural production sites to increasingly profitable markets in the major cities. Emerging dairy chains can be disentangled into downstream operators such as processors and retailers and upstream operators such as farmers. The development of supermarket and small-scale dairy processor chains represent a great opportunity to link African smallholder farmers to emerging markets of dairy products (Francesconi *et al.*, 2010). However, the rises of such small-scale processors pose processing challenges in developing countries such as Ethiopia.

Ethiopia is a country with a huge population of more than 95 million (CSA, 2017) with multi-ethnic groups characterized by old and diversified cultures, languages and history. Ethiopia is considered as a country of center of diversity in the world in terms of plant, animal, and microbial species as a result of its diverse agro-ecologies, range of altitude, rainfall pattern and soil types (Harlan, 1969; Tolera, 2008). It is the country that has never been colonized by Europeans. Hence, the dairy products as well as their processing procedures are indigenous to the country. Fermented foods play an important role in human nutrition and protective role against infectious diseases. Investigating the characteristics of traditionally fermented dairy products and proper analysis of the indigenous processing steps are important in order to design or recommend appropriate manufacturing techniques and to develop indigenous dairy starter cultures. Therefore, the objective of this review was to critically assess and summarize research results on the characteristics and processing practices of indigenous Ethiopian fermented dairy products.

2. Common Ethiopian Fermented Dairy Products

Traditional dairy products of Ethiopia are mainly fermentation products of lactic acid bacteria (LAB) and yeasts. LAB are ecologically diverse group of microorganisms characterized by formation of lactic acid

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as their main product of carbohydrate metabolism. The dominance of LAB during fermentation and their antagonistic activity against undesirable microorganisms in fermented dairy products is mainly due to resource competition, production of different low molecular weight substances, lowering pH and bacteriocin production (Abdelabasset and Djamila, 2008; Mora *et al.*, 2000)

Ergo, spontaneously fermented milk, is the major raw material for the manufacturing of different Ethiopian traditional dairy products. In Ethiopia, fermented dairy products are traditionally produced by leaving fresh milk to spontaneously ferment for two or more days in pre-smoked traditional milk containers. Smoking milk containers using different plant species is a traditional practice in the manufacturing of Ethiopian dairy products (Ashenafi, 2006). Indigenous knowledge about smoking of milk containers indicate that the practice of smoking the containers has sensorial and safety benefits. The smoke enhances the taste and aroma of the dairy products and helps in decontaminating the container due to its anti-microbial activity by reducing spoilage microorganisms and thereby extends the shelf life of the product (Ashenafi, 1996).

Most of the milk produced by the Ethiopian farmers is consumed at household level as fresh or fermented milk. However, processing of fresh milk into dairy products results in value added products and improves shelf life and functional properties of the product. Popular Ethiopian fermented dairy products manufactured using traditional methods include *ergo*, *ititu* (spontaneously fermented milk curd), *kibe* (traditional butter), *neter kibe* (ghee), *ayib* (Ethiopian cottage cheese), *hazo* (spiced fermented buttermilk), *arera* (defatted sour milk) and *aguat* (acid whey). Figure 1 shows an overview of the various indigenous fermented dairy products produced in Ethiopia.

2.1. Ergo (Spontaneously Fermented Whole Milk)

Ergo is the most common dairy product in Ethiopia and is traditionally made by spontaneous fermentation of milk at ambient temperature for 2-3 days, without addition of starter cultures. However, the temperature and duration of incubation varies from place to place depending on the prevailing environmental conditions (Assefa et al., 2008). *Ergo* resembles set yoghurt and has a semisolid thick consistency, smooth and uniform appearance, a white color and pleasant flavor. *Ergo* is consumed either spiced or natural. The consistency and flavour of *ergo* varies within and among the ethnic groups of the country due to the difference in the spices used and application of smoking materials. *Ergo* is the basic raw material for the production of most of the Ethiopian dairy products. Therefore, standardization of the addition of spices and smoking material may be an area that deserves further research attention.

The microorganisms found in *ergo* are of different types and species. *Lactococus, Streptococcus, Leuconostoc, Lactobacillus, Pediococcus, Enterococcus,* coliforms, yeasts and moulds are common in *ergo* (Ashenafi, 1996; Gonfa *et al.*, 1999). In highland areas where ambient temperature is relatively low and the growth of LAB is also relatively slow, the use of backslopping techniques, i.e. using a portion of *ergo* from a previous batch as a starter is a common practice. Backslopping is not common in the lowlands and this may be due to sufficient amounts of LAB that can proliferate on the inner walls of the container and serve as starter cultures. The traditional containers (made of clay pot, hollowed wood, calabash (gourd), woven grass, or skin of animals) which have been in use continuously develop smooth slimy inner surfaces being sources of fermenting microorganisms (Coppock *et al.*, 1991).

Ashenafi (1996) reported the importance of smoking milk container in improving the shelf life of *ergo*. The practice of smoking milk container slowed fermentation, improved flavor characteristics and slowed down the growth of pathogenic and spoilage microorganisms. The total count of non-lactic acid bacteria in milk in the non-smoked containers reached a relatively high level ($>10^8$ cfu ml^{-1}) within 12 hours, whereas milk in the smoked container required more than 24 hours to attain the same level. Likewise, the growth of coliforms and LAB was slow in the smoked containers. The common plant species used for smoking milk containers in Ethiopia is African olive tree (*Olea africana)*. An inhibitory effect of smoking on the pathogen *Listeria monocytogenes* was reported by Ashenafi and Fikadu (1994). At temperatures of 20ºC and in smoked containers, lactococci were the dominant species whereas lactobacilli were dominant in unsmoked containers and at 37ºC incubation temperature. At 40ºC incubation temperature, fermentation was rapid and over-souring occurs resulting in a separation of the liquid and solid phase and gas production, thus leading to deterioration of appearance and texture of the product, especially when unsmoked vessels were used (Ashenafi, 1996).

Insufficient fermentation in rare cases is a problem in the highlands and requires an extended fermentation time of 3–5 days due to the low ambient temperatures. Storage stability of the product depends on the storage temperature. It can be stored for 15-20 days at 16 to 18ºC as reported by O'Connor (1994). The relatively low pH of *ergo*, ranging from 4.3 to 4.5 (Gonfa *et al.,* 2001), is the main factor that enables the storage stability of the product. *Ergo* is considered as a special traditional food and is particularly served as a nutritional supplement to sick people, children, and pregnant and lactating women (O'Connor, 1994). *Ergo* is also consumed, either spiced (green pepper, onion, salt) or as it is, and usually as a side dish with different traditional foods such as *injera* (flat, thin pancake made from fermented cereal dough). In

Ethiopia, *Ergo* is mainly made from cow milk but it can also be made from goat and sheep milk.

2.2. Ayib (Traditional Ethiopian Cottage Cheese)

Ayib is an acid-heat coagulated cottage type cheese which is popular in almost all parts of Ethiopia. It is made from *arera* (defatted sour milk) obtained after churning of fermented whole milk (*ergo*) (Figure 1). The churning is carried out by slowly shaking the contents of the pot back and forth until butter grains are formed and the fat is finally separated by scooping or ladling. The defatted liquid remaining in the churn is called *arera*. During *ayib* making, the *arera* is heated in a clay pot on a fire to 40 -70°C until clear separation of the whey from the curd is obtained (FAO, 1990). Subsequently, whey is drained off through a fine mesh cloth or similar material and the cheese curd is kept in a clean bowl or pot. The *ayib* produced has white color and is soft curd in consistency.

Cooking of the curd is also practiced which is expected to decrease the microbial load prior to consumption of the product. However, *ayib* samples collected from local markets of the country have been found to contain pathogenic and spoilage microorganisms such as aerobic mesophilic bacteria, *Bacillus cereus*, *Staphylococcus aureus*, *Klebsiella* spp., *Escherichia coli, Enterobacter* spp., yeasts, *Listeria* spp. (Ashenafi, 2006; Mekonen *et al*., 2011; Seifu, 2013). The sources of contamination could be from handlers, water sources, utensils used for processing and possibly from packaging materials.

Ayib can be consumed as a side dish or it may be blended with various spices according to the common practices of the various ethnic groups in the country (O'Connor, 1994). According to FAO (1990), an average of 8 liters of traditional buttermilk is needed to produce one kilogram of *ayib* having an average of 1.8% fat, 14.7% protein, 0.9% ash, 20.4% total solids and 79.6% moisture content. Likewise, O'Connor and Tripathi (1992) reported that *ayib* contains 76% moisture, 14% protein, 7% fat and 2% ash.

Ayib is a product that has a short-shelf life because of its high moisture content. Gonfa *et al*. (2001) has reported that although the product is acidic in nature (pH 3.7), its storage stability is still 2-3 days at high ambient temperature while at 4°C it can be kept for about 7 days. The keeping quality can be improved by heating the curd to at least 75°C with accompanying removal of as much whey as possible, adding salt and storing in airtight container.

Ayib is also the sole type of acid-heat coagulated traditional cheese since rennet coagulated cheese varieties are not common in Ethiopia. Although *ayib* is the dominant cheese produced in Ethiopia, Seifu (2013) and Seifu and Tassew (2014) reported two variants of *ayib* namely *metata ayib* and *zure ayib* which are produced in the West Gojam Zone of the Amhara Regional State of the country. According to Seifu (2013), the production of *metata ayib* (fermented cottage cheese) involves the use of different spices and spontaneous fermentation for 15 days. The manufacturing of *metata ayib* involves production of different batches of *ayib* by heating fermented buttermilk at 40-50°C for about 30 min and drainage of whey for three days. The different batches of *ayib* manufactured are mixed together and spices such as black mustard (*Brassica nigra*) and Coriander (*Coriandrum sativum)* are added into the mixture after which whey is drained for three more days. Then the accumulated *ayib* curd is mixed with additional finely powdered spices such as ginger (*Zingiber officinale)*, Ethiopian cardamom (*Aframomum korerima),* garlic *(Allium sativum),* tossign *(Thymus serrulatus),* rue *(Ruta graveolence) or* nigella *(Nigella sativa).* The mixture is allowed to ferment spontaneously at ambient temperature in a tightly closed container for about 15 days. The vessel should not be opened before 15 days and this is the minimum time required for fermentation. Seifu (2013) reported that the composition of *metata ayib* was 42.3, 28.7, 43.7, and 3.2% for moisture, fat, protein and ash content, respectively.

According to Seifu and Tassew (2014), *zure* is manufactured from further processing of fresh whole milk and *arera* or *ergo*. The initial substrate is heated at approximately 30-40°C for 30 minutes in a clay pot or similar container and then *arera* or *ayib* is added and the mixture is then continuously stirred with a wooden stick while heating is still ongoing at the same temperature. The stirring is continued for approximately 20-30 minutes until a thick coalesced semi-solid product called *zure* is formed. After slowly cooling at room temperature, *zure* is separated from the whey and taken out of the pot using a ladle. The addition of *arera* or *ayib* helps for the acidification of the warmed fresh whole milk so as to precipitate the caseins into the coalesced semi-solid product (*zure*) during the heating and stirring period.

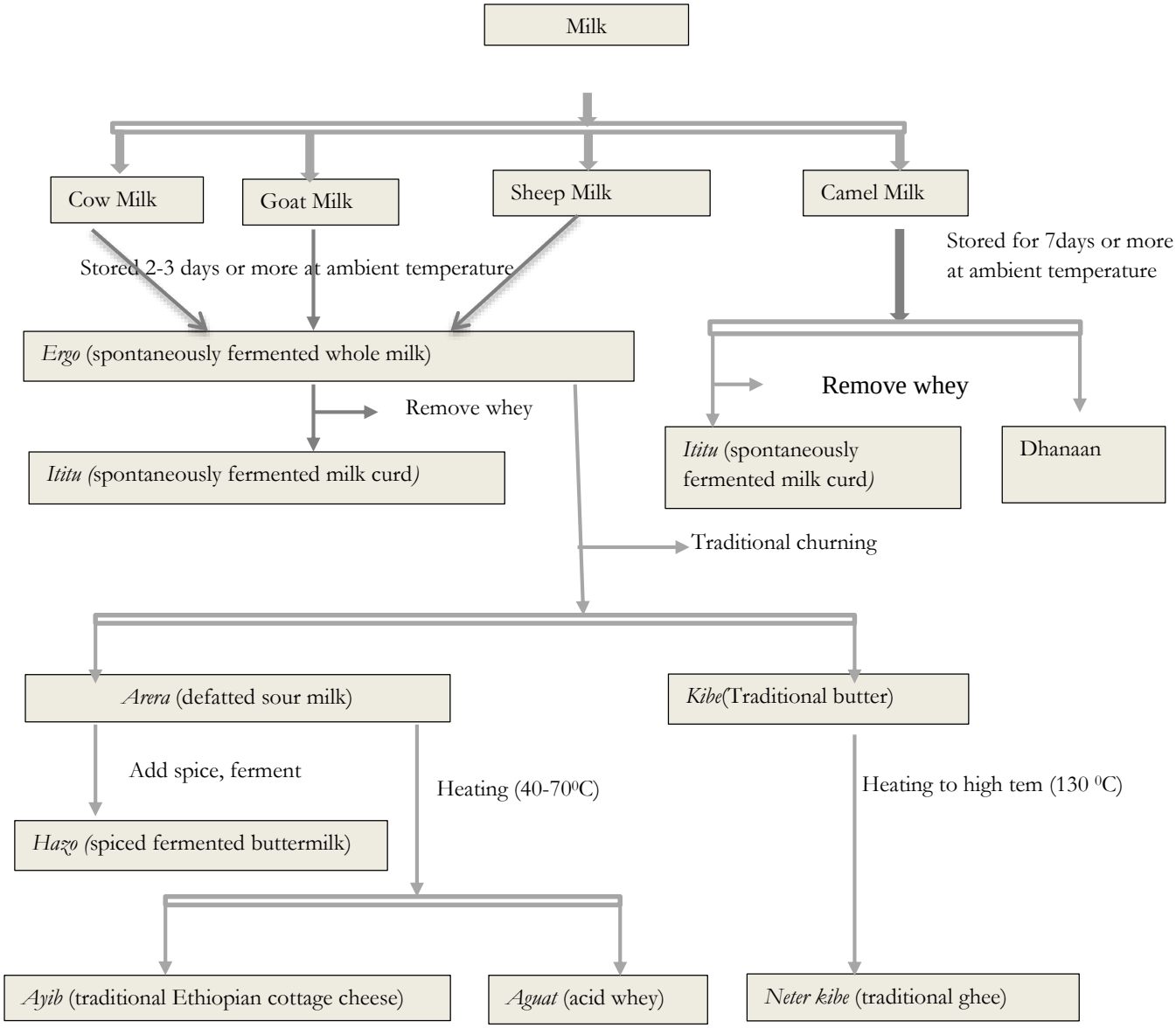

Figure 1.Flow diagram of processing steps of various Ethiopian traditionally fermented dairy products.

*2.3. Kibe (*Traditional Butter)

Processing of cream into butter is not common in Ethiopia and instead *ergo* is the base for traditional butter making (O'Connor and Tripathi, 1992). Milk intended for churning is accumulated over several days by adding fresh milk to the already accumulated fermenting milk. When a sufficient amount of milk has been collected and fermented into *ergo*, it is filled into a traditional churner up to 0.5-0.75 part of the volume of the churner. The churner is then agitated back and forth after covering the mouth of the churner securely with materials such as false banana (*Enset edulis*). After butter granules have coalesced into large grains, the churner is rotated on its base to collect butter grains and to form lumps of butter in the center. The butter is then skimmed off, kneaded in cold water and washed to remove visible residual buttermilk (FAO, 1990). *Kibe* has a relatively good keeping quality and is the most stable of all traditionally processed fermented milk products except *neter kibe* (traditional ghee). *Neter kibe* has shelf life of more than one year without any change (Gonfa *et al*., 1991). *Kibe* has white to light yellowish color. In addition to direct consumption as a side dish, it is used as cooking oil for food preparation, and hair dressing and as a skin cosmetic by both female and male (Gonfa *et al.,* 2001).

The liquid part that remains after the butter grains are collected is called *arera* which is used as a raw

material for *ayib* and *aguat* production. It can also be used for the manufacturing of *hazo* (spiced fermented buttermilk). Yilma *et al.* (2007) reported about 21 liters of milk was needed to produce one kg of butter (83% total solids) and the average fat recovery was 90%. The traditional production of butter from cow milk is common practice in the country; however, the possibility of making butter from camel milk has also been reported. Berhe *et al.* (2013) reported that butter made from camel milk had a fat recovery efficiency of 80% and a churning time of 120 min at a churning temperature of 22ºC. The total solids, fat, acid degree value, pH, melting point and refractive index of the butter were 64.1%, 55.8%, 6.7 mg KOH/g, 4.9, 43.2ºC and 1.4530, respectively. The method of agitation used was rapid swaying of the churn by up and downward movement after hanging the container on a pole using a rope. This method of churning was found to be easy because it mainly requires application of force in the upward direction whereas the downward movement is accompanied by gravitational force and it helped to exert a higher churning force thus facilitating better extraction from camel milk as compared with the common back and forth agitation method.

It has been reported that butter making from camel milk is difficult due to the inherent physicochemical properties of the milk. Camel milk fat globules are more firmly bound to proteins (Khan and Appena, 1967), have smaller size (Yagil and Etzion, 1980) and thicker membrane compared with the fat globule membranes of cow milk fat (Knoess *et al*., 1986). As a result, more force is required to rupture the fat globule membrane from the camel milk fat and allow the globules to coalesce.

2.4. Neter Kibe (Traditional Ghee)

Kibe may be converted into *neter kibe* when there is surplus amount for later consumption and distribution as it can be kept for over one year without any change as reported by Gonfa *et al.* (2001). *Neter kibe* is mainly processed at home, and only in rare cases can be purchased from the market (O'Connor and Tripathi, 1992). It has a grainy texture and a light yellow color and is solid at ambient temperature. It is manufactured by evaporation of the water from *kibe* by heating it over clay or an iron pan. Heating of the melted butter is continued until bubbling stops. Herbs or spices such as *Ocimum hadiense, Ocimum basilicum (basil)*, *Allium sativum (*garlic) and *Zingiber officinale* (ginger*)* may be added during processing for flavor improvement. The *neter kibe* is decanted into another container leaving the scum in the pan. *Neter kibe* is a popular product and is considered as a major food item in the diet. It is consumed in all parts of the country by all classes of people. It is used mainly for cooking purposes, for preparation of different kinds of stew (*dorro wot*) or as a side dish with various foods.

2.5. Arera (Defatted Sour Milk)

Arera is a liquid product that remains after butterfat is separated from *ergo* (fermented whole milk). It has a thin and smooth consistency and basically contains the casein and whey portion of the milk. Its taste and aroma are similar to those of *ergo*. It is either consumed as it is or cooked to produce *ayib*. According to Ehnri (1997), *arera* comprises 91.5% moisture, 3.1% protein, 1.4% fat, 3.4% lactose, and 0.6% ash. The consumption of buttermilk depends on the standard of living of the family and is mainly used to supplement the diets of children and the elderly in rural areas. When surplus amounts are obtained, it is given to calves, lactating cows and dogs. *Arera* has a shorter shelf life compared to all other fermented milk products (24-48 h) even when smoke is applied to the equipment used for its storage due to the high moisture content of the product (Gonfa *et al.,* 2001).

2.6. Hazo (Spiced Fermented Buttermilk)

The production of *hazo* is common in the northern part of Ethiopia (Tigray Regional State) and the main purpose of *hazo* processing is to improve the keeping quality or the nutritional status of the product. Gebreselassie *et al.* (2012) reported that the main processing steps in the manufacturing of *hazo* involves addition of pulses or cereal grain flour as well as flavoring spices (mainly pepper and garlic) to *arera* in a cleaned and smoked container with subsequent fermentation for 2-3 days at ambient temperature. The final product is reddish in color and has a thicker consistency than buttermilk. The reddish color results from the added spices, mainly pepper and the taste is more sour and spicy than buttermilk as a result of the further fermentation and added ingredients.

The shelf life of *hazo* was reported to be 1-2 weeks at ambient temperature (Gebresllasie *et al*., 2012). In addition, the practice of adding newly fermented *hazo* at every week to stored *hazo* is supposed to prevent early spoilage and to extend the shelf life up to one month. According to Gebresllasie et al. (2012), the main herbs and spices added to the fermented buttermilk in one or the other way include *Alium sativum* (Garlic), *Lepidium sativum* (Garden cress), *Ruta chalepensis* (Rue) *Ocimum basilicum* (Basil), *Cuminum cyminum* (Cumin), *Trachyspermum ammi* (Adjwain seed), *Trigonella foenum-graecum* (Fenugreek), *Piper nigrum* (Black pepper), *Nigella sativa* (Nigella), *Zingiber officinale* (Ginger), *Aframomum corrorima* (Ethiopian cardamom), *Curcuma domestica (*Turmeric*)*. *Hazo* is believed to confer health benefits since most of the herbs and spices used had traditional medicinal values. *Hazo* is served as a special drink to guests and respected family members.

2.7. *Agua*t (Acid Whey)

Aguat is the liquid that remains after *ayib* is made from the *arera* and most of the fat and protein in the milk have been removed during the butter and ayib processing. *Aguat* is thus usually given to animals (calves, cows and dogs) and sometimes consumed by humans. It does, however, contain valuable nutrients (whey proteins, amino acids, lactose and minerals) and the protein content of *Augat* has been reported to be 0.75% (O'Connor and Tripathi, 1992). The nutritional content of the liquid (whey) after making of *ayib* vary according to the processing applied and, therefore, the content of protein, minerals and lactose will also vary.

2.8. *Dhanaan* (Ethiopian Fermented Camel Milk)

In Ethiopia, there are two main fermented camel milk products: *dhanaan* (common in Somalia region) and *ititu* (common in Afar/Oromia region). *Dhanaan* is the major fermented camel milk to rural and urban settlements in Somali Regional State (Bekele and Kebebew, 2001). The traditional production of *dhanaan* is based on spontaneous fermentation of camel milk at ambient temperature (25°C to 35°C) over an extended period of time. *Dhanaan* is made by placing fresh camel milk in a clean and smoked container, wrapping the container with a piece of cloth and keeping it at ambient temperature. Back slopping is practiced through inoculation of the fresh milk by previously fermented camel milk (Farah *et al*., 1990).

Seifu (2007) reported that pastoralists in Somali Regional State of eastern Ethiopia produce *dhanaan* for its advantages of perceived high nutritional value; it enables collection of milk over a few days and delivery of the milk to the market when surplus milk is produced. It has also high demand by urban dwellers because of the preference of consumers for its taste and long shelf life as compared to raw camel milk. It has been reported that *dhanaan* has storage stability of more than three months as per the pastoralists' claim. The reported long shelf life of the product could be speculated to the inherent anti-microbial properties of the milk. Kassa and Seifu (2012) reported that the pH, titratable acidity, total protein, fat, total solids, solids-not-fat and ash contents of *dhanaan* samples were found to be 4.18, 1.8, 4.1, 2.5, 11.1, 8.6 and 1.0 %, respectively. Smoking milk containers with Ejersa/Wiger (*Olea africana)*, Kedi *(Balanites galabra)* and Sogsog *(Acacia ethaica)* was common and the pastoralists claim that smoking increases the shelf life of the product and also adds value to the product by improving its taste and aroma. The pastoralists increase the shelf life of *dhanaan* by frequent addition of fresh milk. Shaking is practiced that might be used to prevent the formation of the granules of fat particles and make the lactic acid production continue thus preventing the growth of spoilage microorganisms such as yeasts and moulds (Kassa and Seifu, 2012). Pastoralists claim that, tightly covering the container and putting it in a relatively warm place favors the fermentation of *dhanaan.*

Compared to *ergo, dhanaan* has thin consistency. Camel milk α-lactalbumin showed relatively higher digestibility by pancreatic proteases and has antioxidant activity than bovine α-lactalbumin (Salami *et al*., 2009). This suggests the potential benefit of camel α-lactalbumin to be taken as an ingredient in the infant formula. Human milk lacks β-lactoglobulin but its presence in cow milk causes allergenicity in children; hence its absence in camel milk can be taken as an advantage over cow milk (El-Agamy *et al*., 2009)

2.9. *Ititu* (Spontaneously Fermented Milk Curd)

Ititu is common around Kereyu areas of Eastern Ethiopia (Seifu *et al*., 2012). *Ititu* like *ergo* is commonly produced from raw camel milk without addition of any defined starter cultures. The difference is that *ititu* is allowed to ferment spontaneously at ambient temperature for a long time (up to 14 days or more) in a large traditional fermenting vessel called *Gorfa* and the separation of the whey from the fermented milk is the main manufacturing property of *ititu* (Kassaye *et al*., 1991). When the whole milk has coagulated to produce fermented milk, the whey is removed using a wooden pipette. After removal of the whey, another portion of fresh whole milk is added and the process of whey removal and milk addition continues until enough amount of curd is accumulated, i.e., in about 14 days. *Ititu* is white in color and similar to *ergo* in appearance, but looks more solid, resembling *ayib*. Fermentation of *ititu* is a natural process which is carried out by the spontaneous fermentation process (Ashenafi, 1996).

Ititu is preferably manufactured from camel milk. However, manufacturing of *ititu* from milk of other livestock species such as cows, goats, and sheep is reported among pastoralists of the Borena Zone of the Oromia Regional State (Kassaye *et al.,* 1991). *Ititu* is common in the Somali Regional State and the Kereyu area (between Eastern Oromia and Afar Regional State). The suitability of manufacturing of *ititu* from camel milk may be due to the fact that whey separation from fermented camel milk is more easily achieved than whey separation from cow, sheep, and goat fermented milk. *Ititu* is reported to have good nutritional quality, medicinal properties and shelf life of 2-3 months at ambient temperature of 25-30^{o}C (Gonfa *et al*., 2001). Over-souring and risk of spoilage due to the high frequency of surface mold growth are some of the major problems encountered. Local people control this problem by adding roasted *Trigonella foenumgraceum* (fenugreek) pre-mixed with fresh raw milk and smoking the container with plant species prior to serving.

Smoking of the container using different plat species such as *Acacia nilotica* is a common practice during manufacturing of *ititu*. The lid of the container is washed by rubbing with leaves of *Ocimum basilicum* (basil) and then replaced, trapping some of the smoke inside. Kassaye *et al.* (1991) reported the average pH, titratable acidity (as lactic acid), fat, protein, total solids content of *ititu* produced in Borana region to be 3.65, 1.9, 9.1, 7.2, and 20.9%, respectively. *Lactobacillus casei* and *Lactobacillus plantarum* were the dominant LAB species in the product and they also report that *ititu* had increased contents of free and total amino acids when compared to fresh whole milk and was rich in amino acids such as glutamic acid, alanine, proline, leucine and serine. Similarly, Fekadu and Abrahamsen (1997) reported that *ititu* had 3.3 - 3.7% fat, 3.3 - 3.6% protein and 3.3 - 3.5% lactose. Variation in the results of the chemical composition of *ititu* indicates that the product is not well characterized and standardized in its manufacturing protocol.

3. Conclusion

In this review we found that the dairy processing practice in Ethiopia is characterized by the indigenous processing techniques accompanied with the application of smoking techniques and addition of different spices. Moreover, the traditional dairy products of the country are generally not well characterized and their manufacturing has not been standardized which need further investigations. Therefore, we recommend the huge potential of microbial biodiversity can be utilized through selection and development of technologically important fermenting microorganism to improve the quality and safety of these dairy products. Additionally, there will be a need for studying the functional properties of the camel milk proteins. The absence of β-lactoglobulin as well as the relatively higher digestibility of α-lactalbumin by pancreatic proteases and its antioxidant activity suggests the potential benefit of camel milk in the infant formulations.

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5. References

Abdelabasset, M. and Djamila, K. 2008. Antimicrobial activity of autochthonous lactic acid bacteria isolated from Algerian traditional fermented milk "Raïb". *Afrrican Journal of Biotechnology*, 7 (16): 2908-2914.

Assefa, E., Beyene, F. and Santhanam, A. 2008. Isolation and characterization of inhibitory substance producing lactic acid bacteria from Ergo, Ethiopian traditional fermented milk. *Livestock Research For Rural Development*, 20 (3): 44-47.

Ashenafi, M. 1996. Effect of container smoking and incubation temperature on the microbiological and some biochemical qualities of fermenting *ergo*, traditional Ethiopian sour milk. *International Dairy Journal,* 6: 95–104.

Ashenafi, M. 2006. A review on the microbiology of indigenous fermented foods and beverages of Ethiopia. *Ethiopian Journal of Biological Sciences*, 5(2): 189-245.

Ashenafi, M. and Fikadu, B. 1994. Microbial load, micro flora and keeping quality of raw and pasteurized milk from dairy farm. *African journal of science,* 43: 171-176.

Bekele, T. and Kebebew, T. 2001. Camel Production and Productivity in Eastern Lowlands of Ethiopia. Proceedings of the 9th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 30-31.

Berhe, T, Seifu, E. and Kurtu, M. Y. 2013. Physicochemical properties of butter made from camel milk. *International Dairy Journal*, 31: 51-54.

CSA (Central Statistical Agency) 2017. Population Projection of Ethiopia for all Regions at Wereda Level from 2014 – 2017. Addis Ababa, Ethiopia.

Coppock, D. L., Holden, S. J., O'Connor, C. B. 1991. Milk Processing and Peri-urban Dairy Marketing in Semi-arid Ethiopia and Prospects for Development. ILCA, Addis Ababa Ethiopia, pp.44

Ehnri, 1997. Food composition table for use in Bulletin 468, Ethiopia. Part III. Ethiopian Health and Nutrition Research Institute. Addis Abeba, pp: 34

El-Agamy, E. I., Nawar, M., Shamsia, S. M., Awad, S. and Haenlein, G. F. W. 2009. Are camel milk proteins convenient to the nutrition of cow milk allergic children? *Small Ruminant Research,* 82: 1–6.

FAO (Food and Agriculture Organization) 1990. The technology of traditional milk products in developing countries. FAO Animal Production and Health Paper 85. Food and Agriculture Organization of the United Nations, Rome, Italy, pp: 333.

Farah, Z., Streiff, T. and Bachmann, M. R. 1990. Preparation and consumer acceptability tests of fermented camel milk in Kenya. *Journal of Dairy Research*, 57: 281-283

Fekadu, B. and Abrahamsen, R. K. 1997. Farm made fermented milk and cottage cheese in southern Ethiopia. *Tropical Science,* 37: 75-79

Francesconi, G. N, Heerink, N and Haese, M. D. 2010. Evolution and challenges of dairy supply chains:

Evidence from supermarkets, industries and consumers in Ethiopia. *Food Policy* 35: 60–68.

Gebreselassie, G., Abrahamsen, R. K., Beyene, F and. Narvhus, J. A. 2012. A survey on spontaneously fermented buttermilk in Northern Ethiopia. *African Journal of Food Science and Technology*, 3(3): 78-89.

Gonfa, A., Fite, A., Gashe, B. A., Urga, K. 1991. Survey of the microbial population of indigenous fermented milk. Proceedings: Public Health, 2nd Annual Scientific Conference, Public. Health Association, Addis Ababa, Ethiopia, p. 25

Gonfa, A, Alemu, F., Urga, K., and Abegaz, B. 1999. Microbiological aspects of Ergo (*Ititu*) fermentation. SINET: *Ethiopian Journal of Science*, 22(2): 283-290.

Gonfa, A., Foster, H. A. and Holzapfel, W. H. 2001. Field survey and literature review on traditional fermented milk products of Ethiopia. *International Journal of Food Microbiology*, 68:173-186.

Harlan, J. R. 1969. Ethiopia: A Center of Diversity. *Economic Botany,* 23 (4): 309-314.

Kassa, B. and Seifu, E. 2012. Physicochemical properties and microbiological quality of Dhanaan: traditional fermented camel milk produced in eastern Ethiopia MSc thesis submitted to school of Animal and Range Sciences, Haramaya University, Ethiopia.

Kassaye, T., Simpson, B.K., Smith, J. P. and O'Connor, C. B. 1991. Chemical and microbiological Characteristics of '*Ititu*'. *Milchwissensch,* 46: 649-653.

Khan, K. U., and Appena, T. C. 1967. Carotene and vitamin A in camel milk. *Journal of Nutrition and Dietetics,* 4: 17-20.

Knoess, K. H., Makhudum, A. J., Rafiq, M., and Hafeez, M. 1986. Milk production potential of the dromedary with special reference to the province of Punjab, Pakistan. *World Animal Review,* 57: 11-21.

LSM (Livestock Resources Development Sector, Livestock State Ministry State Ministry, Ministry of Agriculture). 2014. *Livestock sector analysis report*. Addis Ababa, Ethiopia: MoA.

Mekonen, A., Mahder, P. and Moses, N. K. 2011. Isolation and identification of staphylococcus speces from Ethiopian cottage cheese (*Ayib*) from Debrezeit. *Ethiopian Veterinary Research*, 4(1): 13-17.

Mora, D., Fortina, M. G., Parini, C., Daffonchio, D. and Manachini, P. L. 2000. Genomic subpopulations within the species *Pediococcus acidilacti* detected by multilocus typing analysis: relationship between peptide through a three - component regulatory system. *Microbiology.* 146: 2155-2160.

O'Connor, C. B. 1994. *Traditional Cheese Making Manual*. ILCA (International Livestock Center for Africa), Addis Ababa, Ethiopia, pp. 43

O'Connor, C. B. and Tripathi, B. R. 1992. *Milk Processing Techniques*— Sour Milk. ILCA, Addis Ababa, Ethiopia, No. 2, pp. 20.

Salami, M., Yousefi, R., Ehsania, M. R., Razavi, S. H., Chobert, J. M., Haertle, T., Saboury, A. A., Atri, M. S., Niasari N. A., Ahmad, F., Moosavi-Movahedi, A. A. 2009. Enzymatic digestion and antioxidant activity of the native and molten globule states of camel α-lactalbumin: possible significance for use in infant formula. *International Dairy Journal,* 19: 518–523.

Seifu, E. 2007. Handling, preservation and utilization of camel milk and camel milk products in Shinile and Jijiga Zones, eastern Ethiopia. *Livestock Research for Rural Development. Volume 19, Article #86*. Retrieved October 29, 2015, from http://www.lrrd.org/lrrd19/6/seif19086.htm

Seifu, E., 2013. Chemical composition and microbiological quality of *Metata Ayib*: a traditional Ethiopian fermented cottage cheese. *International Food Research Journal*, 20(1): 93-97.

Seifu, E., Abraham, A., Kurtu, M. Y., Yilma, Y. 2012. Isolation and characterization of lactic acid bacteria from *Ititu*: Ethiopian traditional fermented camel milk. *Journal of Camelid Science*, 5: 82-98.

Seifu, E. and Tassew, A. 2014. Small-scale milk processing, utilization and marketing of traditional dairy products in Bahir Dar Zuria and Mecha districts, northwestern Ethiopia. *Journal of Food Technology Research*, 1(3): 122-132.

Tolera, M. 2008. Woody species diversity in a changing landscape in the south-central highlands of Ethiopia. *Agriculture, Ecosystems and Environment,* 128: 52–58.

Yilma, Z, Loiseau, G. and Faye, B. 2007. Manufacturing efficiencies and microbial properties of butter and *Ayib* - Ethiopian cottage cheese. *Livestock Research for Rural Development. Volume 19, Article #88*. Retrieved October 29, 2015, from http://www.lrrd.org/lrrd19/7/yilm19088.htm

Yagil, R. and Etzion, Z. 1980. The effect of drought conditions on the quality of camels' milk. *Journal of Dairy Research*, 47: 159-166.