Fermenter Technology Modification Changes Microbiological and Physicochemical Parameters, Improves Sensory Characteristics in the Fermentation of Tella: An Ethiopian Traditional Fermented Alcoholic Beverage

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Abstract
Tella is an indigenous, a home processed and commercially available traditional fermented alcoholic beverage in Ethiopia. It is a main source of income for low-income women in Ethiopia. Tella gets easily spoiled and causes economic loss, as result; brewed in small amount while there are many users. This study investigated effects of fermenter technology modification on microbiological, pshysicochemical parameters and sensory characteristic of tella brewed in modified and traditional fermenters. Experiments were conducted using modified and traditional fermenters. Microbiological analysis was done for the fermenting mashes at 12 h interval. The physicochemical parameters consisted of pH, TA, Mash and environmental temperatures, Total carbohydrate, reducing sugar and ethanol content were determined. Sensory evaluation was performed for tella brewed in modified and traditional fermenters using Sensory attributes such as appearance and color, aroma, taste, strength (alcoholic) and overall acceptability. The counts of lactobacillus, lactococcus, yeasts and aerobic mesophilic bacteria showed increment during the first two phases in both fermenters but gradually decreased at phase IV in both fermenters. The counts of Enterobacteriaceae were high at day zero and not detected at phase II in both fermenters. Acetic acid bacteria were detected at the beginning of phase II in traditional fermenter but at phase III in modified fermenter. Total carbohydrate was 26.4 mg/ml and 25.7 mg/ml at day zero in modified and traditional fermenters respectively and reached 77 mg/ml at phase III in modified and 78.1 mg/ml in traditional fermenter and then has shown decrement in next phases. Ethanol was detected at phase II in both fermenters and showed gradual increment with fermentation period. Aroma, taste and alcoholic strength were superior for tella brewed in modified fermenter. Using appropriate fermenter technology is important to brew tella with preferable sensory attributes, to make its brewing continuous, and generate continuous income.

Keywords: Alcoholic beverage; Modified fermenter; Physicochemical parameters; Sensory attributes; Tella

Introduction
Fermentation is a widely practiced ancient technology and fermented foods are an essential part of diets in all regions of the world. Traditional fermented beverages are those that are indigenous to a particular area and have been developed by the local people using age-old techniques and locally available raw materials [1]. Nearly in 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 [2], at festivals and social gatherings, at burial ceremonies and settling disputes [3]. Some information is available on the microbiology and biochemical properties of a variety of African traditional fermented beverages such as the Ethiopian tella, borde and shamita [4-7], the Nigerian pito and burukut [8], the Zambian munkoyo [9], the Southern African bantu or sorghum beer [10], the Zimbabwean chibuku and mulewu [11], the Sudanese merissa and bulu-wur [12,13], the Kenyan bussa [14], the Egyptian bouza [15], the Ugandan busheera [16], Zimbabwean masvusvu and mangisi [2], and the Tanzanian togwa and mbege [17-19].

Ethiopian traditional fermented indigenous beverages are described by some Ethiopian scholars. These include ‘tej’ [20,21], ‘tella’ [4,22], borde and shamita [5-7], and borde [23-25].

The traditional methods and age-old techniques of food processing are still used in developing countries especially in communities with economic status. The traditional fermentation processes and the potential for their modernization are increasingly attracting the attention of scientists and policy makers as a vital part of food security strategies [26] and commercial use. Developing countries require food processing technologies that are appropriate, suitable for their regions and affordable to rural and urban economies.

The house hold-level fermentation is indigenous technology and has been developed for a wide range of foods and beverages from an extensive range of raw materials. Moreover, such type of fermentation has limitations. Some of the limitations are; the fermentation process takes long time, the brewed product easily get spoiled, and if not sold/consumed within short period of time, causes economic loss. However, the transformation of home-based arts in to modern industries necessities acquisition of scientific knowledge of the raw materials and the processes used [27] so that the problems involved in scaling up can be addressed.

The recommended research priorities on traditional fermented foods are improving the understanding of fermentation processes; refining the processes; increasing the utilization of processes and

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Received March 01, 2014; Accepted March 25, 2014; Published April 13, 2014

Citation: Berza B, Wolde A (2014) Fermenter Technology Modification Changes Microbiological and Physico-chemical Parameters, Improves Sensory Characteristics in the Fermentation of Tella: An Ethiopian Traditional Fermented Alcoholic Beverage. J Food Process Technol 5: 316. doi:10.4172/2157-7110.1000316

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developing local capacities [28], and developing and/or modifying appropriate technology to extend shelf-life of these foods and beverages.

Tella, an opaque, light yellow to dark brown colored alcoholic beverage (ethanol content 2-8% (v/v), pH 4-5), is indigenous to Ethiopia [4]. It is a home processed and commercially available indigenous traditional fermented alcoholic beverage. It is a malt beverage brewed from various cereals such as barley (Hordeum vulgare L.), wheat (Triticum sativum), maize (Zea mays), millet (Eleusine coracana), sorghum (Sorghum bicolor), teff (Eragrostis tef) and others.

In Ethiopia, methods of brewing tella differ slightly between and within the regions and ethnic groups respectively and depend on tradition and the economic situation of the brewers. Although the basic processing steps are similar, but every tella-brewer seems to have her own recipe.

Tella is the main source of income for many low income women in towns and cities of Ethiopia. Similar to other traditional fermented foods and beverages in Africa, tella preparation is traditional and only a household art. Besides its importance, its fermentation takes relatively long time (7-15 days) [4] consisting of four easily modifiable phases. Moreover, tella gets easily spoiled within short period of time and causes tremendous economic loss to brewers. As a result, brewers brew small amount of tella that must be sold/consumed within a short period of time. Consequently, traditional brewers were food non-secured and lead life without any surplus. Hence, the problem requires solution and should be addressed through research and technology modification and/or development.

Therefore, traditional tella fermentation could be scaled-up through development of starter culture technology to shorten processing time, by developing appropriate technology for increasing the shelf-life, and making fermentation processes continuous by modifying and/or developing fermenter as result continuously generation of income could be achieved.

To our knowledge, there is scanty published information on the microbiological and physicochemical changes and sensory characteristics associated with technology modification and processing factors on the fermentation of tella. Therefore, the objective of this research was to investigate the effects of fermenter technology modification on microbiological, physico-chemical parameters and the Sensory characteristics of tella.

Materials and Methods

Barley (Hordeum vulgare L.) or wheat (Triticum sativum) of any variety may be used as source of bikil (malt) for brewing tella. In this study, wheat (Triticum sativum) was used. It was first cleaned to remove dirt and extraneous materials and then steeped in clean water for 24 h at room temperature (16-25°C). Excess water was drained and wheat was packed in a container and placed to germinate for 72 h. After germination, the malt was sun dried and milled to coarse powder.

The dried leaves of gesho (Rhamnus prinoides) were purchased from local market at Debre Markos town and further sun dried at Debre Markos University, Department of Biology, Microbiology Laboratory. The well dried gesho (Rhamnus prinoides) leaves were pounded to powder using a wooden mortar and pestle. The fresh leaves of grawa (Vernonia amygdalina) were collected and used to wash and scrub fermenters. The leaves of Vernonia amygdalina are refuted for their detergent agent activities and expected to contain antimicrobial role [4]. Dried weyra wood (Olea europaea) and tunjut leaves (Otosegna integrifolia) were used for smoking the inside part of the fermenters for 10-20 min.

Fermenter technology modification

Description of fermenters: In this study, two fermenters were used, the modified and traditional fermenters. The modified fermenter was served as experimental and the traditional fermenter was as control. There were differences between the two fermenters.

The modified fermenter: In the modified fermenter, there are set ups connecting four small fermenters one another (representing the four phases in traditional tella fermentation). There were three valves controlling the passage of contents from first fermenter (phase I) to second (phase II), second fermenter (phase II) to the third fermenter (phase III) and then from the third fermenter (phase III) to the fourth fermenter (phase IV) (Figure 1). The flow of contents in this fermenter is unidirectional (from phase I to II, II to III and then from III to IV).

The modified fermenter was sealed with plastic material to create anaerobic condition and was opened only during addition of ingredients, and the sample removal was through valves (Figure 1) without opening the sealed mouth of the fermenter. Tella for consumption was removed through the valves in a similar manner as sample removal.

The traditional fermenter: During fermentation, the fourth phases are completed using two fermenters. These fermenters were not connected as in modified one. The first fermenter completes phase I and the second fermenter completes phases II, III and IV. When the fermentation of the first phase completed, all the contents of the first fermenter were poured in to the second fermenter, where phase II begins. After the completion of fermentation of phase II, ingredients were added in to the same fermenter and addition of ingredients continued in to the same fermenter until fermentation completed (phase IV). The ingredients were added when fermentation time at each phase was completed. The fermenter was sealed with plastic material and opened during addition of ingredients, sample removal and during removal of tella for consumption.

Steps in tella fermentation

The traditional fermentation of tella has four major phases marked by the introduction of ingredients in to fermenters at different times. The details of traditional tella fermentation processes were described in Sahle and Gashe [4]. However, due to variations in the use of raw materials, the four phases and fermentation setup are described briefly hereunder. Tella brewing was carried out by a brewer woman by making use of fermentation setup prepared in a microbiology laboratory, the
Phase I: Powdered leaves of Gesho (Rhamnus prinoides) (0.103 Kg), Bikil (malt) (0.308 kg) and water (1.250 litter) were separately added in to each fermenters (modified fermenter and traditional) and mixed well in each fermenter. The content in each fermenter was then allowed to ferment for (3 days) at room temperature. This fermenting material is commonly called *tinnisi* (starter development stage).

Phase II: When the fermentation of *tinnisi* in each fermenter was completed (4 th days), to the *tinnisi* both fermenters, powdered malt (0.075 kg), powdered leaves of *Rhamnus prinoides* (0.038 kg), pieces of *kitta* (unleavened bread) (0.6083 Kg) and water (1.50 litres) were added and the content in both fermenters was left to ferment for 1 more day. This phase is more of starter adaptation period.

Phase III: Maize (*Zea mays*) was roasted to make *asher* (roasted Maize). The amount of heat treatment is controlled by the breeder and researchers, there for between 70 °C to 100°C. Roasted maize has color imparting to final the *tella*. Since the researchers were interested in *tella* with brown coloration, the maize seeds were roasted to brown color. The roasted maize was milled to a granular powder and water was sprinkled on it and then placed on a hot breit mitad (griddle made of a flat thick iron sheet) and steamed to make *enkuro*. After 24 h fermentation of phase II of each fermenter, *enkuro* (1.368 kg) was added to each fermenters and the content was thoroughly mixed in each fermenter. Following addition of *enkuro* thick mash was produced. The resulting thick mass is known as *difidif*. *Difidif* in each fermenter was then left to ferment for further one more day.

Phase IV: After 24 h, to the *difidif* in both fermenters, 1.250 liters of water was added and the content was further mixed thoroughly. This addition of water was enough to fill the fermenters to the rim. This phase serves as a dilution phase and helps in proper completion of fermentation. The filled fermenters were covered with plastic material and sealed to create anaerobic conditions and left to ferment for 2 more days. Samples were removed at 12 h regular intervals for analysis of microbial, physical and chemical parameters. The volume of sample removed at each time from each fermenter was about 100ml.

Microbiological analysis of ingredients

One gram of each of the following ingredients: bikil flour, gesho, *kitta* or ashero was separately mixed with 9ml sterile distilled water in a screw capped sterile bottles. The mixture of each ingredient was shaken thoroughly at normal speed for 2-3min. One ml of the supernatant of each ingredient was then serially diluted. Aliquots of 0.1ml of each ingredient from appropriate dilutions were separately spread plated in duplicate on MRS, PCA, M17, VRBGA, Frauter’s ethanol medium (FEM) and YGC agar plates. Each plate was incubated at appropriate temperature for respective days.

Microbiological enumeration of fermenting mash

From each fermenter, 25 g or mL of sample was aseptically taken using sterile beaker or crucible and transferred separately to a screw capped bottle containing 225 mL sterile 0.1% peptone water and then homogenized by shaking for 2-3 min, at ‘normal’ speed. The homogenate was then serially diluted and aliquots of 0.1 mL from appropriate dilutions were spread-plated in duplicate on the following agar plates: violet red bile glucose (VRBG), plate count agar (PCA), MRS, M17, Frauter’s ethanol medium (FEM) and yeast extract glucose chloramphenicol bromophenol blue (YGC). All the culture media were from Oxoid, except YGC, which consisted of (gram L-1); yeast extract, 5.0; glucose, 20.0; chloramphenicol, 0.1; bromophenol blue, 0.01; agar, 15; pH, 6.0 to 6.2 and Frateur’s ethanol medium ,which consisted of (gram L-1); yeast extract, 10 g; CaCO3, 20 g; ethanol, 20 ml; agar, 20 g and distilled water, 1000 ml. After incubation at 30°C for 24 h, purple-red colonies on VRBG agar plates were counted as Enterobacteriaceae (EB). The total Aerobic Mesophilic Bacteria Count (AMC) was enumerated on PCA plates after incubation at 30°C for 48 h. Colonies of Lactobacillus (LB) and Lactococcus (LC) were counted on MRS and M17 agar plates respectively after anaerobic incubation at 30°C for 72 h. The yeast and mold colonies were counted on YGC plates after incubation at 28°C for 3 to 5 days and acetic acid bacteria (AAB) were counted on FEM after incubation in aerobic condition at 30°C for 4 days. The viable counts of EB, AMC, LAB (Lactobacillus and Lactococcus), AAB or yeasts and molds from their respective duplicate countable plates were reported as log CFU.

Measurement of physicochemical parameters

The temperatures of the fermenting mash in both fermenters and the room wherein the fermentation was carried out were recorded at 12 regular intervals. The changes in pH were recorded using digital pH meter (ORION 420A, Boston, USA) after calibration at 25°C using buffers of pH 4 and 7 (Merck KGaA, 64271 Darmstadt, Germany). The pH of thick samples was measured after blending with distilled sterile water at 1:1 ratio (w/v) in to thick slurry. Trituratable acidity (TA), expressed as a percentage lactic acid, was determined by titrating 5ml samples with 0.1 N NaOH using 0.5% phenolphthalein as indicator. Total carbohydrate (TC) was determined using the phenol-sulphuric acid method as described in Dubois et al. [29]. Reducing sugar (RS) was estimated following the procedures described in Clark and Switzer [30]. Ethanol content was estimated using the procedures of Williams and Reese [31].

Sensory evaluation

A consumer-oriented panel of judges was used to assess the sensory quality of *tella* produced during this experimental study. Sensory attributes were evaluated by eleven trained judges who regularly consume *tella*. *Tella* samples were taken from each fermenter and coded with random numbers and presented in 100ml beakers to judges. Each judge evaluates *tella* from both fermenters. Samples were then evaluated for sensory attributes that include appearance and color, aroma, taste, strength (alcoholic) and overall acceptability. The panelists were instructed to sip water before and after assessing each sample. The judges were asked to evaluate sensory attributes of each sample using 5 - point rating scales; 5 = excellent, 4 = very good,3 = good,2 = Fair,1 = poor .Each treatment was evaluated twice by each panelist.

Statistical analysis

Physicochemical parameters were computed at each fermentation phase, in both modified and traditional fermenters. The sensory evaluation data obtained during consumption at end of phase IV. Calculations were made using the statistical software for windows 8. Both physicochemical parameters and sensory evaluation data were analyzed and compared between modified and traditional fermenters using two-tailed student’s t-test at 95% confidence interval. The results of microbiological analysis were transformed to log CFU.

Results and Discussion

Microbial counts of major ingredients of *tella*

Based on the nature of the ingredients, the distribution of the
microbial community is variable (Table 1). *Gesho* (*Rhamnus prinoides*) and *bikil* (malt) were major sources of yeasts and *bikil* (malt) was the major source of Lactic Acid Bacteria (LAB). Acetic acid bacteria were not detected from any ingredient; similarly Enterobacteriaceae and yeasts were not detected in *ashero* and *kita*.

**Table 1:** The high heat treatment applied during preparation of *Kita* and *Ashero* probably inactivated the growth and viability of susceptible microorganisms.

### Changes in microbial, physical and chemical parameters

**Phase I:** During this phase, there are changes in microbiological, chemical and physical parameters. There was an increasing trend in microbial counts except Enterobacteriaceae (EB) and mash temperature, while the counts of EB, total carbohydrate, reducing sugar and pH were decreased (Figures 2 and 3). The changes in all physicochemical parameters at this phase were statistically non-significant. At the beginning (day 0) the counts of lactobacillus (LB) were 5.11 and 5.21 log CFU/ml in traditional and modified fermenters respectively, whereas the counts of lactococcus (LC), yeasts and Aerobic Mesophilic Bacteria (AMB) in both fermenters were in similar and in the ranges 4.01-4.51 log CFU/ml or gram. Duration of the Fermentation (Figures 2A and 2B). This could be due to the breakdown of macromolecules that generate heat in the fermenting mash where acid producing bacteria and other microorganisms producing secondary metabolites are growing fast [4]. Moreover; the extraction of the contents of *Rhamnus prinoides*, which impart special bitter taste to *tella* and also its antimicrobial activity was reported in Sahle and Gashe [4] and Andualem and Gessesse[32] that might inhibit the growth of spoiling microorganisms [22]. The sharp decrease of EB counts while the other microbial counts (except AAB) increased is due to decrease in pH resulted from the active growth of acid producing microorganisms. The low pH could be responsible for inhibition and inactivation of the growth of EB [23,33,34] Figures 2A and 2B.

**Phase II:** At the beginning of this phase, to the fermenting green and foamy *tinsis*, powdered malt, powdered leaves of *Rhamnus prinoides*, pieces of *kitta* (unleavened bread) and water were separately added to each fermenter and thoroughly mixed. The counts of EB become below detectable level and AAB detection began in traditional fermenter and still not detected in modified fermenter. There were no significant changes in microbial counts during this phase, which might be because; this phase is of selective adaptation of competitive microorganisms developed in the previous phase and serve as starter culture for next phases too [22]. Total carbohydrates increased from 16.4 to 62.8 mg/ml and 15.8 to 62.1 mg/ml in modified and traditional fermenters respectively (Figures 3A and 3B). Similarly, reducing sugars which were sealed and the fermentation condition was anaerobic. There are major Changes in microbial counts, physical and chemical parameters (Figures 2A and 2B). This could be due to the breakdown of macromolecules that generate heat in the fermenting mash where acid producing bacteria and other microorganisms producing secondary metabolites are growing fast [4]. Moreover; the extraction of the contents of *Rhamnus prinoides*, which impart special bitter taste to *tella* and also its antimicrobial activity was reported in Sahle and Gashe [4] and Andualem and Gessesse[32] that might inhibit the growth of spoiling microorganisms [22]. The sharp decrease of EB counts while the other microbial counts (except AAB) increased is due to decrease in pH resulted from the active growth of acid producing microorganisms. The low pH could be responsible for inhibition and inactivation of the growth of EB [23,33,34] Figures 2A and 2B.

![Figure 2A: The microbial dynamic of the modified fermenter.](image1)

![Figure 2B: The microbial dynamic of the traditional fermenter.](image2)

| Ingredient | Enterobacteriaceae | Yeasts | Lactobacillus | Lactococcus | Acetic acid bacteria | Aerobic Mesophilic counts |
|------------|-------------------|-------|---------------|-------------|---------------------|--------------------------|
| GESHO      | 5.86 ± 0.01       | 5.55 ± 0.21 | 0.00 ± 0.00   | 0.00 ± 0.00 | 0.00 ± 0.00         | 5.85 ± 0.91              |
| BIKIL      | 5.88 ± 0.11       | 5.77 ± 0.10   | 5.52 ± 0.32   | 5.79 ± 0.00 | 0.00 ± 0.00         | 5.97 ± 0.63              |
| KITA       | 0.00 ± 0.00       | 0.00 ± 0.00   | 0.00 ± 0.00   | 0.00 ± 0.00 | 0.00 ± 0.00         | 4.8 ± 0.12               |
| ASHERO     | 0.00 ± 0.00       | 0.00 ± 0.00   | 0.00 ± 0.00   | 0.00 ± 0.00 | 0.00 ± 0.00         | 4.83 ± 0.34              |

*Figure 2A:* The microbial dynamic of the modified fermenter.

*Figure 2B:* The microbial dynamic of the traditional fermenter.
Phase IV from 0.8% in traditional fermenter at phase II to 5.1% in the same fermenter at phase IV (Figures 3A and 3B). All the changes in physicochemical parameters at this phase were non-significant except pH. The increase in ethanol content was related with decrease in total carbohydrate and reducing sugar and this is in agreement with Sahle and Gashe [4]. The growth of acetic acid began during day 3 in the traditional fermenter and at day 5 in the modified fermenter. This is probably due to gradual increment in alcohol concentration in both fermenters but in the case of traditional fermenter, the sample removal raised from 5.6 to 19 mg/ml in both fermenters (Figures 3A and 3B).

The changes in total carbohydrate, pH and mash temperature were significantly higher in modified fermenter. This increment is due to additional of carbohydrate rich ingredients (malt and Kita) and the trend is in agreement with Sahle and Gashe [4]. Ethanol detection began at this phase in both fermenters, this is also in line with Sahle and Gashe [4]. Even though; the general trend showed lowering of pH with when fermentation time increases, but no changes in pH at this phase in both fermenters (Figures 5A and 5B). The mash temperatures increased almost by 1°C in both fermenters (Figures 5A and 5B). This is probably due to high heat generated as result of substrate breakdown by the action fermenting microorganisms and/or their enzymes (Figures 3A and 3B).

**Phase III:** During this phase (day 5), enkuro was added to both fermenters and the content was thoroughly mixed. Enkuro is carbohydrate rich ingredient, producing thick mass is known as difidif. There were no significant changes in microbial count at this phase (Figures 2A and 2B). The total carbohydrate was reached to 77 gm/ml in modified fermenter and 78.1 gm/ml in Traditional (Figures 3A and 3B). The maximum mash temperature of (27.1°C) and (26.4°C) was recorded in modified and traditional fermenters respectively (Figures 4A and 4B). The percentage of ethanol also began to raise in this phase (Figures 3A and 3B). The changes in pH, ethanol and total carbohydrate values were significantly higher in modified fermenter. Total carbohydrate was increased and maximum following addition of enkuro in phase, this result is in line with Sahle and Gashe [4] (Figures 4A and 4B).

**Phase IV:** During this phase, there was no addition of ingredients to both fermenters except water. The addition of water is to fill the fermenters to the rim. The concentration of ethanol was raised from 0.6% at phase II in modified fermenter to 4.3% in the same fermenter at
was by opening the sealed fermenter by exposing to atmospheric oxygen that initiates the growth of acetic acid bacteria. The acetic acid bacteria increased to 3.0 log CFU/ml at this phase in both fermenters. The growth of acetic acid bacteria at in the modified fermenter at this phase may be due to exposure to oxygen when adding ingredients. The ethanol content in this research was 4.3% in modified fermenter and 5.1% in traditional fermenter, and this is in the same range as in Sahle and Gashe [4] who experimentally determined the ethanol content of Tella at Addis Ababa (Ethiopia) and Yohannes et al. [35] who collected samples of Ethiopian traditional fermented beverages from Jimma City, South West Ethiopia. But the results of this work has showed some variations when comparing with these author, probably due to (1) difference in ingredients used for the preparation of Tella, (2) the difference in recipe of Tella brewing among brewer women and differences in fermenting containers. In traditional Tella fermentation, fermenters made of clay materials such as Insera and Gan were commonly used [4,35]. But due to easily breakability of these clay fermenters, now days, brewers prefer to use plastic fermenters as in our research (Figures 5A and 5B).

Total titratable acidity increased from zero at day zero to 0.71 percent at day 7 in modified fermenter and from zero to 0.69 percent at the same fermentation period in traditional fermenter. This could be due to the activities of acid producing microorganisms breaking down sugars to produce different acids and other secondary metabolites. This work is in agreement with those other scholars [2,4]. The special and unique taste of Tella which makes it popular to Ethiopia consumers was achieved at end of fermentation periods, following increased production of lactic acid and ethanol, and probably due to the growth of non-saccharomyces yeasts that produce flavor imparting secondary metabolites. The special and unique taste of could be the combination attributes of ethanol, lactic acid and other secondary fermentation products produced by microorganisms.

The sensory evaluation results revealed that Tella from both fermenters was acceptable by consumers with regard to all sensory characteristics. As shown in (Figure 6), all the sensory attributes of Tella from modified fermenter outweighed that of traditional fermenter.

In the figure above AC=Appearance and Color, AB=Aroma, Tast= Taste, Strength=Alcoholic, Tot=Over all acceptability.

In both fermenters, none of the sensory attribute was rated as excellent by all assessors. Strength (alcoholic strength), aroma and taste of Tella were rated as very good and the difference is statistically significantly higher in modified fermenter compared to traditional one. Even though, the color of Tella from both fermenters was comparable, relatively Tella color from the traditional fermenter was preferred. The preferred sensory attributes from the modified fermenter may be due to reduced oxidation, conversion of ethanol to lactic acid and better production of secondary metabolites that might have roles in sensory characteristics.

Conclusion

In this research we brewed Tella with very good sensory attributes, made the brewing process continuous, modified fermenter (from fed batch to continuous mode). As result of fermenter modification, growth and detection of acetic acid bacteria was delayed, Tella having preferable sensory characteristics was produced, implying that fermenter modification is vital for continuous production of Tella with very good sensory qualities that again help in continuous generation of income for low income women in Ethiopian Towns and Cities. Developing and upgrading traditional fermentation processes and fermenters might play role in food security.

Acknowledgment

We are grateful to Debre Markos University for funding this work under project code RCS-BST/04/11. We wish to thank the brewer women Yeshi Alawekewum
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