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Review Article

Common Ethiopian Fermented Products: Beverages-Alcoholic/Semi-Alkali, Dairy Products

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Abstract: Fermented foods play an important role in human nutrition and protecting against infectious diseases. Ethiopia is one of the countries where a wide variety of traditional fermented beverages are prepared and consumed, not only of animal origin, but also of plant origin. In everyday life people enjoy fermented beverages and particularly when having guests, they like to treat them to traditional alcoholic beverages and fermented dairy products. Understanding the properties of traditionally fermented beverages and 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. The traditional beverages deals with popular products ; Among this Borde, shameta, tej, chaka, tella, Korefe, keribo and areki are plant origin brews and 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) are animal origin products that each household produce. Substrates for their production are from locally available raw materials. This publication provides to determine the general principles underlying how the processing and keeping affects traditional fermented food quality, facilitate further investigations of the fermented food mechanisms that affect food quality. The indigenous dairy and traditional fermented beverages products have good nutritional and functional potential to scale up to commercial production. In conclusion, the review discusses the nature of beverage preparation and daily products in Ethiopia and traditional household processing.

Keywords: Fermentation, Traditional fermentation brews, dairy products.

INTRODUCTION

Ethiopia is a country with a huge population of more than 95 million [1] with multi-ethnic groups characterized by old and diversified cultures, languages and history. Fermented foods play an important role in human nutrition and protective role against infectious diseases. The variety of foods and beverages processed and consumed among the various ethnic groups are manifestations of this diversity. The preparation of many indigenous or traditional fermented beverages is still a household art. In Ethiopia, although some data were generated on the economic and nutritional implications of the indigenous fermented Traditional. The aim of this paper was to review studies Made by various researchers on Fermentation and other processing methods of traditional Ethiopian fermented foods which is important in order to design or recommend appropriate manufacturing techniques and to develop indigenous dairy and brew starter cultures.

Traditional fermented beverages-Alcoholic/semi-alkali

Cheka

Cheka is a cereal and vegetable-based fermented beverages which is consumed in Southwestern parts of Ethiopia mainly in Dirashe and Konso. People of all ages including infants, pregnant and lactating women drink cheka. The processes of cheka preparation are very complex

and vary among households, villages and localities. The duration of cheka fermentation varies from 12 hours for menna to months for parshota. The type and proportion of ingredients depend on the volume of cheka to be produced, the availability of the ingredient and type of the cheka being produced. Most cheka preparation methods involve three major phases that are marked by cooking.

Phase I

Grain flour is thoroughly kneaded with water in gebete and allowed to ferment for 14 hours to over a month (in low-land rural areas). In this case, taro leaves are chopped and cooked in a metal or clay pot. The overcooked taro leaves are allowed to ferment for about 6 days in a gebete. The fourth day, the fermented product is mixed with a handful of malt and left to ferment for extra 2 days. Brewers believe that the added malt facilitate the decomposition of the leaves. After that the fermented taro is mixed with fresh flour as usual and is kneaded with water which also ferments for 36-40 hours. This fermenting material is commonly referred to as pulota. In Dirashe, leaf cabbage is chopped into pieces with traditional double-bladed knife prepared only for this purpose. The chopped cabbage is put in a bowl or bath and little quantity of water is sprayed on it. Then, it is tightly covered with leaves of ensete or plastic sheet. Some producers spread small quantity of flour on the surface of cabbage. The cabbage is allowed to ferment for 4 to 6 days and is then blended with small quantity of flour. After fermenting for additional 2-3 days, the fermented cabbage is milled with a grinding stone. The milled product is blended with excess water in a bath and is sieved through wonfit (traditional sieve). The filtrate is mixed with fresh flour, exhaustively kneaded and is allowed to ferment overnight. Some brewers may blend cooked and smashed taro roots kneaded with little flour and the fermented product. However, several brewers in the low land areas of Dirashe allow the chopped cabbage, leaves of moringa or decne to dry and then mill them with some grain (15-20 kilograms) and dried food leftovers, if any. Then, the flour is kneaded with water and allowed to ferment for at least 1 month while being uncovered and the fermenting product is kneaded with little amount of water with an interval of 2-3 days. When leafy vegetables are unavailable, only flour can be used and the fermentation time becomes relatively short. The fermented product is then blended with fresh flour one day earlier before the day it is desired to cook.

Phase II

The fermented product (pulota) is kneaded with little or no water and then made into dough balls called qabot (gafuma). The dough balls shouldn't be less or much moistened. If the balls are less moistened, they become uncooked at the centre and if too moistened they are too tiresome for kneading. During cooking, pieces of dried hop wood or peeled barks of some plants are placed at the bottom of the pot or barrel and excess water is added to prevent the dough balls from burning. If a lot of balls are prepared, most brewers add the dough balls thrice at an interval of 10-15 minutes. The balls are added when the water is boiled (93-95.5°C) and the barrel or pot is covered with a lid or a gourd that fits the pot.

The dough balls are cooked for about 45 minutes to 1½ hours depending on the amount of balls and intensity of the fire. Cooking of the dough balls in water would be expected to gelatinize cereal starch granules and thereby increase the efficiency of starch degradation by amylase. The process of gelatinization occurs over a temperature range depending on the type and size of granules and starch to water ratio. Leaching of amylose occurs during gelatinization and thus create available carbohydrate for the proliferation of fermentation microorganisms [2]. Brewers often insert stick into the balls to check whether they are cooked well or not. When the dough balls are cooked well producers take one ball at a time and dip their hands quickly into water in a container handled by the other hand to avoid damage to them. Then, the qabot is smashed in gebete using a beer bottle or a round-headed (pestle-like) material made from wood called tomambayt.

Once the dough balls are broken down into pieces, they are kneaded with little water and spread on a plastic sheet, large sized gebete or a bed made from wood to cool for few minutes to 7 hours. However, the time of cooling not only depends on the amount of the product, but also the thickness of the product spread on the plastic sheet or gebete. After cooling, it is mixed with adequate milled malt, thoroughly kneaded and allowed to ferment overnight in a gebete. However, most brewers in Dirashe allow this product to ferment for 36-40 hours to enhance the bitterness of the product. Most brewers spread a handful of malt on the surface of the kneaded product. The proportion of malt added during this phase can be as high as 25% of the unmalted ingredient. Next day early in the morning, the product is transferred into large fermentation vessel (barrel or rotto); water is added and is then well mixed together. This actively fermenting material is commonly referred to as sokatet (difdif). Sokatet can be stored for more than a week and so brewers may utilize a portion of it for preparing cheka for home consumption. Some consumers would like to use this product and it is usually given

to respectable people such as hard-workers and close relatives.

Phase III

On the same day the Sokatet is transferred into large containers and mixed with water, a very thick porridge (koldhumat or hanshalt) is prepared by pouring boiling water (94.5-97° C) on to flour in gebete and thorough mixing using a material made from wood for this purpose or a flat cattle bone (Scapula). The porridge is allowed to cool to room temperature for 5-7 hours and malt is kneaded with the cooled porridge. The respondents indicated that the amount of malt added at this stage depends on the strength of the sokatet and amount of cheka being produced. If the sokatet tastes much bitter, small quantity of malt is added or otherwise it would increase. Then, the koldhumat (equivalent term in Dirashe is hanshalt) is added into the vessel containing the sokatet; sufficient water is added and is thoroughly mixed together using a thick stick with flat end. In some cases, brewers use their hands to mix the two products and also to adjust the consistency of the mixed product.

The cheka is ready for consumption after 4-12 hours of fermentation. As the duration of fermentation in the preparation of hiba (Dirashe cheka) is too long, the sokatet becomes much bitter and as a result the amount of malt added into hanshalt in the preparation of fasha (Konso cheka) is slightly larger than for hiba and also the proportion of the sokatet in the final product is much greater than hanshalt in fasha. The amount of malt used during menna preparation is smaller than amount utilized during both hiba and fasha production [3].

Tella

Tella has various vernaculars in the various regions and is a malt beverage based on substrates such as barley, wheat, maize, millet, sorghum, teff or other cereals. It is, by far, the most commonly consumed alcoholic beverage in Ethiopia. According to Samuel Sahle and Berhanu Abegaz Gashe [4], over 2 million hectoliters of tella is thought to be produced annually in households and tella vending houses in Addis Ababa. The way of preparing tella differs between the ethnic groups and depends on tradition and the economic situation. Although the basic processing steps are similar, every tella-maker seems to have her own recipe. The clay container (insera) is washed with water and fresh leaves of grawa (Vernonia amygdalina) several times. The well-cleaned container is then inverted over smoking splinters of weyra (Olea europaea) for about 10 minutes. This will eliminate microorganisms sensitive to antimicrobial components of wood smoke. It also contributes to the desirable flavor of the fermented product. To make bikil (malt), grains of barley or wheat are moistened while in a container and left to germinate for about three days. And this is finally sun-dried. Bikil is the source of amylase for the fermenting cereals used in tella preparation. The gesho plant (Rhamnus prinoides), which is different from hop (Humulus lupulus) is widely cultivated in Ethiopia and is available dried in the local market. Although gesho may have antibacterial effect against some groups of bacteria, its main purpose in the process is to impart the typical bitter taste to tella.

The fermentable grains for tella preparation are usually prepared in two forms. Flours of millet, barely or teff (dark variety) are toasted, milled, mixed in water and baked on a wide metal pan into kita (unleavened bread). The kita is broken into small pieces. Barley flour is separately toasted on a metal pan sprinkling water on it during toasting until it turns dark brown. This is called enkuro. The color of tella, which may vary from light yellow to dark brown, is determined by the extent of baking the kita or toasting the enkuro. Samuel Sahle and Berhanu Abegaz Gashe [4] described the processes and microbiology of tella fermentation. The fermentation is divided into four phases.

During the first phase, powdered leaves of gesho are mixed with water in a small earthen pot and allowed to ferment for four days. The fermenting material is commonly called tinsis. This is transferred to a large earthen pot and the second stage begins by mixing it with barley malt, pounded stems of gesho, pieces of kita and water.

The third stage, chopped pounded stems of gesho, bikil, enkuro and water are added to the container and the contents are mixed into thick slurry called difdif. This is also allowed to ferment for two more days.

At the final stage, the container is filled with water to the brim and the contents are again mixed thoroughly. The container is then sealed to create anaerobic conditions and left to ferment for two more days. At the end of the fermentation, most suspended materials settle to the bottom of the container. The clear liquid is tella.

In general, about 1 kg of gesho (leaves and pounded stems), 0.5 kg of bikil, 15 kg of grains, in the form of kita (5 kg) and enkuro (10 kg) are mixed with 30 liters of water to prepare tella. Good quality tella has a final ethanol content of 2-8% (v/v) and the pH is 4-5 (Samuel Sahle and Berhanu Abegaz Gashe, 1991). When the clear tella is completely decanted from the sediment, fresh water is added to the sediment and mixed well. This is left to ferment. The resulting beverage is known as kirari and is

weaker than the regular tella. It is most often used for family consumption, and sometimes is given to children. The better quality is often kept for guests. Sometimes, at the end of the third stage, a smaller volume of water is mixed with the difdif and a more concentrated tella is obtained by filtering the difdif through a cotton cloth and keeping it in a closed container. Such tella is known as filtered tella. Samuel Sahle and Berhanu Abegaz Gashe [4] reported that the first phase was important to extract the components of gesho. The liquid at this stage was very dark in color with a strong bitter taste. The microbial count increased markedly towards the end of the phase and reduction in content of total carbohydrate and reducing sugar occurred. The microbial flora consisted of molds, Lactobacillus spp. and other bacteria. Molds disappeared, however, towards the end of the phase. Ingredients added in the subsequent phases served as sources of fermenting microorganisms and increased amounts of carbohydrates and reducing sugars. Active fermentation resulted in vigorous foaming and bubbling.

Borde

Borde is a traditional fermented beverage made from maize, barley or wheat and their malts. Its production is based on natural fermentation of the ingredients. It is an opaque, effervescent light brown beverage consumed while at an active stage of fermentation. It is a very popular meal replacement consumed by both children and adults in southern Ethiopia and some other parts of the country. Maize is the most common ingredient for the preparation of borde. The malt is usually made of a mixture of cereals. Kebede Abegaz *et al*., [5] described in detail the processes of borde preparation as practiced in southern Ethiopia.

Cereal for malting is carefully cleaned, rinsed in water several times and soaked in clean water until malting. The malt is then sun-dried and a portion is milled into flour for immediate use. Equipment used for processing, such as clay pots, grinding stones, straw sieves, gourd bottles, etc, are locally available. Production of borde has four major phases.

In phase I, maize grits are immersed in water in a clay pot and left to ferment for 44 to 72 hours. The contents are apportioned in three parts at different periods (44h, 66h and 72h).

In the second phase, the portion obtained at 44h of phase fermentation is cooked on a hot metal pan at 90 o C for 30-45 minutes, into a well roasted granular mass (enkuro). The enkuro is allowed to cool down and fresh malt flour is added to it and blended in water in a clay pot. The clay pot is beforehand washed with water and fresh leaves of Vernonia amygdalina and smoked with glowing splinters of Olea africana. This mixture is known as tinsis and is allowed to ferment for about 24 hours. At this stage, three quarters of the malt component and a quarter of the unmalted ingredient is utilized.

In phase III, a 66h fermented mass from phase I is slightly roasted, cooled, thoroughly kneaded with more flour and water and molded into dough balls. This is steam-baked in a clay pot for 1-1.5 hours and results in cooked dough with pleasant aroma of fresh bread. This is known as gafuma. The gafuma is cooled and blended with tinsis and water into a thick brown mash called difdif. This is allowed to ferment for 18 hours. At phase IV, porridge is made from flour and mixed with fermenting mass obtained from 72h fermentation of phase I. The thick porridge is blended with fermented difdif along with some additional malt and water. This is followed by repeated wet-milling, each followed by slurrying with water and sieving. Borde is usually consumed by low-income groups and, on the average; a laborer consumes two to three liters of borde per day. This amount will sustain the consumer for a good part of the day. It is consumed even in large quantities at cultural festivals, on market days and at collective work gatherings [5]. Many factors could account for the role that many traditional fermented beverages play as meal replacements. The high carbohydrate content coupled with the small amount of alcohol serve as good source of energy.

High microbial count of yeasts and lactic acid bacteria qualify borde as good source of microbial protein. The relatively high lysine content of yeast protein would improve the nutritive value when added to grains such as maize, wheat, etc. According to Kebede Abegaz *et al*., [5], borde is also traditionally used for medical and ritual purposes. Mothers are encouraged to consume borde after giving birth to enhance lactation. It is believed to alleviate problems related to malaria, diarrhea, constipation and abscesses. Children are fed with gafuma and blended borde as meal replacement. According to consumers and brewers, the most important sensory properties of good quality borde are active effervescence, refreshing aroma, uniform turbidity, thick consistency, sweet sour taste and fairly smooth texture [5].

Borde has a short shelf life as it turns too sour to consume after about 4 hours after completion of phase IV of the fermentation. It is, Journal of Natural Sciences Research www.iiste.org ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online) Vol.5, No.15, 2015 99 nevertheless, one of the important nutritious and low alcohol beverages in Ethiopia. Back slopping. Soaked and deeply roasted

wheat flour is mixed with malt and water and allowed to ferment for 24 hours to give borde. Mogessie Ashenafi and Tetemke Mehari (1995) studied microbiological and nutritional properties of ready-to-consume borde in Awassa town and reported that mean pH of the samples was 4.1. Counts of aerobic mesophilic bacteria and lactic acid bacteria were around 10 9 cfu/ml. Counts of Enterobacteriaceae was around 10 6 cfu/ml, and yeast count ranged between 10 7 and 10 8 cfu/ml. Variations in counts were markedly low among the samples. Total protein, soluble protein, fat and ash content of borde was 9.55%, 3.31%, 6.88% and 3.66%, respectively and, compared with the raw ingredient, fermentation resulted in increased protein, fat and ash contents of the finished product. Ketema Bacha *et al*., [6] studied the microbial dynamics of borde fermentation as practiced in Addis Ababa and reported that the ingredients consisted of wheat flour and barley malt and the product was ready for consumption within 12 hours of fermentation. The malt contained a considerable number of aerobic mesophilic bacteria, lactic acid bacteria and yeasts. The aerobic mesophilic bacteria at the start of fermentation were dominated by micrococci, staphylococci, members of Enterobacteriaceae and Bacillus spp. The Grampositive cocci and rods dominated after four hours and coli forms and Enterobacteriaceae disappeared thereafter. Lactic acid bacteria had initial counts of 10 5 cfu/ml and reached counts as high as 10 9 cfu/ml at 24 hours. Hetero fermentative lactobacilli dominated the lactic flora throughout the fermentation and a steady increase in yeast count was observed as the fermentation proceeded. The pH of fermenting borde declined from 5.2 at the start to 3.8 at 12 hours.

Borde is one of the various nutritious and low alcoholic traditional fermented beverages in Ethiopia. The scaling up of such products, although important, may have to be undertaken with great care so as not to lose the nutritive value as well as the public acceptance of the beverages. Identification of the strains important for fermentation and optimization of the process parameters should be done in detail to design mechanisms for production of industrial-based products. Kebede Abegaz *et al*., [7], for example, studied effect of technological modification on fermentation of borde and suggested simpler and shorter process that can yield acceptable borde, but the microbial safety of the product was questionable. Girum Tadesse *et al*., [8] studied survival of E. coli O157:H7, Staphylococcus aureus, Shigella flexneri and Salmonella spp. in fermenting and ready to consume borde.

The fermentation markedly reduced the number of the pathogens but most were detected at low levels at 24h. The various genera of lactic acid bacteria isolated from borde inhibited the test pathogens at different rates [8], and the same test pathogens could survive in ready-to-consume fresh borde for 12 to 24 hours [8].

Areke (sometimes spelt as "Arki")

Areke is a distilled alcoholic beverage. It is a colorless, traditional alcoholic beverage which is distilled from fermentation products prepared in almost the same way as *tella* except that fermentation mass in this case is more concentrated.

Areki is a distilled beverage. It is a colorless, clear, traditional alcoholic beverage which is distilled from fermentation products prepared in almost the same way as tella except that the fermentation mass in this case is more concentrated [9]. Areki is usually brewed in rural and semi-urban areas and is used more commonly by farmers and semi-urban dwellers than by people who live in the cities. In cities, those who drink areki are predominantly lower class people or those who have become dependent on alcohol and cannot afford to buy industrially produced alcohol [10]. Traditionally areki is classified into two: Terra-areki and Dagim-areki. The term dagim in Amharic refers to 'second time' and, indicates that it is distilled second time, whereas the term terra in Amharic refers to 'ordinary'. Terra-areki is a colorless, clear, local alcoholic beverage, which is distilled from a fermentation product known as Yereki-tinsis [11]. According to the report of [11], yereki-tensis is prepared by mixing powdered Gesho leaves and powdered bikil (1:2 ratios) with water to give a mixiture of free flowing consistency, and which will be put aside to ferment for about five days. An amount of Dagussa (Elusine coracann) roughly equivalent to four times that of the bikil, is powdered kneaded with water to make dough and baked into cakes. The hot cakes are broken into pieces, added to the first mixture and with more water, well mixed and again left aside to ferment for about four days. Portions of the second mixture are transferred to the traditional distillation apparatus and distilled to give what is known as terra-areki. The alcohol content of terra-areki was reported to be 34.09% (v/v) [11], and varies between 22.0 – 28.0% (v/v) [12]. Dagim-areki is a stronger type of terra-areki, which is prepared in the same way as terra-areki, except that the distillation process is allowed to proceed for a shorter period of time, or three volumes of terra-areki are redistilled to give about one volume of dagim-areki [11]. The redistilled areki will then have higher alcohol content. The average alcohol content of dagim areki is around 45% (v/v) Selinus R, 1971 [12]. It was also

reported to have a mean value of 46.6% (v/v) ethanol content [11]. Since the government has no control over the production of locally brewed alcoholic drinks, it is difficult to estimate the amount of alcohol production and consumption in Ethiopia [12]. However, the unrecorded alcohol consumption is estimated to be 1.0-liter pure alcohol per capita for population older than 15 years of age for the years after 1995 [10].

Korefe

Korefe is the name of the local beer made in Begemder Province among the Koumant ethnic group.

Dehusked barley is left in water overnight, and after that toasted and milled. It is mixed with water, and dried gesho leaves and fermented in a clay container for 2-3 months. When the beverage is needed, a small quantity of the mixture is taken, more water is added and after a day's fermentation the beverage is ready for consumption.

Tej (Honey Wine)

Tej is a home processed, fermented alcoholic beverage. It is prepared from honey, sugar, water and leaves of *Gesho* (*Rhamnus prepoides*). Preparation procedure was similar to those reported by Bahiru *et al*., [13]. According to Vogel and Gobezie [14], during the preparation of tej, the fermentation pot is seasoned by smoking over smoldering Rhamnus prenoides stems and olive wood. One part ofhoney mixed with 2–5 (v/v) parts of water is placed in the pot, covered with a cloth for 2–3 days to ferment after which wax and top scum is removed. Some portion of them must is boiled with washed and peeled R. prenoides and put back to the fermenting must. The pot is covered and fermented continuously for another 5 days, in warmer weathers, or for 15–20 days, in colder cases. The mixture is stirred daily and finally filtered through cloth to remove sediment and R. prenoides. Good quality tej is yellow, sweet, effervescent and cloudy due to the content of yeasts. The flavor of tej depends upon the part of the country where the bees have collected the nectar and the climate [14].

Keribo

Keribo is produced mainly from barley and sugar. Fermented Keribo constitutes a major part of the beverages being served on holidays, wedding ceremony and also as sources of income of many households. The popularity of this traditional fermented beverage is more reflected among the religious groups and those do not like alcoholic drinks. Being considered as a non- or low- alcoholic beverage, Keribo is popular among both adults and children. It has poor keeping quality with shelf-life of not more than a day or two and it has a pronounced characteristic of the deteriorating beverage at the end of 48 h of fermentation. Keribo is a traditional, non-alcoholic, dark brown colored fermented beverage commonly consumed in rural and urban areas of Jimma zone, southwestern of Ethiopia, with some similarity to Boza of Bulgaria, Albania, Turkey and Romania [15].

It is produced by an over-night fermentation of cereal (barley) predominantly by activities of LAB like the fermentation of shamita [16]. Deep-roasting of the cereal and boiling at about 65-70°C for 15 to 20 min during Keribo preparation must have eliminated most of the contaminant associated with the raw materials. As most of the isolates failed to tolerate temperature above 40°C, the single species of LAB that dominated in the final product must have joined the system from sugar used for fermentation. Efiuvwev were and Akoma [17] reported similar treatment of ingredients at 70°C for 30 min during preparation of pasteurized Nigerian beverage, Kunun-zaki, in which most Journal of Natural Sciences Research www.iiste.org ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online) Vol.5, No.15, 2015 97 of the microorganisms were destroyed except the Bacillus species and the thermo-tolerant lactic acid bacteria [18]. Since the cooking process (deep roasting and boiling at 65 to 70°C) and low pH inactivates the contaminants, contamination of Keribo with Staphylococcus and Enterobacteriaceae could be due to post production contamination. The occurrence of Staphylococcus (0.83%) and Enterobacteriaceae (0.75%) are evidence of poor hygienic conditions of some of the Keribo samples. These organisms may be contaminants from unsafe water used either to dilute the ready-to-consume Keribo or wash utensils. The utensils used for preparation of Keribo and serving are made of low quality plastic and necked-bottles that are difficult to be cleaned. Although, there are no microbiological standards set for the traditional fermented foods/beverages of Ethiopia, the mean counts of staphylococci, Enterobacteriaceae, yeasts and molds observed among the samples of Keribo were on the lowest margin of the standards set for fruit juices served in the Gulf region, indicating the maximum count permitted for total colony count of coliforms, yeast and molds are 1x104, 100 and 1x103 CFU mL-1, respectively [19]. However, the means counts of aerobic spore-formers and aerobic mesophilic bacteria of the samples were 4.96 log CFU mL-1 (with the maximum count of 7.97 log CFU mL-1) and 2.34 log CFU mL-1 (with maximum of 8.31 log CFU mL-1), respectively. On the basis of the Gulf Standards, it is clear that the colony counts of LAB, AMB and ASF in our Keribo samples exceeded the standard by considerable margin. From long history of its safety, the high counts of LAB may not pose

hazard to the health of consumers [18]. The low mean counts of staphylococci also avoid the risk of enterotoxin production as toxin production among these groups is possible after the counts exceed or equals 106 CFU mL-1 [20]. High counts of aerobic mesophilic bacteria may trigger health problems provided that there are potential pathogenic strains among the strains including E. coli and Salmonella species. The microbiology of Keribo samples drawn an intervals during controlled laboratory fermentation were observed to have mean counts of Coliforms, Enterobacteriaceae, Enterococci and Staphylococci below detection level. The two steps heat treatment during Keribo preparation (deep roasting of barley and boiling of roasted barley in water to dissolve it) has contributed to eliminate these bacterial groups. Moreover, the drop in pH level in the course of fermentation due to rise in the level of percent lactic acid could account to the betterment and microbiological safety of the fermented product. Laboratory prepared Keribo had comparable microbial counts with samples obtained from local Keribo brewers in Jimma Zone [18]. Although with steady increase and below detectable level at the end of fermentation, the mean counts of yeasts increased throughout fermentation (over a period of 48 h) of the laboratory prepared Keribo. Likewise, there was an increase in the number of LAB and aerobic spore formers. The growth of yeasts appeared not to be inhibited by the acidity developed by the activities of lactic acid bacteria and proliferation with ease [21]. Although, the first report from traditional Ethiopian fermented beverages, the dominance of Leuconostoc species was reported earlier during the cassava fermentation for gari production [22]. Besides dominating microflora of the final product, several studies have shown that Leu. mesenteroides could also initiate fermentation processes such as the fermentation of idli [23], sauerkraut [24, 25]. Aerobic Mesophilic Bacteria (AMB) initiated Keribo fermentation at 0 h to 6 h as shown by their early leading rate of growth followed by the succession of LAB. The initial high pH 5.75 of the Keribo fermentation at 0 h would explain the reason for growth of Aerobic Mesophilic Bacteria (AMB) while the lower pH (pH = 4.47) at 6 h fermentation began to inhibit their growth. The high numbers of LAB attained after 6 h fermentation was responsible for a marked reduction of pH and increment in TA resulting in inhibition of most Aerobic Mesophilic Bacteria (AMB). Thus, fermentation for 24 h appeared to be a turning point for an accelerated reduction in number of aerobic mesophilic bacteria and stabilization of the maximum numbers of acid producing bacteria involved in Keribo fermentation [18]. Improving the processing condition and upgrading traditionally fermented food production could improve the food in-security problems of the community. In order to produce the desired amount of traditional fermented beverages, it calls for optimization of the production processes and/or techniques. Hence, future studies should include the selection of most suitable strains for starter culture development that may be used to scale up the production of Keribo from house holdslevel to large scale production [18].

Common Ethiopian Fermented Dairy Products

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 [26]. 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 [27, 28]. 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 [29]. Ashenafi [27] 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 nonsmoked containers reached a relatively high level (>108 cfu ml-1) within 12 hours, whereas milk in the smoked container required more than 24 hours to attain the same level. An inhibitory effect of smoking on the pathogen Listeria monocytogenes was reported by Ashenafi and Fikadu [30]. 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 [27]. 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 [31]. The relatively low pH of ergo, ranging from 4.3 to 4.5 [32], 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 [31]. 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.

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).

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 [33]. 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 [34-36]. 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 [31]. According to FAO [33], 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 [37] 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*., [32] 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 isthe dominant cheese produced in Ethiopia, Seifu [36] and Seifu and Tassew [38] 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 [36], 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 40-50oC 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 [36] 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 [38], 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.

Kibe (Traditional Butter)

Processing of cream into butter is not common in Ethiopia and instead ergo is the base for traditional butter making [37]. 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 [33]. 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 [39]. 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 [32]. The liquid part that remains after the butter grains are collected is called arera which is used as a rawmaterial for ayib and aguat production. It can also be used for the manufacturing of hazo (spiced fermented buttermilk). Yilma *et al*., [40] 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*., [41] 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 [42], have smaller size [43] and thicker membrane compared with the fat globule membranes of cow milk fat [44]. As a result, more force is required to rupture the fat globule membrane from the camel milk fat and allow the globules to coalesce.

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*., [32]. Neter kibe is mainly processed at home, and only in rare cases can be purchased from the market [37]. 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.

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 [45], 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 [32].

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*., [46] 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 [46]. 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*., [46], 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.

Aguat (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% [37]. 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.

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 [47]. 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 [48]. Seifu [49] 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 [50] reported that the pH, titratable acidity, total protein, fat, total solids, solidsnot-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 [51]. 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 [52]. 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 [53].

Ititu (Spontaneously Fermented Milk Curd)

Ititu is common around Kereyu areas of Eastern Ethiopia [51]. 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 [54]. 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 [27]. 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 [54]. 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 25-30oC [32]. 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.*, [54] 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 [55] 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.

Future Considerations

Due to the shortage of standardization traditional processing does not have a mechanism to stop the fermentation at a stage where the quality of the product is at its best. More studies must be conducted at the processing effect, nutritional, physic-chemical, storage and keeping quality to draw reliable conclusions about traditional fermented foods.

CONCLUSION

In this review I found that the traditional brew and dairy processing practice in Ethiopia is characterized by the indigenous processing techniques accompanied with the application of basic fermented brews /smoking techniques and addition of different spices. Moreover, the traditional brew and dairy products of the country are generally not well characterized and their manufacturing has not been standardized which need further investigations. Unfortunately, traditional processing does not have a mechanism to stop the fermentation at a stage where the quality of the product is at its best. Therefore, I 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 fermented products.

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