A Review on Traditional Fermented Beverages of Ethiopian

Abstract

Ethiopia is one of the countries where a wide variety of traditional fermented beverages are prepared and consumed. The various traditional fermented beverages consumed in Ethiopia consist of both high alcoholic and low alcoholic beers. This paper reviews the available literature on the Microbiology of Traditional beverages and the diversity of fermented beverages from Ethiopia. The traditional beverages deals with popular products such as *'Kribo', 'Borde', 'Areki'* and *'Tella'*.Here, the nutrional, difference in p^H values and other chemical properties of the products are also presented. In conclusion, the review discusses the nature of beverage preparation in Ethiopia, traditional household processing, the extent and limitation of scientific work done so far and suggests some recommendation to curb the problem.

Key words: *Borde, Kribo, Areki, Tella* , fermentation,

I. INTRODUCTION

In nearly all areas of the world, some type of alcoholic beverage native to its region is prepared and consumed. In Africa, fermented alcoholic beverages are consumed in different occasions such as marriage, naming and rain making ceremonies (Zvauya et al., 1997), at festivals and social gatherings, at burial ceremonies and settling disputes (Steinkraus, 1983). They are also used as medicines for fever and other ailments by adding barks or stems of certain plants (Okafor, 1972). Fermented beverages produced from cereals usually referred to as beers while those produced from fruits are classified as wines (Pederson, 1979).

Traditional recipes are handed down through generation and are still used for food processing in many developing countries (Kebede et al., 2002). The traditionally fermented beverages are low-cost product in all aspect as they are usually manufactured using only rudimentary equipment. Because of their cheapness, low-income groups mostly consume them. Thus their handling and consumption often takes place under conditions of poor hygiene (Steinkraus, 1983).

Ethiopia is a country rich in cultural diversity. The variety of foods and beverages processed and consumed among the various ethnic groups are manifestations of this diversity. Ethiopia is one of the countries where a wide variety of traditional fermented beverages are prepared and consumed. The various traditional fermented beverages are produced on a fairly small scale and usually for local consumption. Among Ethiopian fermented beverages are varieties of *Tella, Tej, brode, areki, Keribo, korefe* consumed in Ethiopia.

Fermentation of tej, *Tella, areki,* and *korefe* like other traditionally fermented alcoholic beverages relies on the microorganisms present in the substrates, fermentation vats, or equipments. So, with the variable micro flora of such spontaneous fermentation variability of the product is imminent.

Ethiopian indigenous fermented beverages are products of acid-alcohol type of fermentation. 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 Alcoholic Beverages in the 1970s, the involvement of

Ethiopian researchers in studying the microbiology of traditional fermented Beverages started only in the 1980's and quite a number of publications have appeared during the last two decades. Considering the rich diversity in fermented beverage types in the country, however, the microbiology of a variety of Ethiopian beverages still remains to be studied. . Most of the works hitherto addressed microbioogical issues on *Tej, Tella, Areki* and *Keribo*. Topics of concern in most of these works were basically fermentation and accompanying changes, processing and Beverages. The aim of this paper was to Review Microbiological studies Made by various researchers on Fermentation, other processing methods, and microbial safety of traditional Ethiopian Alcoholic Beverages.

TRADITIONAL FERMENTED BEVERAGES

Fermented beverages constitute a major part of the diet of traditional African homes serving the fermented beverages are consumed in different occasions such as marriage, naming and rain making ceremonies (Zvauya et al., 1997), at festivals and social gatherings, at burial ceremonies and settling disputes (Steinkraus, 1983). They are also used as medicines for fever and other ailments by adding barks or stems of certain plants (Okafor, 1972). Fermented beverages produced from cereals usually referred to as beers while those produced from fruits are classified as wines (Pederson, 1979).

Microorganisms of various groups appear to be involved in the fermentation of beverages indigenous to different parts of the world. The sources of the microorganisms are usually the ingredients and the traditional utensils used for fermentation processes. Initially, therefore, a wide variety of microorganism are involved but most give way to more adaptive genera as the fermentation goes on. It may, thus be said that the initiation of fermentation of most traditional fermented beverages may be undertaken by different groups of microorganisms as far as sufficient fermentable sugars are available in the substrate. As the fermentation proceeds and the environment becomes more and more acidic, yeasts and lactic acid bacteria dominate the fermentation. These two groups of microorganisms usually determine the alcohol content and flavor of the final product.

Areki Fermentation

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 (Fite *et al*., 1991). *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 (WHO, 2004).

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

Terra-areki is a colorless, clear, local alcoholic beverage, which is distilled from a fermentation product known as *Yereki-tinsis* (Desta , 1977). According to the report of (Desta , 1977), *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) (Desta , 1977), and varies between
22.0 – 28.0% (v/v) (Selinus R., 1971).

Dagim-areki

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* (Desta , 1977). The redistilled *areki* will then have higher alcohol content. The average alcohol content of *dagim areki* is around 45% (v/v) Selinus R, 1971. It was also reported to have a mean value of 46.6% (v/v) ethanol content (Desta , 1977).

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 (Selinus R, 1971). 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 (WHO, 2004).

Chemical properties of the Areki

Table 1: Data of the control experiment for *areki*.

Samples	Measured Value (%v/v)	True Value (% v/v)
1	95.5	96
2	48.8	48
3	25.8	24
4	12.8	12
5	5.0	6

Source: **Tadele Yohannes, Fekadu Melak* and Khalid Siraj (2013)**

Table 2.Experimental results of pH and ethanol level of Ethiopian traditional alcoholic drinks, *areki*.

S/N	**Collection area**		**Alcoholic Content (%v/v)**
1	Qochi	4.30	36.99
2	Ajjip	4.40	33.95
3	Matrik	4.51	39.90
4	Markato	4.49	38.96
5	Menihara	4.48	36.30
6	Average	4.436	37.22

Source: **Tadele Yohannes, Fekadu Melak* and Khalid Siraj (2013)**

Table 3. Percent ethanol content of traditional beverages (*areki*)

Beverages	No. of Samples	Alcohol Contents (%v/v)	Averages
Terra-areki	1	39.80	
	2	38.30	
	3	30.50	37.22
	4	39.50	
	5	38.00	
Dagim-areki*		48.00	

*Only one sample was considered.

The alcoholic content of *terra-areki* varies from 30.50 - 39.80% (v/v) with the average value of 37.22% (v/v).

The alcoholic content of some of the beverages that are most frequently consumed by the masses is very high. According to (Desta, 1977), a comparison of traditional beverage with those that are industrially produced (locally) indicates a potency of similar magnitude. There is a significant difference in alcoholic content between the various traditional beverages (Desta, 1977). Bahiru , 2000).

The mean alcoholic content of Ethiopian traditional beverage varies from report to report. (Desta ,1977), in his survey of alcoholic content of some traditional beverage of Ethiopia, The alcoholic content of *terra-areki* varies from 30.5 - 39.8% (v/v) with the average value of 37.22% (v/v). This ethanol value for *terra- areki* is higher than the reported value. Mean value for *terra-areki* is 34.09. The highest value of ethanol in *Dagim-areki* is reported to be 47.59% (v/v) with a mean value and range of 46.60 and 45.72 – 47.59% (v/v) (Desta , 1977).

The alcohol content of *dagim-areki* is relatively high, 48.00% (v/v), and even *terra areki* has high mean alcohol content, 37.22% (v/v), with a range of 30.20 - 39.80% (v/v). The relatively high alcohol content of the traditional distilled liquor (*areki*) is a matter of concern in terms of alcoholism that may be rapidly introduced and also considering the high and ever expanding production and consumption of these products (Desta , 1977).

Keribo Fermentation

Keribo is an indigenous traditional fermented beverage produced and consumed in different parts of the country, including Jimma zone. It 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 in Jimma zone. 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 (Blandino *et al*., 2003). It is produced by an over-night fermentation of cereal (barley) predominantly by activities of LAB like the fermentation of shamita (Bacha *et al*., 1999).

High count of LAB could account for acidification of the product with extension of fermentation periods. LAB has been involved in the natural fermentation of many traditional Ethiopian fermented foods and beverages (Bahiru *et al*., 2006).

Deep-roasting o f 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 (1997) reported similar treatment of ingredients at 70°C for 30 min during preparation of pasteurized Nigerian beverage, Kunun-zaki, in which most of the microorganisms were destroyed except the *Bacillus* species and the thermo-tolerant lactic acid bacteria(Rashid *et al*.,2013).

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 $1x10^4$, 100 and $1x10^3$ CFU mL^{-1}, respectively (Gulf Standards, 2000). 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 (Rashid *et al*., 2013).

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 10^6 CFU mL^{-1} (James, 2000). 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 (Rashid *et al*., 2013).

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 (Etchells *et al*., 1943).

Although, the first report from traditional Ethiopian fermented beverages, the dominance of *Leuconostoc* species was reported earlier during the cassava fermentation for gari production (Okafor, 1977). 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 (Mukherjee *et al*., 1965), sauerkraut (Pederson and Albury, 1969; Steinkraus, 1992).

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 (Rashid *et al*.,2013). Thereafter, the LAB entered steady growth and showed relative decline during 36 h fermentation that corresponds with lactic acid production. This was because the cocci which would normally initiate fermentation were suppressed by rapid decrease in pH with accelerated increase in acidity followed by high growth rate of LAB responsible for end fermentation. This result was in agreement with the

disappearance of *Leu. mesenteroides* beyond the first 48 h of the cassava fermentation during *fufu* production due to its inability to tolerate the increasing acidity of the fermenting mash.

The microbiological analysis of common sugar used in *Keribo* preparation was showed LAB with the same morphological and physiological characteristic which was similar to LAB obtained from dynamics and sample collected from venders. Overall, the results obtained from analysis of *Keribo* samples, laboratory fermented *Keribo* (dynamics) and samples of sugar used for the making of *Keribo* were similar in morphological and physiological characteristics. Therefore, the addition of sugar and yeast to un-malted, deeply roasted and boiled barley to initiate fermentation of *Keribo* is the possible source of LAB responsible for Keribo fermentation (Rashid *et al*.,2013).

Antimicrobial resistance has been increasing in many parts of the world; it becomes increasingly important to monitor the antimicrobial susceptibility of lactic acid bacteria isolated from food and drinks including *Keribo*. All *Leu. mesenteroids* isolates were resistant to vancomycin and susceptible to penicillin G, gentamicin, ampicilin. The low resistance to the commonly used antibiotics of these strains could show low contribution of these strains in the dissemination of resistance genes to potential pathogens in the environment, including fermented foods. Thus, the observed intrinsic resistance of LAB to vancomycin could be the result of natural resistance of the isolates (Salminen *et al*., 1998).

To sum-up, during production and sales, venders and local processors must always keep their personal hygiene to discourage contamination. Sellers should also ensure that they do not expose the fermented products during display because this may predispose them to contamination. 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 households-level to large scale production (Rashid *et al*., 2013).

***Borde* fermentation**

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*. (2002) 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 (Kebede Abegaz *et al*., 2002). 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*. (2002), *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 (Kebede Abegaz *et al*., 2002). *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, 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*. (1998) 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 Gram-positive 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*. (2004), 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*. (2005b) 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 24 h. The various genera of lactic acid bacteria isolated from *borde* inhibited the test pathogens at different rates (Girum Tadesse *et al.*, 2005a), and the same test pathogens could survive in ready-to-consume fresh *borde* for 12 to 24 hours (Girum Tadesse *et al*., 2005b).

Tella fermentation

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 (1991), 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 (1991) 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. This is left to ferment for two more days. During the third stage, chopped pounded stems of *gesho*, *bikil*, *enkuro* and water are added to the container and the contents are mixed into a 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 (1991) 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.

Table 4 Changes in total aerobic count, moisture content and pH occurring during the fermentation of *tella*.

phase	Fermentation time	PH	Moisture	Total aerobic count CFU*/ml
I (0-4 days)	0	5.2	95.6	$2x10^3$
	1	5.2	95.6	$4x10^3$
	2	5.1	95.6	$1x10^4$
	3	5.0	94.8	$2\ x10^6$
II (4-6 days)	4	4.7	94.5	$3\ x10^6$
	5	4.6	83.1	$3x10^7$
III (6-8 days)	6	4.8	84.8	$7\ x10^7$
IV (8-12 days)	8	4.6	74.0	$1\ x10^8$
	10	4.5	93.4	$1\ x10^8$
	12	3.9	96.6	$9x10^7$

*CFU = Colony forming units

Source: Samuel Sahle and Berhanu Abegaz Gashe (1991)

The fermenting organisms were composed of *Saccharomyces* spp., (mostly *S. cerevisieae*) and *Lactobacillus* spp. (mostly *Lactobacillus pastorianumi*). The yeasts dominated the fermenting flora after the end of the first stage till the completion of fermentation. Increase in alcohol content was accompanied by yeast growth and decrease in reducing sugars and total carbohydrates.

The pH and ethanol content are in the range of 4.5-4.8 and 2.8-5.0% (v/v) respectively, when *tella* is considered to be the most suitable for consumption. After ten days of fermentation, *tella* becomes too sour to consume due to the growth of *Acetobacter* spp. which convert ethanol to acetic acid under aerobic conditions. According to Alemu Fite *et al*. (1991), *tella* collected from Debre Berhan, Ataye and Addis Ababa had alcohol content of 2.4-3.3%, 2.1-2.7% and 1.6-2.8%, respectively. Mean fusel oil content for the three places was 59 ppm, 59 ppm and 47 ppm, respectively and mean methanol content was 55 ppm, 27 ppm and 28 ppm, respectively. Belachew Desta (1977), in his survey of alcoholic content of some traditional beverages of Ethiopia, found that the ethanol content of *tella* ranged from 5.65% to 6.56%.

Table 5 The microbial flora of fermenting *tella* (CFU/ml).

Fermentation Time (day)	*Arthrobacter spp*	*Bacillus spp*	*Acetobacter* spp.*	*Lactobacillus* spp.**	*Saccharomyces* spp.***	Molds
0	$1x10^{2}$	$1\ x10^{2}$	$1\ x10^{2}$	$1\ x10^{2}$	-	**2** $x10^{2}$
1	$1\ x10^{3}$	$3\ x10^{2}$	$2\ x10^{2}$	**4** $x10^{2}$	-	**2** $x10^{2}$
2	$1\ x10^{3}$	$3\ x10^{2}$	$5\ x10^{2}$	**1** $x10^{3}$	-	**2** $x10^{3}$
3	$2\ x10^{5}$	$3\ x10^{3}$	$6\ x10^{2}$	**4** $x10^{3}$	**2** $x10^{3}$	-
4	$2\ x10^{6}$	$4\ x10^{5}$	$8x10^{3}$	**2** $x10^{4}$	**6** $x10^{5}$	-
5	$2\ x10^{5}$	$8\ x10^{5}$	**2x**10^{4}	**1** $x10^{5}$	**2** $x10^{7}$	-
6	$2\ x10^{5}$	$1\ x10^{6}$	**6x**10^{4}	**7** $x10^{5}$	**6** $x10^{7}$	-
8	$2\ x10^{5}$	$8\ x10^{4}$	**5x**10^{5}	**3** $x10^{6}$	**9** $x10^{7}$	-
10	$5\ x10^{5}$	$4\ x10^{2}$	**5x**10^{6}	**2** $x10^{7}$	**9** $x10^{7}$	-
12	$3\ x10^{5}$	-	**8**10^{7}	**7** $x10^{6}$	**39** $x10^{6}$	-

**Acetobacter xylinum* was the most predominant species

***Lactobacillus pastorianum* was the most abundant species

****Saccharomyces cerevisieae* was the most abundant species

Source: Samuel Sahle and Berhanu Abegaz Gashe (1991)

Conclusion

The traditional beverage preparation is predominantly a household phenomenon in Ethiopia. The Beer industry in the country is not well developed. Every household appears to process traditional beverage starting from raw ingredients to the final products. In cases where fermentation is important to obtain a certain product, the microorganisms naturally present on the raw ingredients or in the containers spontaneously take care of the process. The creation of a suitable environment for the microorganisms to result in a desirable product is based on women's indigenous knowledge, which has improved through generations.

The majority of the microbiological studies conducted so far have concentrated on those traditional beverages popular among the people inhabiting the central and northern highlands of the country. People living in other regions of Ethiopia either have their own distinct fermented

products or have a different version of a product consumed by those living in other regions. Microbiological studies must be extended to other less-known indigenous beverages, the popularity of which is limited only to the areas of origin. This may help to come across novel microorganisms with novel metabolites, which subsequently may have industrial application.

Most of the fermentation studies hiether to attempt to describe the microbiological successions and the accompanying chemical changes during the fermentation process. As can be observed in previous studies, different workers reported different values for the parameters they measured during the fermentation process. Microbiological and chemical variability in the various products could be attributed to the spontaneous fermentation, as this depends on the micro flora naturally present in the substrates, on utensils and equipment used. The different metabolic products of these randomized micro flora at different stages, the physical and chemical environments and duration of fermentation have influence on the succession of microorganisms during fermentation and consequently result in microbiological and chemical variability of products at the time they are ready for consumption.

Attempts should be made to undertake controlled fermentation studies with selected mixed culture starters and to optimize the process conditions. This would result in products which are consistent and definable in their flavor and other biochemical parameters have good keeping quality and are, in general, wholesome. This may pave the way for large-scale commercial production. Large-scale production, in addition to improving the keeping quality of the products, has the advantage of reducing wastage during processing, which is significant at household level.

The beverages considered so far are preserved products in that their keeping quality is improved considerably over that of the raw materials from which they are made. 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. Consequently, although other spoilage microorganisms or pathogens may not grow in the products, the keeping quality of the fermented products is compromised because the same microorganisms responsible for the acceptable attributes of the products would make the products too sour to consume after a few days. Studies are, thus, needed to control the spoilage process of fermented products.

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