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Preparation and Quality Evaluation on Local Beverage (*Tella*) Prepared with Clay Pot (*Insira*) and Plastic Jar in North-Eastern Ethiopia

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ABSTRACT

Tella is one of an indigenous traditional fermented alcoholic beverage in Ethiopia and the most commonly consumed in different occasions such as marriage, and other social gatherings. Based on the ingredient used and ethnic group, *tella* has various vernaculars in the country. The common container to prepare *tella* has been clay pot (*insira*) even though plastic container is currently preferred with respect to availability and non-fragility. However, the quality of *tella* prepared using plastic container was observed to be different from that of clay container. In the present study, *tella* was prepared using clay pot container (*insira*) and plastic jar in two towns having different mean annual temperature. Ethanol level, pH, specific gravity, turbidity, and color were measured and found in the range of (5.91 - 6.41% v/v), (4.44 - 4.91), (1.00 - 1.01), (4.70-4.83), and (69.33 – 75.47), respectively. The result showed that Ethanol level (5.91%), pH (4.91), specific gravity (1.01), turbidity (4.83), and color (75.47) were found in *tella* prepared using clay pot in Dessie town. The difference in Ethanol level and pH value within *tella* samples in clay pot and plastic jar were significant ($p \leq 0.05$). Sensory evaluation was also performed using sensory attributes: bitterness, flavor, color, and turbidity. The analytical sensory test result showed that the overall acceptability of *tella* prepared using clay container in Dessie (3.43) > clay container in Kombolcha (3.27) > plastic jar in Dessie (3.19) > plastic jar in Kombolcha (2.97). According to our study based on the lowest ethanol level and most acceptability in sensory attributes of traditional beverage, clay pot is a convenient container for preparation of *tella*.

Keywords: *Tella*, Clay pot, Plastic jar, Ethanol level, Sensory.

INTRODUCTION

Fermentation is a chemical process by which organic compounds are broken down under anaerobic conditions with the help of microbes and play an important role for the production of food and beverage products (Mani, 2018). Fermenting food is a means of preservation, improving nutritional quality and enhancing sensory characteristics (Ashenafi & Mehari, 1995; Marsh et al., 2014). Fermented beverages have been a part of the human diet in almost all countries for millennia and have an inseparable relationship with the life of humankind in history. These fermented beverages are usually prepared from locally available materials using age-old techniques, and their art is believed to pass down by cultural and traditional values to subsequent generations (Worku et al., 2015).

In Africa, traditionally 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). Ethiopia is one of the countries where a variety of traditional fermented foods and beverages are produced on a small scale and usually for local consumption (Steinkraus, 1983; Teshome et al., 2017).

Indigenous Ethiopian fermented beverages are *tella, tej, borde, shamita, areki, keribo, korefe* (Sahle & Gashe, 1991; Vogel & Gobezie, 1983; Fite et al., 1991). *Tella* is a very popular traditional alcoholic beverage and has different vernaculars in the various regions reflecting the ethnics and ingredients for production: Amhara *tella*, Tigray *siwa*, Oromo *tella*, and Gurage *tella* (Fite et al., 1991). Amhara *tella* and Tigray siwa have g

esho (*Rhamnus prenoids*) whereas Gurage *tella* is delicately flavored with a variety of spices; Oromo *tella* has no *gesho*, and it is thick sweet taste

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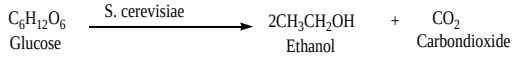
(Vogel & Gobezie, 1983). *Tella* production process utilizes the natural microorganisms present on the ingredients for fermentation (Arroyo-Lopez et al., 2009). *Saccharomyces cerevisiae* and *Lactobacillus pastorianumi* are the major organisms and *S. cerevisiae* is most importantly responsible to change glucose into ethanol and carbon dioxide (Lee et al., 2015; Andualem et al., 2017). The chemical equation below summarizes the conversion (Arroyo-Lopez et al., 2009; Gasmalla et al., 2012; Tekluu et al., 2015)



Scheme 1: Chemical equation for the conversion of glucose in to ethanol and carbon dioxide.

During fermentation, the change of temperature is inevitable and can be originated from the climate change and biochemical reaction along depolymerization carbohydrate (Arroyo-Lopez et al., 2009). Temperature is a very useful factor on the alcoholic beverage fermentation and which has been previously showed the influence on growth rate of S. cerevisiae with positive and linear effect in the interval 15-35 ºC (Amato et al., 2006; Arroyo-Lopez et al., 2009).

Tella is brewed from barely (*Hordeum vuldare*), wheat (*Triticum sativum*), maize (*Zea mays*), millet (*Eleusine coracana*), sorghum (Sorghum bicolor), tef (*Eragrostis tef*), *gesho* (*Rhamnus prenoids*) and variety of spices (Sahle & Gashe, 1991). Grains mainly provide starch, which is made up of long chains of glucose units, and production of ethanol is necessarily breaking down the chains of this carbohydrate for obtaining glucose syrup (Vohra et al., 2014).

Although the way of preparing *tella* differs among ethnic groups, traditions, and economic situation, the basic processing steps are similar (Getachew, 2015; Lee et al., 2015). A container, which is used for *tella* preparation, is usually cleaned with water and leaves of *grawa* (*Vernonia amygdalina*) and then fumigated by the smoke of burning chips of *weyra* (*Olea africana*) to eliminate some adverse microorganisms and to get the desirable flavor of the fermented product (Getaye et al., 2018). Leaves and stems of *gesho* plant (*Rhamnus prinoides*) are chopped, sun-dried and pounded into finer powder to make beverages biologically stable and impart the typical bitter taste (Ketema et al., 1998; Berhanu & Teshome, 1995).

Malt (*bikil*) is a major source of the dominant yeast in *tella* and can be prepared from different grains: barely, wheat, maize, and sorghum or finger millet (Berhanu & Teshome, 1995). The grains are first cleansed of all chaff, broken kernels and extraneous materials, rinsed repeatedly followed by soaking in water for one day. After draining excess water, the grains are wrapped in false banana (Ensete ventricosum) or other large leaves and kept moist. The germination takes 2 days for finger millet and 3 days for other cereals. After removal of non-germinated grains, germination is halted by sun drying. The malt is then stored separately in a dry place until required (Kebede et al., 2002).

Flour of millet or barely or *tef* (dark variety) is toasted, milled, mixed with water and baked on a wide metal pan into *kita* (a thin, 5 to 10 mm thick, pancake- like bread). Barely flour is toasted on *mitad*, sprinkled with water and toasted until it becomes dark brown to form what is known as *enkuro* (Getaye et al., 2018). *Kita* (unleavened bread) and enkuro (toasted flour) are determinant of *tella* flavor and color which may vary from dark brown to dark (Chala, 2019; Getachew, 2015). When all the necessary ingredients are ready, *tella* fermentation process has different phases and is then provided for consumption either filtered to yield what is popularly known as filter-*tella* or diluted with water and drank as a regular *tella* (unfiltered *tella*) (Berhanu & Teshome, 1995).

Several studies analyzed quality of *tella* with respect to Ethanol level, pH, specific gravity and color, and range of results are 2-8% (v/v), 4-5, 1.003-1.008 and 40-70, respectively (Tekluu et al., 2015; Getachew, 2015). Very common container for preparation of *tella* has been clay pot (*insira* or *gan*) (Berhanu & Teshome, 1995; Getachew, 2015). However, nowadays people are using plastic container for preparation. In fact, plastic containers are affordable and non-fragile as compared to clay pot.

In Ethiopia, people claim that the quality of *tella* prepared using clay container and plastic jar has significant difference. To the best of our knowledge, there is no study has been conducted on the effect of different type of container for production of local traditional beverage '*Tella*'. In the present study, we attempt to investigate the difference in quality of local beverage *tella* prepared using clay container and plastic jar in the North-Eastern Ethiopia, as part of Amhara regional study covering two towns (Dessie and Kombolcha) having different mean annual temperature (Fazzini et al., 2015).

MATERIALS AND METHODS

Study area:

Dessie and Kmobolcha are found in South Wollo Zone, Amhara National Regional state, Ethiopia. Dessie is located between 11°8′N and 11.133°N, and 39°38′E and 39.633°E, with an elevation between 2,470 and 2,550 meters above sea level. Its maximum and minimum annually average

temperatures are 23.1 ºC and 7.4 ºC, respectively. Kombolcha is also located between 11°5′N and 11.083°N, 39°44′E and 39.733°E with an elevation between 1842 and 1915 meters above sea level. The highest and the lowest annually average temperatures of Kombolcha are 35.2 ºC and 11.3 ºC, respectively.

Materials

The clay container (*insira*), plastic jar, maize, wheat, *bikil* (malt from barely), and *gesho* (*Rhamnus prenoids*) were purchased from local market in Dessie town.

Fig. 1: Flow chart of traditional preparation of *tella* (Mulaw & Tesfaye, 2017).

Preparation of *tella*

Tella preparation was purposely conducted at vendors' house in Dessie and Kombolcha at the same time and the researchers followed the steps exactly similar to the usual practiced processes (Berhanu & Teshome, 1995; Getachew, 2015). Both clay container (*insira*) (20 L) and plastic jar (20 L) were used at each study place and washed with water and fresh leaves of *grawa* (*Vernonia amygdalina*) several times until they were believed clean. The well-cleaned containers were fumigated with splinters of *weyra* (*Olea africana*) wood for about 10 minutes and then fermentation process was started. The preparation of *tella* was conducted based on flow charts as shown in Fig. 1. The fermentation was processed with four phases and each phase was designated as stage I, II, III and IV. In stage I, 0.4 kg powder of *gesho* leaves was soaked in 1 L water for 2 days in each clay container and plastic jar simultaneously in both study cities. In stage II, 4 kg *kita*, which was made from maize flour and broken into small pieces, 0.3 kg milled *bikil* and 0.2 kg the pounded *gesho* stems were added and mixed to the fermented mixture which was already prepared at the first phase. The mixture was left again to ferment for 2 days. In stage III: 3 kg *enkuro* (prepared from wheat) was mixed into thick slurry and allowed to ferment for 2 days. In stage IV, the fermented slurry was diluted with water to the brim and mixed thoroughly. The containers were sealed (Fig. 2) using piece of cotton cloth to create anaerobic condition and left for 2 days and then unfiltered *tella* was decanted for a drink (Fig. 3).

Sampling

Four samples of prepared *tella*, which were two samples from clay container and two samples from plastic jar, were taken from both study place

Fig. 2: Photo of as prepared *tella* sealed Clay pot (*insira*) and plastic jar to create anaerobic condition.

Fig. 3: Photo of as prepared unfiltered *tella*

(Dessie and Kombolcha) for laboratory analysis. Purposive sampling technique was used for sensory evaluation of *tella*. Accordingly, eleven regular *tella* consumers were subjected to taste the prepared *tella* and were interviewed for their assessment of the quality of *tella* prepared using clay and plastic containers for both study areas.

Physicochemical measurement of *tella*

All the physicochemical analyses (Ethanol level, pH, Specific gravity, turbidity and color) were done in the laboratories of quality control of St. George Brewery at Kombolcha, Wollo, Ethiopia and the result is tabulated in Table1.Triplicate measurements were taken for each samples.

pH measurement

The pH of each sample was measured by dipping the electrode of digital pH meter to the samples. The pH electrode was rinsed with deionized water before each measurement.

Ethanol level

The ethanol level of each sample was determined with Alcohol meter (Anton Paar).

Specific gravity

The specific gravity of the sample was determined using a pycnometer. The weights of an empty

pycnometer, pycnometer with distilled water, and pycnometer with the samples were measured using a balance (Sartorius BP211D).

Color

The absorbance of each *tella* sample was measured using a Jenway model 7315 spectrophotometer set at 430 nm against water blank. The spectrophotometer was set up in concentration mode to calculate the European Brewery Convention (EBC) value directly.

Turbidity

Turbidity of each sample was measured by Haze meter, with the percentage of light deflected from the incoming light direction.

Temperature

The temperatures of fermenting place room wherein the fermentation carried out were recorded at 12 regular intervals. During preparation of *tella* for this study case the average temperatures were 21 ºC and 27 ºC at Dessie and Kombolcha, respectively.

Sensory evaluation

Prior to be enlisted in the consumer and descriptive panel, eleven members (two women, nine men, and ages 22–59 years) were selected by purposive sampling technique and briefed about the study to enable them to make an informed decision (Lawless & Heymann, 2010). Members were free to withdraw from the study at any time. *Tella* samples (Table 2) were scored by a semi trained sensory panel using a quantitative descriptive analysis. The panel was composed of regular customers at vendor house who had been screened for familiarity with the product and were spaced about 1 meter in a booth area to avoid interaction. Sessions were conducted at the vendor house under air conditioned (outside of house) and language used for sensory testing was Amharic. The panelists were selected to give their perception regarding bitterness, turbidity, color and flavor. The panelists rinsed their mouths with water before and after testing each sample. A 4-level hedonic test was used: 4=excellent, 3=very good, 2=good, 1=poor. All the members of panelists were used in both study cities.

RESULTS

Measurement of Physicochemical parameters

Ethanol level of *tella* samples, which were prepared using both clay pot container and plastic jar in the same time by following similar processes in Dessie and Kombolcha, ranged between 5.91% (v/v) and 6.41% (v/v) (Table 1). *Tella* prepared in Dessie using clay pot had the lowest ethanol level 5.91% (v/v), while in Kombolcha with plastic jar had the highest 6.41% (v/v). The statistical analysis revealed that ethanol level of *tella* prepared at the same place with different container showed variations ($p \leq 0.05$), whereas at various place with the same container were not significantly different from each other. The pH measurements 4.91, 4.46, 4.62 and 4.44 were for *tella* samples prepared using clay container in Dessie, plastic jar in Dessie, clay container in Kombolcha and plastic jar in Kombolcha, respectively (Table 1). The pH value of *tella* prepared at same place using clay container and plastic jar showed variations ($p \leq 0.05$). The specific gravity measurements of all samples were in the range of 1.00-1.01. The turbidity measurements revealed that the highest (4.82) value was recorded from clay container in Dessie and the smallest one (4.47) was from plastic jar in Kombolcha. The measured colors of *tella* samples also resulted in the highest (75.47) value for the one prepared using clay container in Dessie and the smallest (69.33) one for the sample prepared using plastic jar in Kombolcha.

Table 1: Experimental result of *tella* samples

Samples	Ethanol %v/v	pH	Specific gravity	Turbidity (EBC)*	Color (EBC) *
1	5.91±0.051	4.91±0.040	1.01±0.000	4.83±0.015	75.47±0.447
2	6.38±0.045	4.44±0.264	1.00±0.001	4.7±0.020	71.48±1.146
3	6.20±0.199	4.62±0.040	1.01±0.001	4.73±0.015	73.7±0.535
4	6.41±0.083	4.46±0.161	1.00±0.001	4.47±0.020	69.33±0.420

Key: *Tella* prepared with: Clay container in Dessie (sample number 1), Clay container in Kombolcha (sample number 2), Plastic jar in Dessie (sample number 3), Plastic jar in Kombolcha (sample number 4); Values are mean of triplicate measurements and expressed as mean + Standard deviation.
*Turbidity and color share the same unit in the brewing industry (EBC: European Brewery Convention) but their meanings are still different.

The sensory evaluation result (Table 2) showed that the overall acceptability of *tella* samples prepared using clay container and plastic jar was observed as: Clay container in Dessie > Clay container in Kombolcha > Plastic jar in Dessie > Plastic jar in Kombolcha. Bitterness liking scales

were recorded as the highest (3.18) from clay container in Dessie and the smallest (2.45) from plastic jar in Kombolcha whereas the highest (3.82) turbidity liking score was observed from plastic jar in Kombolcha and the smallest (3.27) was recorded from clay pot in Dessie. Flavor and color liking scales were also recorded as flavor highest (3.72) from clay pot in Dessie; flavor smallest (2.45) from plastic jar in Kombolcha; color highest (3.5) from clay pot in Dessie and color smallest (3.18) from plastic jar in Kombolcha.

Table 2: Sensory Attributes of *tella* samples (Consumer liking scores: bitterness liking, flavor liking, turbidity liking, color liking, and overall liking)

Samples	Bitterness	Flavor	Turbidity	Color	OA
1	3.18	3.72	3.27	3.54	3.43
2	2.90	2.81	3.63	3.45	3.19
3	2.90	3.45	3.36	3.36	3.27
4	2.45	2.45	3.82	3.18	2.97

Key: *Tella* prepared with: Clay container in Dessie (sample number 1), Plastic jar in Dessie (sample number 2), Clay container in Kombolcha (sample number 3), and Plastic jar in Kombolcha (sample number 4), OA: Overall acceptability. Scale test results: 4= excellent, 3= very good, 2= good, 1=poor

DISCUSSION

Physicochemical measurements

Preparation of *tella* has common basic processing steps in the country, even though there is difference among ethnic groups, traditions and economic situation with respect to the ingredients used (Getachew, 2015; Lee et al., 2015). The common container has been clay pot (*insira*) however, plastic container was also used since people are currently using plastic jar and then quality evaluation was done. *Tella* prepared using clay pot and plastic jar in Dessie and Kombolcha town showed alcoholic content variation. The result showed that ethanol level of *tella* prepared using plastic in Kombolcha (6.41%) > plastic in Dessie (6.38) > clay pot in Kombolcha (6.20%) > clay pot in Dessie (5.91).

According to (Berza & Wolde, 2014) alcoholic content on production of *tella* depends on population of microorganisms that enhance the fermentation process and in turn decreases the amounts of reducing sugar and total carbohydrate of ingredients. The counts of lactic acid bacteria, yeasts, aerobic mesophilic bacteria and temperature gradually increased along fermentation period (Ketema et al., 1998) and temperature supported the increment of microorganisms count in *tella* preparation process (Getnet & Birhanu, 2016).

Plastic container can hold the temperature formed inside fermented materials whereas clay container cannot maintain heat due to some evaporates through porous materials (Fred et al., 2013; Packiyam et al., 2016). The change of temperature along *tella* preparation process might be varying within container types whereby plastic jar could have higher temperature than clay container during fermentation process. Thus, plastic jar might be supportive to the rate of *tella* fermentation in changing carbohydrate into alcohol. Apart from the effect of container type there was some statistical calculation difference in ethanol level of *tella* prepared with clay in Kombolcha and Dessie. Thus, higher alcoholic content was measured from clay pot in Kombolcha. The environmental temperature difference of Dessie and Kombolcha town may be another effect to the result obtained variation between two samples of *tella* prepared using the same storage but in different place.

According to (Sahle & Gashe, 1991) the pH value of *tella*, this has good quality, ranged from 4 to 5. In this study the pH value of *tella* prepared using clay pot and plastic jar were evaluated and results lied within the reported range. The pH value of *tella* prepared using clay pot and plastic jar had shown significant difference and *tella* samples having higher acidic property were observed in plastic jar in the same study place. The change of alcohol into acid is due to the production of acetic acid by the microorganisms that involve in the fermentation and brings change in the process of *tella* making (Lucas et al., 2013; Guesh & Anteneh, 2017).

The turbidity value of *tella* prepared using clay pot (4.83) in Dessie, plastic jar (4.7) in Dessie; clay pot (4.73) in Kombolcha and plastic jar (4.43) in Kombolcha. The result showed that turbidity of tella reduced in plastic jar compared with clay pot in the same study place. On the other hand, turbidity variation was observed within the same container in different place. Turbidity of *tella* from clay pot (4.73) in Kombolcha < clay pot (4.83) in Dessie, and turbidity of *tella* from plastic jar (4.43) in Kombolcha < plastic jar (4.7) in Dessie. This could be due to an increment of microbes along temperature change that enhance breakdown of

macromolecule and similar to that reported by Arroyo-Lopez et al. (2009). According to (Chala, 2019; Getachew, 2015) and the standard of European Brewery Convention (EBC) the color of *tella* samples were found to be into two categories: *tella* prepared using clay pot in Kombolcha (73.7) and Dessie (75.45) lied to dark brown whereas *tella* prepare using plastic in Kombolcha (69.33) and Dessie (71.48) fell to brown (Fig 3).

In alcoholic beverage fermentation, specific gravity is widely used instead of density. The result of specific gravity of *tella* prepared revealed (1.01) from clay pot and (1.00) from plastic jar in both study site. In the fermentation process of *tella*, yeasts convert glucose into ethanol and carbon dioxide. Afterward, decrease in the carbohydrate content and the increment of ethanol makes considerably less thick and drops the density of *tella* (Yohannes et al., 2013; Suleiman et al., 2017). Thus, the result of specific gravity supports ethanol content datum and showed that *tella* prepared using plastic jar had the highest ethanol level.

Sensory evaluation

Average score for the attributes bitterness of *tella* prepared using clay pot in Dessie, plastic jar in Dessie, clay pot in Kombolcha and plastic jar in Kombolcha were: 3.18, 2.90, 2.90, and 2.45 respectively. According to Adam, 2001 and the regular consumers' opinion obtained through interview, desirable bitterness and flavor are the most common tastes to identify the quality good *tella*. This indicated that *tella* prepared using clay pot in Dessie was most preferred followed by *tella* prepared using clay pot in Kombolcha and then came *tella* prepared using plastic jar in Dessie and Kombolcha consecutively. The feature of flavor scores for *tella* prepared with clay pot in Dessie, clay pot in Kombolcha, plastic jar in Dessie, and plastic jar in Kombolcha were 3.72, 3.45, 2.81, and 2.45, respectively. The comparison of preferable *tella* flavor result showed that *tella* prepared using clay pot in Dessie > clay pot in Kombolcha > plastic jar in Dessie > plastic jar in Kombolcha. The overall acceptability scores were recorded 3.43, 3.27, 3.19 and 2.97 for *tella* prepared using clay container in Dessie, clay container in Kombolcha, plastic jar in Dessie, and plastic jar in Kombolcha, respectively. The result provided that *tella* prepared using clay container in Dessie was accepted highly, followed by *tella* prepared using clay container Kombolcha, plastic jar in Dessie and plastic jar in Kombolcha along their sequence. This could be mainly a type of container for *tella* preparation provides variation of temperature during fermentation process and the place where *tella* is prepared also affects the quality *tella*. According to the interview made during the assessment, the judges also emphasized that taste of *tella* depends on the ingredients, aeration, and method of preparation, which can play an important role in the perception of the people to drink.

In conclusion, Alcoholic content of traditional fermented beverage *tella* was found to be affected with variation of temperature and container type for preparation. Clay pot can modulate the temperature varies during fermentation process of *tella*. However, plastic jar maintains the heat created inside, supports the rate ethanol production, and subtle formation of acetic acid for sourness of alcohol making product. The common characteristics of *tella* are desirable bitterness, color, turbidity, and flavor. Even though availability and non-fragility have drawn people attention to prefer plastic jar as an optional container, the result of this study showed that clay pot container (*insira*) is an appropriate container for preparation of *tella*. Ingredients, aeration, and method of preparation have also played an important role in the perception of the people to drink local fermented beverage *tella*. This observation raises the question about the effect of container type on other Ethiopian traditional fermented food and beverages and thus further studies could be necessary to verify it.

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