SINET Ethiop. J. Sci., 40(1)16-35, 2017 ISSN: 0379–2897 (Print)
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ETHANOL, METHANOL, ACID CONTENT AND OTHER QUALITY PARAMETERS OF ETHIOPIAN TRADITIONAL FERMENTED, DISTILLED AND FACTORY PRODUCED ALCOHOLIC BEVERAGES.

Seferu Tadesse, Bhagwan Singh Chandravanshi*, Estifanos Ele and Feleke Zewge

Department of Chemistry, College of Natural Sciences, Addis Ababa University, P.O. Box 1176, Addis Ababa, Ethiopia. E-mail: bscv2006@yahoo.com.

ABSTRACT: Five brands of Ethiopian traditional fermented alcoholic beverages, ten brands of traditional distilled alcoholic beverages and five brands of factory produced alcoholic beverages were collected from Addis Ababa, Ethiopia for the measurement of their ethanol, methanol, solid, salinity contents, acidity, pH and electrical conductivity. The overall average values of pH, ethanol% (v/v), acidic content (g/L), solid content (mg/L), conductivity (μS/cm) and salinity (%) in all brands of the beverages studied were found in the range of 4.6–7.5, 2.80–51.2, 0.02–105, 0.00–20328, 5.87–8391 and 0.1–4.6, respectively. The methanol contents of the beverages were determined using GC-MS. The results showed that the level of methanol in some brands of the studied traditional distilled and factory produced alcoholic beverages were found in the range between 0.867–0.979% (v/v). However, methanol was not found in all of the analyzed traditional fermented beverages. Therefore, the studied traditional fermented beverages do not pose any health threat to the human health due to methanol. However, the normal alcohol health risk associated with high consumption of beverages remains a problem.

Keywords/phrases: Acids, Alcoholic beverages, Ethanol, Ethiopia, Methanol,

INTRODUCTION

Alcoholic beverages are widely consumed in the world. Alcoholic beverages are produced locally for home consumption or in factories in small or large quantities for trading from the available resources across the world. The raw materials used for the production of alcoholic beverages are fruits, cassava, palm, sugar cane, cereal crops, etc. The basic method for the production of alcoholic beverages is by fermentation and simple distillation. Most traditional alcoholic beverages manufacturers are ignorant about the basic chemical compositions of the beverages and hence may end up producing alcoholic drinks with higher methanol content and other potential health threatening components. Methanol has similar physicochemical properties to that of Ethanol and is present as by-products after distillation. Toxic chemicals such as lead and methanol may present at trace level in the beverages and pose a threat to human health (Paine and Dayan, 2001).

World Health Organization (WHO, 2014) has estimated that 2.5 million deaths occur every year due to the harmful use of alcohol. The harmful use of alcohol also contributes to the health burden caused by communicable diseases such as tuberculosis and HIV/AIDS (WHO, 2014). There is also emerging evidence that methanol may be generated in alcoholic drinks during the fermentation process. The presence of methanol content in the products is due to the lack of proper fermentation and distillation techniques used by traditional or artisanal distilleries (Canaroglu and Yilmaztekin, 2011). The presence of methanol and other toxic substance in the alcoholic beverages affects the health of the people resulting in the complications and chronic diseases or ill health such as blindness, dizziness, respiratory diseases, etc (Lachenmeier, 2007). The oral lethal dosage of methanol via ingestion in human range from 15 to 250 g; the ingestion of 10 mL of methanol can cause permanent blindness and 30 mL can be fatal to human (Paine and Dayan, 2001).

Fermented beverages are an essential part of diets in all regions of the world. It constitutes a major part of the diet of traditional African rural homes in addition to their role in social functions (Getachew Tafere, 2015). Traditional fermented beverages are indigenous to a particular area and produced by the local people using an age-old techniques and locally available raw materials

*Author to whom correspondence should be addressed.

(Kebede Abegaz *et al.*, 2002). Traditional fermented beverages contain low levels of alcohol and are usually non-intoxicating (Wang *et al.*, 2003; Tadele Yohannes *et al.*, 2013; Guesh Mulaw and Anteneh Tesfaye, 2017). Commercial beverages for human consumption are prepared from widely available starch and sugars by modern fermentation techniques. Ethanol affects many organs of human. Besides causing health problems, there are other damaging effects of alcoholism such as mental problems, job trouble, frequent block outs, loss of control, etc (Oladeinde *et al.*, 2002).

Among the traditional fermented beverages in Ethiopia, the most popular alcoholic beverages are Tej (honey wine), Tella (a malt beverage like beer), Shameta, Bordie and Areki (distilled liquor). These drinks are widely served on celebrations and at social gatherings (Tadele Yohannes *et al.*, 2013; Getachew Tafere, 2015; Guesh Mulaw and Anteneh Tesfaye, 2017). The traditional 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 (Kebede Abegaz *et al.*, 2002). Traditional fermented foods and beverages in Ethiopia are prepared from different raw materials such as cereals, ensete (false banana), honey, milk, etc. The customs and rituals involving the Ethiopian traditional fermented foods and beverages are still followed in urban areas, village communities and rural households.

The very fact that illicit or non-commercial beverages are unrecorded means these are widely produced at households for home consumption. Hence it is obviously difficult to assess their accurate alcohol contents or how much of these types of local drinks are being produced and consumed compared to legally sold alcohols. Yet they remain to be the most widely consumed alcohol, as they are inexpensive and easily accessible than factory produced beverages. For this reason factory produced drinks tend to be mainly consumed by people who can afford the more expensive price and by urban dwellers while locally produced and home-brewed alcoholic beverages are pre-dominantly used in the rural areas and by people living in the urban areas who cannot afford factory made drinks. Many households in the country especially women engage in the production and sales of these beverages as their main source of income to support themselves and their families (Kebede Abegaz *et al.*, 2002; Tadele Yohannes *et al.*, 2013; Getachew Tafere, 2015; Debebe *et al.*, 2016; Guesh Mulaw and Anteneh Tesfaye, 2017).

In assumption, the chemical properties of beverages home distilled and factory produced distilled drinks can pose health threats due to their high alcoholic strength and undesirable additives. In Ethiopia, there are different traditional fermented, traditional distilled and factory produced alcoholic beverages. The ethanol content of some of the factory produced beverages are indicated in the label of container. However, the ethanol, methanol, solids, salinity, conductivity and acid contents of all types of alcoholic beverages are not known. Therefore, this research focused on quantifying the ethanol, methanol, solids, salinity, conductivity and acid content of some fermented and distilled alcoholic drinks consumed in Ethiopia particularly in Addis Ababa. Even though, several parameters are factors for the quality of beverages methanol is very toxic and a critical component to determine the quality of beverages than others. Several studies have found that the addition of pectolytic enzymes induces an increase of methanol levels in various fermentation products (Canaroglu and Yilmaztekin, 2011). However, it is not possible to know whether the pectolytic enzymes are used in the traditional fermented beverages. But there is a possibility that pectolytic enzymes may occur in some of the ingredients used in the preparation of traditional fermented beverages. Hence, it is believed that higher methanol content may be present in some alcoholic drinks produced by traditional distilleries or some alcohol brewing companies. In addition, some alcoholic beverage companies have used the natural ingredients extract from herbal using methanol as a solvent that the residual level of methanol might be present in these products (Kofi *et al.*, 2017). Because of this, there could be a higher risk of methanol concentration in products. Therefore, to determine the content of methanol in alcoholic beverages is required for consumer protection.

Some studies have been reported on the levels of essential and non-essential elements in selected Ethiopian wines (Daniel Minilu Woldemariam and Chandravanshi, 2011), ouzo (Dereje Bekele and Chandravanshi, 2012), traditional fermented alcoholic beverages (Ayelew Debebe *et al.*, 2017a) and levels of the fluoride in traditional alcoholic fermented beverages (Yohannes Belete *et al.*, 2017).

Total contents of phenolics, flavonoids, tannins and antioxidant capacity of selected traditional alcoholic beverages (Ayelew Debebe *et al.*, 2016; Siyum Shewakena *et al.*, 2017) have also been reported. Some studies have also been reported on the alcohol content in distilled alcoholic beverages (Ayelew Debebe *et al.*, 2017b; Ayelew Debebe *et al.*, 2017c) and in fermented alcoholic beverages (Ayelew Debebe *et al.*, 2017d) and on the sugars contents in fermented alcoholic beverages (Ayelew Debebe *et al.*, 2018). However, no systematic study has been reported on the assessment of all the quality parameters (levels of the methanol, ethanol, solids, acids, pH, salinity and conductivity) of different brands of traditional fermented alcoholic beverages.

Therefore, the main objective of this study is to determine methanol, ethanol and acid content of locally and factory produced alcoholic beverages. Specific objectives are: (i) to determine the methanol, ethanol, solids, acids, pH, salinity and conductivity of alcoholic beverages and (ii) to compare the quality parameters between different types of alcoholic beverages.

MATERIALS AND METHODS

Instrument and apparatus

The orbital shaker (KS125 basic, Germany) was used for homogenizing the samples. Centrifuge (Janetzki, model T32c, Olympus, Japan) was used for separating the two phases. Electronic balance (SP 1500, USA) was used for measuring the weight of samples. Fractional distillation set up was used for separating the alcohols. The pH meter (Orion model SA 72, USA) was used for measuring the pH of the beverages. The dissolved solids of alcohols were determined by Conductivity Meter (EC-215R Hanna Instrument, Italy). The electrical conductivity was determined using Conductivity Meter (Orion 4 Stars, USA). The Agilent GC 7890 coupled to a MS 5975 (Agilent Technologies, CA, USA) gas chromatograph was used for GC analysis of the samples.

Chemicals

Methanol (99.9%, Sigma-Aldrich, France), ethanol (99.9%, Fisher Scientific, UK), and anhydrous ethyl acetate (99.8%, Sigma-Aldrich, USA) were used to prepare standard solutions. Sodium hydroxide pellets (98%), hydrochloric acid (37%, Fine Chemicals, Mumbai, India) and phenolphthalein indicator (98%, Fisher Scientific, UK) were used for the determination of acidic content of alcohols. Distilled water was used for dilution of samples.

Alcoholic beverage samples

For this study five brands of traditional fermented (Tella, Tej, Shameta, Bordie, Korfie) and ten brands of traditional distilled (Yemar Areki, Dagim Areki, Wheat Arefa Areki, Wheat Sharata Areki, Dagusa Arefa Areki, Dagussa Sharata Areki, Wheat Berkrakie Areki, Koso Areki, Mixed Areki and Gibto Areki) alcoholic beverages were collected from Addis Ababa (Kality and Kotibe). Five brands of most commonly factory produced alcoholic beverages (Lomie, Ananas, Ouzo, Dry gin and Vodka) were purchased from five different groceries. These samples were selected based on universality of their consumption and availability at both the local market and the household levels. From each sampling area, three samples, each of 500 mL, were collected from different vending houses, which were selected randomly to prepare one bulk sample of each type by mixing the three samples and analyzing single sample to reduce the variance and resource consumption. The collected alcoholic beverages were grouped as traditionally fermented, traditionally distilled and factory produced beverages. All the samples were collected using polyethylene plastic bottles and the bulk samples were kept in refrigerator at 4 °C until the analysis was done. Triplicate analysis was performed for each sample. The characteristics features of the selected beverages are briefly describes below.

Tella is an Ethiopian home-brewed beer, which differs from the others in some respects. First, it is prepared from barley or wheat, hops, or spices. Secondly, it has a smoky flavor due to the addition of bread darkened by baking and use of a fermentation vessel. Tella is not processed under government regulations hence the alcohol content varies (Teklu *et al.*, 2015). It is the beverage of choice for family occasions and religious celebrations. It is very popular and highly valued, as its production requires considerable skill and patience. Tella is most commonly brewed and consumed alcoholic beverage in almost every household and drinking houses in the country (Ayelew Debebe *et al.*, 2016; Ayelew Debebe *et al.*, 2017a).

Shameta is another traditional beverage of Ethiopia, which is low in alcohol content made by overnight fermentation of mainly roasted barley flour and consumed as meal-replacement. It is the local beer made among the Gurage ethnic group.

Shameta is a widely consumed beverage in different regions of Ethiopia. The microorganisms responsible for fermentation are mostly from back slopping using small amount of Shameta from a previous fermentation as well as from the ingredients and equipment. Ready to consume Shameta has a high microbial count made up of mostly lactic acid bacteria and yeast (Katema Bacha; *et al.*, 1999). These microorganisms make the product a good source of microbial protein.

Tej is a commercially available honey wine, but it also prepared in home on special occasion such as weddings and the breaking of fasting. It is prepared from honey and leaves of Gesho (*Rhamnus prenoides*) are added to give special flavor. Natural food coloring is added in cases where sugar is used as part of the substrate to have a typical yellow color similar to that made from honey. To improve the flavor or potency and to attract customers some people also add different concoctions such as barks or roots of some plants or secrete herbal ingredients. But the producers usually are not willing to tell about additives used and their composition due to concoction adulteration practices and may be due to some other reasons (Ayelew Debebe *et al.*, 2016; Ayelew Debebe *et al.*, 2017a). Tej is yellow, sweet, effervescent and cloudy due to the content of yeasts. Tej produced in different part of the country has different flavor depending upon the nectar used in the production of honey and the climate. Fermentation of Tej relies on the microorganisms present in the substrates and natural and may result in uncontrolled alcohol and acidity, which can be hazardous to health (Bekele Bahiru *et al.*, 2001; Tadele Yohannes *et al.*, 2013).

Bordie is one of the traditional fermented beverages which is used as a common meal replacement in Southern Ethiopia and some other parts of the country (Kebede Abegaz *et al.*, 2002). It has a short fermentation period usually over-night and consumed while actively fermenting (Tadele Yohannes *et al.* 2013). Bordie is prepared from different cereals and their malt. Bordiepreparation varies both within and between localities. The most common ingredients of bordie are maize, barley and wheat both as malt and as unmalted ingredient in southern Ethiopia while in Addis Ababa wheat is the preferred unmalted ingredient (Kebede Abegaz *et al.*, 2002). People believe that Bordie enhances lactation and mothers are encouraged to drink substantial amounts of it after giving birth. To reduce the feeling of fullness and to encourage the intake, some spices are also offered as appetizing accompaniments, which may also contribute to some medical effects (Kebede Abegaz *et al.*, 2002).

Korefie is the local beer made in Begemder province among the Koumant ethnic group. It is prepared from dehusked barley, which is left in water overnight after that roasted and milled. It is mixed with dried Gesho leaves, Areki and water. It fermented in a clay container for long time (usually 2-3 months). To make it ready for consumption, a small quantity of the mixture is taken and more water is added and fermented for one day and used (Belay Getnet and Admas Berhanu, 2016).

Areki is produced by distillation of fermentation products prepared in almost the same way as Tella. Thus it is more concentrated, colorless and clear traditional alcoholic beverage (Ayelew Debebe *et al.*, 2016; Ayelew Debebe *et al.*, 2017a). It is more expensive than the other beverages. It is very strong and dangerous to consume. Areki is brewed and consumed more widely by farmers and semi-urban dwellers in rural and semi-urban areas than cities. Areki is commonly consumed by those who have become dependent on alcohol and cannot afford to buy factory produced alcohol WHO (2014). Areki is classified into Terra-Areki (only once distilled) and Dagim-Areki (twice distilled). The major varieties of areki are Dagussa Areki, Gibto Areki, Mar Areki, Wheat Areki and Koso Areki. The basic method of preparation of different varieties of Areki is similar.

Alcoholic beverage sample preparation for GC-MS

An aliquot of 1000 µL of alcoholic beverage sample was mixed with 2000 µL anhydrous ethyl acetate in 10 mL test tube. Approximately 100–150 mg of sodium sulfate was added to the mixture until saturation followed by intense mixing using a vortex mixer for 10–15 s. The samples were centrifuged for 2 min at 4000 rpm to separate the aqueous and non-aqueous layers. Approximately 200 µL of the upper non-aqueous phase was transferred to a 2 mL GC-MS vial for analysis (Pinu and Villas-Boas, 2017).

Determination of methanol content

Chromatographic separations were carried out using DB-1701 column with 30 m length, 0.25 mm internal diameter and 0.25 µm column phase thickness. Injection mode was split, with split ratio of 100:1 and split flow of 100 mL/min. Helium was the carrier gas and 1µl volume of the sample was injected to the inlet heated to 275 ˚C with the column flow of 1 mL/min. Initial oven temperature was 50 ˚C with 1 min hold time then heated to 200 ˚C with ramp of 40 ˚C/min. The total run time for this method was 4.75 min. The equilibration time was set to 0.25 min with the post run temperature of 280 ˚C. The ion source and mass selector temperatures were set to 230 ˚C and 150 ˚C respectively. The GC and MSD interface was heated to 250 ˚C. The MS detector was turned off between 1.95 min to 2.50 min in order to offload ethyl acetate peak. The MS was operated in scan mode with a mass range of 30 to 200 a.m.u. The ion (m/z) was used for identification and quantification of target compounds (Pinu and Boas, 2017). A methanol stock solution (500 mg/L) was prepared by dissolving 316 µL of absolute methanol (99.9%) in 500 mL distilled water. Then 1, 10, 30, 60 and 100 mg/L methanol working solutions were prepared from stock solution in 25 mL volumetric flasks and injected to the GC-MS.

Determination of pH values of alcoholic beverages

A conventional pH glass electrode with analytical sensors and a pH meter Orion model SA 72 (USA) was used for the pH measurements. The pH meter was calibrated with standard buffers of pH 4, 7, and 10. The sensor was rinsed and immersed in the beverages and the pH was measured in triplicate (Yücesoy, 2011). All the experiments were performed at room temperature (22 ± 2 ˚C).

Determination of acids in alcoholic beverages

Acid values were evaluated by titration with standardized solution of 0.1 N sodium hydroxide using phenolphthalein as indicator and the results were expressed as tartaric acid content (AOAC, 2010a). Volatile acidity is derived from the acetic acid series whereas fixed acidity is derived from tartaric acid series. The contents of total and fixed acids in terms of tartaric acid were calculated by using the formula:

$$\text{Total acid g tartaric acid/L} = \frac{0.00375 \times 2 \times \text{vol. of NaOH taken for titration} \times 1000 \times 2}{\text{The absolute alcohol percent by volume}}$$

$$\text{Fixed acid g tartaric acid/L} = \frac{0.00375 \times 2 \times \text{vol. of NaOH taken for titration} \times 1000 \times 2}{\text{The absolute alcohol percent by volume}}$$

Volatile acidity is determined from the difference of total acidity and fixed acidity.

$$\text{Volatile acidity (g/L)} = \text{Total acidity (g/L)} - \text{fixed acidty (g/L)}$$

Determination of solids in alcoholic beverages

The dissolved solids of alcohols were determined by conductivity meter. It was calibrated according the specification given by the manufacturer. The electrode was immersed in samples and recorded the reading display on the meter. Each sample was analyzed three times. Total solids were determined according to the method set by (AOAC (2010b). Primarily dry empty dish dried at 105 ˚C for 30 min. The dish was taken out from oven and kept in a dissector until it was cooled to room temperature. The weight of empty dish was measured and added 100 mL samples on it. The sample was placed in an oven at 105 ˚C for 3 hours. The sample was taken out from oven and kept in a dissector until it was cooled to room temperature. Weight of dried sample was measured. Total solids in alcohols were calculated by using the equation:

$$\text{Total solid (w/v)} = \text{Weight of dry sample and dish} - \text{Weight of empty dry dish}$$

Suspended solids were determined by taking the difference from total solids and total dissolved solids.

$$\text{Suspended solid (w/v)} = \text{Total solid} - \text{Total dissolved solid}$$

Determination of electrical conductivity and salinity of alcoholic beverages

An Orion 4 Stars conductivity meter was used for the measurements of conductivity. The conductivity meter was calibrated with 1413 µS and 12.9 mS/cm standards. The sensor was rinsed and immersed in the beverage sample and the conductivity was measured in triplicate (Alejandra *et al.*, 2016). The salinity was measured by the conductivity meter. The instrument has two mode of operation: one for conductivity and one for salinity. Salinity was measured by switching the instrument to salinity mode. All the measurements were carried out at room temperature (22 ± 2 °C).

Determination of ethanol content in alcoholic beverages

The ethanol level of samples was determined by fractional distillation method (AOAC (2010c). The method was applied for all types of traditional and factory produced alcohols. The method was verified by running spiked absolute alcohol whose ethanol content was 99.99% for each type of samples and by calculating its recovery. Based on this the recovery was found in the range 91–107%, which is acceptable and indicates that the method reliable and applicable for the analysis of selected samples. The procedure for the determination was as follows: 100 mL sample was transferred to a separating funnel. Sufficient powdered sodium chloride was added to saturate the liquid. The amount varies from beverage to beverage. To this, 50 mL of petroleum ether was added in order to extract ethanol and other volatile components. The solubility of ethanol in petroleum ether is very high as compared to the solubility of ethanol in water. The mixture of ethanol and petroleum ether made a separate layer from aqueous phase. After 15 min the layer of water was removed from the separator funnel while the layer of petroleum ether was poured in to the distillation flask. The layer of petroleum ether was washed with 20 mL of saturated sodium chloride solution two times and added the washing solutions in to distillation flask. The mixture of ethanol and petroleum ether was set to distillation process. The distillation was done by fractional distillation. The final temperature of the ethanol to completely evaporate was identified by running absolute ethanol. This was done by using absolute ethanol five times. Then with similar sample preparation, process the distillation was performed until the recovery absolute ethanol was 100%. Based on the five repeated data the final temperature was 72 °C. At this temperature, ethanol was completely evaporated and collected in the receiver. Therefore, the optimum boiling point of ethanol was 72 °C. By setting this temperature, the ethanol level of the alcohols was determined according to the following formula:

$$\text{Ethanol level\% (v/v)} = \frac{\text{Volume of distillate sample + Volume of petrolium ether}}{\text{Sample volume + volume of petrolium ether}} \times 100$$

RESULTS AND DISCUSSION

Methanol content in alcoholic beverages

The peak area of chromatogram was plotted versus methanol concentration in the range (1.00–100 mg/L) to construct calibration curve to determine the methanol content of beverage samples. The calibration equation was y = 189x + 12930, R^2 = 0.999, where y is peak area of chromatogram, x is concentration of methanol and R is the linear regression coefficient. The calibration curve was linear in a wide concentration range, which is convenient for the determination of methanol in various beverages. The concentrations of methanol in the alcoholic beverages were determined from the calibration curve. The results are given in Table 1 which shows the variations in the concentrations of methanol in the various beverage samples analyzed. Methanol concentration of the beverage samples ranged from "not detectable" to 7735 mg/L. It was also observed that four brands of the traditional alcoholic beverages (Tej, Tella, Korefie and Bordie), one brand of traditional distilled beverage (Gibto Areki) and two brands of traditional fermented beverages (Lome and Ananas Areki) did not showed the presence of methanol. While the nine brands of traditional distilled beverages (Dry Gin, Dagussa Sharata, Ouzo, Mixed, Wheat Sharata, Vodka, Koso, Dagim, Yemar, Wheat Arefa, Dagussa Arefa and Wheat Berkrakie) and three brands of factory produced beverages (Dry gin, Ouzo and Vodka) showed traces of methanol at different concentrations.

Table 1. Methanol content of traditional fermented, distilled and factory produced alcoholic beverages.

No.	Beverage types	Peak area	Methanol concentration (mg/L)
1	Dry gin	1301031	6815 ± 32
2	Daussa Shrata	1301618	6818 ± 53
3	Ouzo	1321681	6925 ± 51
4	Mixed	1325426	6944 ± 58
5	Wheat Sharata	1330075	6969 ± 29
6	Vodka	1341229	7028 ± 59
7	Koso	1385390	7262 ± 75
8	Dagim	1431145	7504 ± 82
9	Yemar	1433920	7518 ± 29
10	Wheat Arefa	1458666	7649 ± 86
11	Dagussa Arefa	1301031	6815 ± 35
12	Wheat Berkrakie	1301618	6818 ± 45
13	Gibto	No peak observed	ND
14	Lomie	No peak observed	ND
15	Ananas	No peak observed	ND
16	Tej	No peak observed	ND
17	Shameta	No peak observed	ND
18	Bordie	No peak observed	ND
19	Tella	No peak observed	ND
20	Korfie	No peak observed	ND

Note: Since no peak was observed for the blank and hence it was not possible to calculate the detection limit and therefore it is common practice to indicate the data as "Not Detected", i.e. ND.

Among the samples that were tested positive for methanol content Dry Gin (factory produced areki) showed the lowest amount of methanol concentration (6852 mg/L) while Wheat Berkrakie Areki (traditional distilled Areki) showed the highest methanol concentration (7735 mg/L). The results showed that low content of methanol in the factory-produced beverages as compared to the traditional distilled beverages. The oral lethal dose of methanol ranges between 0.3–1 g/kg (20 to 60 g or 25–75 mL/person in a 60 kg adult) (Tulashie *et al.*, 2017). A 7735 mg/L methanol level as seen in the analysis implies that 7.74 g methanol may be realized in 1 L of the alcoholic drink (Wheat Berkrakie). The methanol contents of all the other beverages are below that of Wheat Berkrakie, and since their methanol contents is below the oral lethal dose, all the studied beverages possess no potential health threat when consumed. However, it has a health problem in 60 kg adult when drinks continuously 3.2–9.7 L Wheat Berkrakie Areki. The comparison of methanol content in the alcoholic beverages is shown in Figure 1.

As can be seen in Figure 1, the content of methanol across the beverage brands increased in order of Dry gin < Daussa Shrata < Ouzo < Wheat Sharata < Mixed < Vodka < Koso < Dagim < Yemar < Wheat Arefa < Dagussa Arefa < Wheat Berkrakie. The variations in the content of methanol in the beverages are mainly due to variations in the ingredients used (the type of cereals such as barely, wheat, maize, and the nature and source of yeast) and the variations in the time and conditions of fermentation of beverages.

pH, conductivity, salinity, acidity and solid contents in factory produced alcoholic beverages

The quality parameters of factory produced alcoholic beverages are given in Table 2. Total acid results of factory produced beverage samples ranged from 0.024 to 0.156 g tartaric acid/L. Lomie Areki had the highest and Vodka had lowest total acid value from factory produced beverages. Volatile acid results of factory produced traditional beverage samples ranged from values of Vodka, Lomie, Ananas, Ouzo and Dry gin beverages were ND, 0.100, ND, ND and ND g tartaric acid/L, respectively. Lomie Areki had the highest volatile acid value from factory produced beverages. No factory produced beverage samples had volatile acids except Lomie areki, which had 0.100 mg tartaric acid/L. Fixed acid results of factory-produced beverage samples ranged from 0.023–0.076 g tartaric acid/L. The mean fixed acid values of Vodka, Lomie, Ananas, Ouzo and Dry gin were 0.024, 0.069, 0.076, 0.023 and 0.043 g tartaric acid/L, respectively. Ananas Areki had the highest whereas, Ouzo Areki had lowest fixed acid value from factory produced beverages.

The variations in the acid content of the beverages are mainly due to variations in the ingredients used and the variations in the time and conditions of fermentation of beverages. Preferred total acidity levels of beverages are 6–8 g tartaric acid/L (Jahagirdar *et al.*, 2015). Therefore, total acid content of below 6 g tartaric acid/L as seen in all of the analyzed drinks (Vodka, Lomie, Ananas, Ouzo and Dry gin) implies that below 6 g of tartaric acid is contained in 1 L of the alcoholic drink and hence all the beverages are of lower quality. The comparison of total acidity, fixed acidity and volatile acidity contents in factories produced alcoholic beverages is shown in Figure 2.

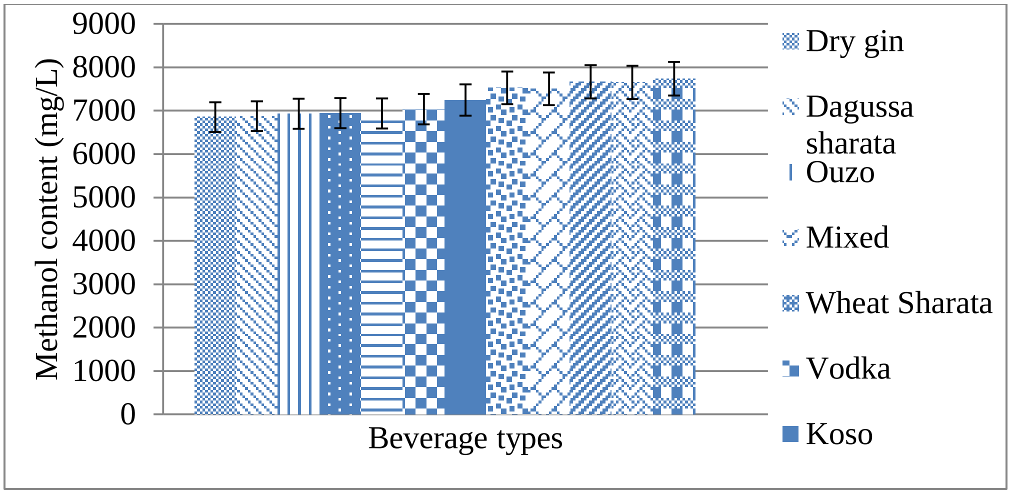

Figure 1. Methanol content of traditional fermented, traditional distilled and factory produced alcoholic beverages.

Total dissolved solid results of factory produced beverage samples ranged from 3.04–64.0 mg/L. TDS values of Ouzo Areki had the highest and Vodka had lowest TDS value from factory produced beverages. Total suspended solid results of factory produced beverage samples ranged from 65.0–11667 mg/L. Lomie Areki had the highest and Vodka had lowest TSS value from factory produced beverages. Total solid results of factory produced beverage samples ranged from 67.7–11723 mg/L. Lomie Areki had the highest total solid value whereas Vodka had lowest total solid value among the factory produced beverages. Preferred solid content of beverages are 500–2000 mg/L (Jahagirdar *et al.*, 2015). Therefore, total solid content of 2000 mg/L and above as seen in two brands of factory produced beverages (Lomie and Ananas) implies that at least 2000 mg of solid is contained in 1 L of the alcoholic drink and may all cause higher health risks due to excess solids when consumed excessively or without care. The mean pH values of the distilled beverages (Vodka, Lomie, Ananas, Ouzo and Dry gin) were in the range 5.85–7.50.

pH value of Ouzo Areki was highest and Lomie Areki had lowest than other brands of factory produced beverages. Preferred pH levels of beverages are 3.5–4.0 (Rajković *et al.*, 2007). The pH value of factory produced beverages (Vodka, Lomie, Ananas, Ouzo and Dry gin) was out of the range of standards. Among the studied factory produced beverages, Lomie Areki had higher pH levels than Vodka, Ananas, Ouzo and Dry gin. Whereas, Ouzo had low quality as compared to Vodka, Lomie, Ananas and Dry gin.

Table 2. Quality parameters in factory produced alcoholic beverages*.

Quality parameters	Factory produced alcoholic beverages				
	Vodka	Lomie	Ananas	Ouzo	Dry gin
pH	7.00 ± 0.01	5.50 ± 0.01	6.50 ± 0.01	7.50 ± 0.04	5.90 ± 0.02
Conductivity (μS/cm)	5.87 ± 0.06	121 ± 0.3	61.5 ± 0.2	135 ± 0.15	9.60 ± 0.2
Salinity (%)	ND	0.100 ± 0.1	ND	ND	0.100 ± 0.01
TDS (mg/L)	3.04 ± 0.05	57.1 ± 0.1	29.0 ± 0.8	64.0 ± 0.1	5.03 ± 0.08
TSS (mg/L)	65.0 ±1	11667 ±3.5	10152 ±3.1	256 ±1	1125 ±0.6
TS (mg/L)	67.7 ± 0.6	11723 ± 2.5	10183 ± 2.5	322 ± 2.9	1132 ± 2
Fixed acidity (g/L)	0.024 ± 0.005	0.069 ± 0.006	0.076 ± 0.006	0.023 ± 0.005	0.043 ± 0.005
Volatile acidity (g/L)	ND	0.100	ND	ND	ND
Total acidity (g/L)	0.024 ± 0.005	0.156 ± 0.006	0.041± 0.006	0.032 ± 0.005	0.043 ± 0.005

***Values are mean ± SD of triplicate readings of triplicate analysis. ND indicates not detected.**

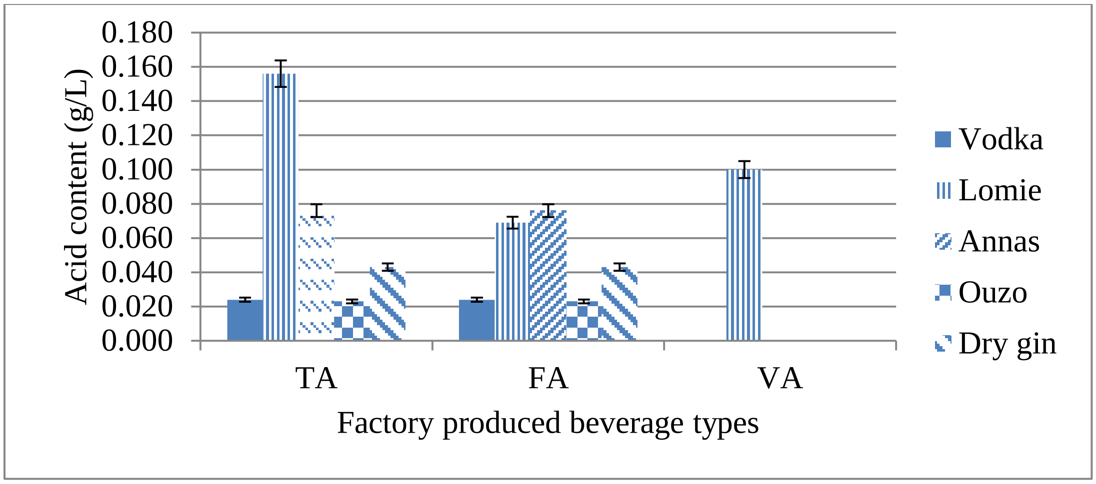

Figure 2. The comparison of total acidity, fixed acidity and volatile acidity contents in factories produced alcoholic beverages.

Electrical conductivity results of factory produced beverage samples ranged from 5.87–135 µS cm^{-1}. The mean electrical conductivity values of Vodka, Lomie, Ananas, Ouzo and Dry gin beverages were 5.87, 121, 61.5, 135 and 9.60 µS/cm, respectively. Electrical conductivity of Ouzo Areki were highest whereas, Vodka Areki had lowest than other factory produced beverages. Among the studied factory produced beverages, Vodka had better quality electrical conductivity than Lomie, Ananas, Ouzo and Dry gin. Whereas, Ouzo Areki had low quality as compared to Lomie, Ananas and Dry gin. The mean salinity values of Lomie and Ouzo Areki, were 0.100%. No salinity was observed in the three brands of factory produced beverages (Vodka, Ananas and Ouzo) while 0.100% of salinity were recorded in Dry Gin and Lomie Areki's.

As can be seen in Figure 2, generally the content of total acid across the beverage brands decreased in order of Lomie > Dry gin > Ananas > Ouzo > Vodka. Whereas, the volatile acid of Lomie > Vodka = Ananas = Dry gin = Ouzo and fixed acid of Ananas > Lomie > Dry gin > Vodka > Ouzo.

The content of total solid across the factory produced beverage brands decreased in order of Lomie > Ananas > Dy gin > Ouzo > Vodka. Whereas the TDS of Ouzo > Lomie > Ananas > Dry gin > Vodka and TSS of Lomie > Ananas > Dry gin > Ouzo > Vodka.

pH, conductivity, salinity, acidity and solid contents in traditional fermented alcoholic beverages

The quality parameters in traditional fermented alcoholic beverages are given in Table 3. Total acid results of traditional fermented beverage samples ranged from 16.7–105 g tartaric acid/L. Thus, Shameta had the highest total acid value whereas; Tej had the lowest total acid value. The results of volatile acid content (in terms of tartaric acid) of traditional fermented beverage samples ranged from 9.81–85.2 g tartaric acid/L. Korfie had the highest and Tej had lowest total acid value beverage. Fixed acid results of traditional fermented beverage samples ranged from 2.86–55.9 g tartaric acid/L. Shameta had the highest and Tella had lowest fixed acid value from factory produced beverages. The acid content plays an important role in alcoholic beverages for the preservation and sensory characteristics of beverages. Preferred total acidity levels of beverages are 4–8 g tartaric acid/L (Rajković *et al.*, 2007).

Therefore, total acid content of 8 g tartaric acid/L and above as seen in all traditional fermented beverages (Tej, Shameta, Bordie, Tella and Korfie) implies that at least 8 g of tartaric acid is contained in 1 L of the alcoholic drink and may all the same cause higher health risks due to excess acids when consumed excessively or without care. Among the studied traditional, fermented beverages Tej had better quality than from Shameta, Bordie, Tella and Korfie. Whereas, Shameta had low quality as compared to Tej, Bordie, Tella and Korfie. However, all acid values of the traditional fermented beverages (Tej, Shameta, Bordie, Tella and Korfie) were found to be above the standard values (Rajković *et al.*, 2007).

The comparison of total acidity, fixed acidity and volatile acidity contents in the traditional fermented alcoholic beverages is shown in Figure 3.

Total dissolved solid results of traditional fermented beverage samples ranged from 387–4520 mg/L. TDS values of Shameta had the highest and Tej had lowest TDS value from traditional fermented beverages. Total suspended solid results of traditional fermented beverage samples ranged from 540–16498 mg/L. TSS values of Bordie had the highest and Tella had lowest TS value from traditional fermented beverages. Total solid of alcohols is the combination of suspended and dissolved solids. Total solid results of traditional fermented beverage samples ranged from 1721–20328 mg/L, respectively. TS values of Bordie had the highest and Tella had lowest TS value from traditional fermented beverages. Preferred solid content of beverages are 500–2000 mg/L (Jahagirdar *et al.*, 2015).

Therefore, total solid content of 2000 mg/L and above as seen in four traditional fermented beverages (Tej, Shameta, Bordie and Korfie) implies that at least 2000 mg of solid is contained in 1 L of the alcoholic drink and may all the same cause higher health risks due to excess solids when consumed excessively or without care. Among the studied traditional, fermented beverages, Tella had better quality than from Shameta, Bordie, Tej and Korfie whereas Bordie had low quality as compared to Tej, Shameta, Tella and Korfie.

The pH values of traditional fermented beverage samples ranged from 3.47–3.80. The mean pH values of Tej, Shameta, Bordie, Tella and Korfie beverages were 3.80, 3.59, 3.80, 3.47, 3.80 and 3.73, respectively. pH value of Shameta were highest and Bordie had lowest pH values from traditional beverages. Preferred pH levels of beverages are are 3.5–4.0 (Rajković *et al.*, 2007). All the pH of traditional beverages (Tej, Shameta, Bordie, Tella and Korfie) pH was in range of standards. Hence, not all beverages can cause higher health risks due to pH when consumed.

Electrical conductivity results of traditional fermented beverage samples ranged from 811–8391 µS cm^{-1}. Measuring electrical conductivity was indicated as a practical method to identify fraud beverages (Lachenmeier *et al.*, 2008). The conductivity of beverages was very stable between replicate measurements of the same type. However, it shows large differences between different beverage types. The mean electrical conductivity values of Tej, Shameta, Bordie, Tella and Korfie beverages were 811, 8391, 7139, 2359 and 3199 µS/cm, respectively. Electrical conductivity of Shameta was highest and Tej had lowest electrical conductivity value from traditional fermented beverages. High electrical conductivity values can mean beverage that tastes bad or is too salty. Among the studied traditional, fermented beverages, Tej had better quality electrical conductivity than Shameta, Bordie, Tella and Korfie whereas, Shameta had low quality as compared to Tej, Bordie, Tella and Korfie. The mean salinity values of Tej, Shameta, Bordie, Tella and Korefie were 0.4%, 4.6%, 3.9%, 1.2% and 1.7%, respectively. Salinity of Shameta was highest whereas, Bordie had lowest than other fermented beverages.

As can be seen in Figure 3, generally the content of total acid across the beverage types decreased in order of Shameta > Korfie > Bordie > Tella > Tej whereas, the volatile acid of Korefie > Bordie > Shameta > Tella > Tej and fixed acid of Shameta > Bordie > Tej > Korefie > Tella.

The content of total solid across the traditional fermented beverage types decreased in order of Bordie > Shameta > Korefie > Tej > Tella whereas, the TDS of Shameta > Bordie > Korefie > Tella > Tej and TSS of Bordie > Shameta > Korefie > Tej > Tella.

pH, conductivity, salinity, acidity and solid contents in traditional distilled alcoholic beverages

The quality parameters of traditional distilled alcoholic beverages are given in Table 4. Total acid results of traditional distilled beverage samples ranged from 0.130–0.35 g tartaric acid/L. Gibto Areki had highest whereas, Koso Areki had lowest total acid value compared to Yemar, Dagim, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie and Mixed traditional distilled beverages. Volatile acid results of traditional distilled beverage had lowest volatile

Table 3. Quality parameters in traditional fermented alcoholic beverages*

Quality parameters	Traditional fermented alcoholic beverages				
	Tej	Shameta	Bordie	Tella	Korefie
pH	3.60 ± 0.01	3.80 ± 0.01	3.50 ± 0.01	3.80 ± 0.01	3.70 ± 0.01
Conductivity (µS/cm)	811 ± 1.00	8391 ± 1	7139 ± 1	2359 ± 2	3199 ± 1
Salinity (%)	0.400 ± 0.001	4.60 ± 0.001	3.90 ± 0.002	1.20 ± 0.01	1.70 ± 0.001
TDS (mg/L)	387 ± 1	4520 ± 1	3830 ± 1	1180 ± 1	1610 ± 1
TSS (mg/L)	4676 ± 2.5	11274 ± 1	16498 ± 1	540 ± 1	5680 ± 1
TS (mg/L)	5063 ± 2.5	15795 ± 2	20328 ± 2	1721 ± 2	7291 ± 1
Fixed acidity (g/L)	6.86 ± 0.06	55.9 ± 0.3	9.27 ± 0.27	2.86 ± 0.03	4.34 ± 0.05
Volatile acidity (g/L)	9.81 ± 0.03	49.4 ± 0.3	70.2 ± 0.1	30.6 ± 0.3	85.2 ± 0.4
Total acidity (g/L)	16.7 ± 0.03	105 ± 0.1	79.5 ± 0.4	33.5 ± 0.3	89.5 ± 0.4

*** Values are mean ± SD of triplicate readings of triplicate analysis**

acid content compared to Yemar, Gibto, Dagim, Wheat Arefa, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie and Koso traditional distilled beverages. Fixed acid results of traditional distilled beverage samples ranged from 0.018–0.146 g tartaric acid/L. Yemar Areki had highest whereas, Dagim Areki had lowest fixed acid value compared to Gibto, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie, Mixed and Koso traditional distilled beverages. Preferred total acidity levels of beverages are 6–8 g tartaric acid/L (Jahagirdar *et al.*, 2015). All acid content of analyzed drinks (Yemar, Gibto, Dagim, Wheat Arefa, Wheat Sharata, Dagussa Arefa. Dagussa Sharata, Wheat Berkrakie, Mixed and Koso) were below the standard value (Jahagirdar *et al.*, 2015).

The comparison of total, fixed and volatile acidity contents of traditional distilled alcoholic beverages are shown in Figure 4.

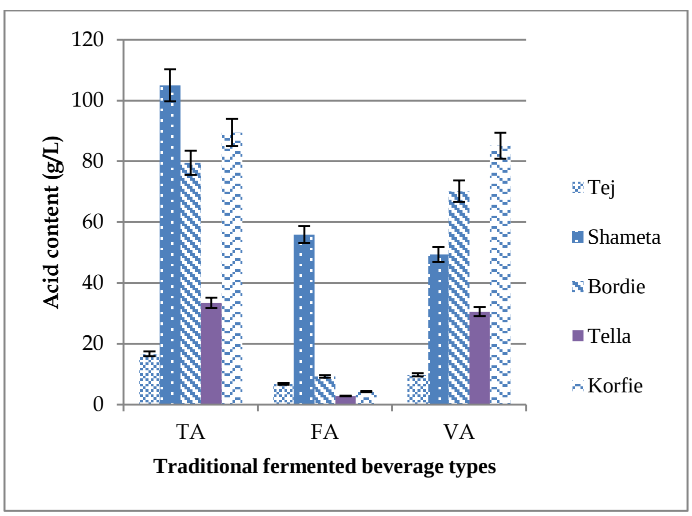

Figure 3. The comparison of total acidity, fixed acidity and volatile acidity contents in g/L between traditional fermented alcoholic beverages.

Table 4. Quality parameters of traditional distilled alcoholic beverages*

Beverage types	Quality parameters in different traditional distilled alcoholic beverages								
	pH	Conductivity (µS/cm)	Salinity (%)	TDS (mg/L)	TSS (mg/L)	TS (mg/L)	Fixed acidity (g/L)	Volatile acidity (g/L)	Total acidity (g/L)
Yemar	4.60±0.01	116±1	0.100±0.001	56.0±0.1	7156±2.1	7211±1.2	0.163±0.005	0.188±0.01	0.350±0.005
Gibto	4.40±0.01	48.0±0.5	ND	21.9±0.1	699±1	720±1.5	0.146±0.004	0.205±0.008	0.351±0.004
Dagim	4.20± 0.01	19.0±0.25	ND	9.03±0.1	1.00±0.03	10.0±0.2	0.018±0.004	0.160±0.006	0.178±0.002
Wheat Arefa Areki	4.00±0.01	24.0±0.1	ND	10.0±0.1	ND	10.0±0.3	0.039±0.004	0.214±0.013	0.253±0.009
Wheat sharata	4.00±0.01	24.0±0.15	ND	ND	ND	ND	0.026±0.005	0.311±0.007	0.337±0.002
Dagussa Arefa	4.10±0.01	26.0±0.2	ND	9.87±0.2	ND	10.0±0.3	0.027±0.004	0.177±0.012	0.204±0.016
Dagusa Sharata	4.10±0.01	19.0±0.21	ND	100±0.1	ND	10.0±0.3	0.023±0.005	0.234±0.003	0.257±0.002
Wheat berkrakie	4.30±0.01	25.0±0.25	ND	ND	ND	ND	0.032±0.005	0.283±0.01	0.315±0.003
Mixed Areki	4.10±0.01	23.0±0.15	ND	11.2±0.2	ND	11.0±0.4	0.114±0.005	0.055±0.00	0.169±0.005
Koso	3.80±0.01	38.0±0.12	ND	17.8±0.3	233±1.53	249±2.1	0.063±0.002	0.067±0.00	0.130±0.004

***Values are mean ± SD of triplicate readings of triplicate analysis. ND indicates not detected**

Total acid results of traditional distilled beverage samples ranged from 0.130–0.35 g tartaric acid/L. Gibto Areki had highest whereas, Koso Areki had lowest total acid value compared to Yemar, Dagim, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie and Mixed traditional distilled beverages. Volatile acid results of traditional distilled beverage samples ranged from 0.05–0.310 g tartaric acid/L. Wheat Sharata Areki had highest and Mixed Areki had lowest volatile acid content compared to Yemar, Gibto, Dagim, Wheat Arefa, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie and Koso traditional distilled beverages. Fixed acid results of traditional distilled beverage samples ranged from 0.018–0.146 g tartaric acid/L. Yemar Areki had highest whereas, Dagim Areki had lowest fixed acid value compared to Gibto, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie, Mixed and Koso traditional distilled beverages. Preferred total acidity levels of beverages are 6–8 g tartaric acid/L (Jahagirdar *et al.*, 2015). All acid content of analyzed drinks (Yemar, Gibto, Dagim, Wheat Arefa, Wheat Sharata, Dagussa Arefa, DagussaSharata, Wheat Berkrakie, Mixed and Koso) were below the standard value (Jahagirdar *et al.*, 2015).

The comparison of total, fixed and volatile acidity contents of traditional distilled alcoholic beverages are shown in Figure 4. Total dissolved solid results of traditional distilled beverage samples ranged from ND–100 mg/L. TDS values of Dagussa Sharata Areki had highest whereas, Wheat Sharata and Wheat Berkarkie beverages had lowest compared to Yemar, Gibto, Dagim, Wheat Arefa, Dagussa Arefa, Mixed and Koso traditional distilled beverages. No dissolved solids were present in Wheat Sharata and Wheat Berkarkie beverages. Total suspended solid results of traditional distilled beverage samples ranged from ND–7156 mg/L, respectively. TSS values of Yemar Areki had highest whereas, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie and Mixed beverages had lowest TSS value compared to Gibto, Dagim and Koso traditional distilled beverages From the result of traditional distilled beverages no TSS was observed in Wheat Arefa, Wheat Sharata, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie and Mixed beverages, whereas Gibto Areki, Yemar Areki, Koso Areki and Dagim Areki had low content of suspended solids.

Total solid results of traditional distilled beverage samples ranged from ND –7211 mg/L. TS values of Yemar Areki had highest whereas, Wheat Sharata and Wheat berkrakie had lowest TS value compared to Gibto, Dagim, Wheat Arefa, Dagussa Arefa, Dagussa Sharata, Mixed and Koso traditional distilled beverages. Preferred solid content of beverages are 500–2000 mg/L (Jahagirdar *et al.*, 2015). Therefore, total solid content of 2000 mg/L and above as seen in one traditional distilled beverage (Yemar Areki) implies that at least 2000 mg of solid is contained in 1 L of the alcoholic drink and may cause health risks due to excess solids when consumed excessively or without care. The solid contents of Gibto, Dagim, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie, Mixed and Koso had within the standard range as set by Drinking water standards as per BIS 10500 (Jahagirdar *et al.*, 2015).

The mean pH values of Yemar, Gibto, Dagim, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie, Mixed and Koso beverages were in the range 3.80–4.60. pH value of Yemar Areki was highest and Koso Areki had lowest pH value from traditional distilled beverages. Electrical conductivity results of traditional distilled beverage samples ranged from 19–116 µS cm^{-1}. The mean electrical conductivity values of Yemar, Gibto, Dagim, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie, Mixed and Koso beverages were 116, 48.0, 19.0, 24.0, 24.0, 26.0, 19.0, 25.0, 23.0, 38.0 µS/cm, respectively. Electrical conductivity of Yemar Arekies was highest whereas, Dagim and Dagussa Sharata beverages had lowest electrical conductivity value from traditional distilled beverages. Among the studied factory produced beverages, Dagem and Dagussa Sharata had best electrical conductivity quality than Yemar, Gibto, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Wheat Berkrakie, Mixed and Koso. Whereas, Yemar areki had low quality as compared to Gibto, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Wheat Berkrakie, Mixed and Koso. The mean salinity value of Yemar Areki was 0.1%. No salinity was observed in nine brands of traditional distilled beverages (Gibto, Dagim, Wheat Arefa, Wheat Sharata, Dagussa Arefa, Dagussa Sharata, Wheat Berkrakie, Mixed and Koso) while 0.1% of salinity was observed in Yemar Areki. This may be due to poor distillation quality and the quality of the water (types of tap water, well water, bottled water) used for dilution.

As it can be seen in Figure 4, the content of total acid across the traditional distilled beverage brands decreased in order of Gibto > Yemar > Wheat sharata > Wheat Berkrakie > Dagussa Sharata > Wheat Arefa > Dagussa Arefa > Dagim > Mixed > Koso. Whereas the volatile acid of Wheat Sharata > Wheat Berkrakie > Dagussa Shrata > Wheat Arefa > Gibto > Yemar > Dagussa Arefa > Dagim > Koso > Mixed and fixed acid of Yemar > Gibto > Mixed > Koso > Wheat Arefa > Wheat Berkrakie > Dagussa Arefa > Wheat Sharata > Dagussa Sharata > Dagim.

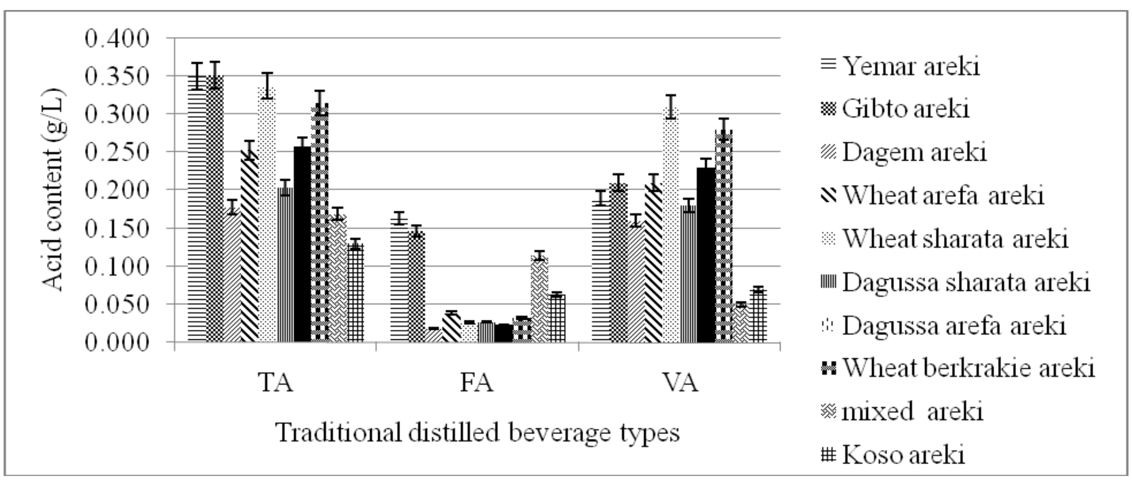

Figure 4. The comparison of total, fixed and volatile acidity contents in g/L between traditional distilled alcoholic beverages.

The content of total solid across the traditional distilled beverage types decreased in order of Yemar > Gibto > Koso > Mixed > Dagim = Wheat Aarefa = Dagussa Arefa > Wheat Sharata = Wheat Berkrakie. Whereas, the total dissolved solid of Dagusa Sharata > Yemar > Gibto > Koso > Mixed > Wheat Arefa > Dagussa Arefa > Dagim > Wheat Berkrakie = Wheat Sharata and total suspended solid of Yemar > Gibto > Koso > Dagim > Wheat Shrata = Dagussa Arefa = Dagussa Sharata = Wheat Berkrakie.

Comparison of acid, solid, pH, conductivity and salinity contents across traditional distilled,

fermented and factory produced alcoholic beverages

Total acid values of Shameta and Korfie were highest compared to all brands of beverages where as Vodka Areki had the lowest total acid value of 0.024 g tartaric acid/L. Fermented beverages have highest total acid values than distilled traditional and factory produced beverages. Volatile acid value of Korfie was highest compared to others where as Vodka, Ananas, Ouzo, Dry Gin Areki had the lowest volatile acid value of 0.0 g tartaric acid/L. Fermented beverages have highest volatile acid values than distilled traditional and factory produced beverages. Fixed acid values of Shameta were highest compared to all other beverages where as Dagim, Ouzo and Vodka Arekies had the lowest fixed acid value of 0.018 g tartaric acid/L, 0.023 g tartaric acid/L and 0.024 g tartaric acid/L, respectively. Traditional fermented alcoholic beverages had high contents of total, fixed and volatile acidity than traditional distilled and factory produced alcoholic beverages. The acid amount in fermented and distilled beverages can vary in wide ranges due to crop variety, harvesting time of crops, climatic conditions during harvesting, type of the soil, phyto-sanitary condition of crops, way of malt processing, conditions under which alcohol fermentation was done, beverage storage time, volatile compounds and additives (Rajković *et al.*, 2007).

TDS values of Shameta and Bordie were highest compared to others where as Wheat Berkrakie and Wheat Sharata had the lowest TDS value of 0.0 mg/L. Fermented beverages had highest TDS values than distilled traditional and factory produced beverages. From the results, traditional fermented beverages had significantly high content dissolved solids than distilled traditional and factory produced beverages. The highest TSS was observed in Shameta, Bordie and Lomie Areki and the lowest in Wheat Berkrakie, Wheat Sharata, Wheat Arefa, Dagussa Arefa, Dagussa Sharata and Mixed Areki. The content of suspended solids present in distilled traditional alcohols were lowest than traditional fermented and factory produced beverages. TS values of Shameta and Bordie were highest compared to others where as Wheat Berkrakie and Wheat sharata had the lowest TS value of 0.0 mg/L. Fermented beverages have highest TS values than distilled traditional and factory produced beverages. The solid content in fermented and distilled beverages can vary in wide ranges due to the difference in sources raw materials (crop varieties), process conditions, volatile compounds, additives, initial TSS as well as the difference in ferment ability behavior of the beverages (Yücesoy, 2011).

Fermented beverages have lowest pH values than distilled traditional and factory produced beverages. Differences in the raw materials (crop varieties), process conditions, volatile compounds, storage time and additives can cause the differences among the pH values. Electrical conductivity of Shameta and Bordie were highest compared to others and Vodka had the lowest conductivity value of 5.87 μS cm^{-1}. Conductivity of fermented beverages were very high than distilled beverages. Differences in the raw materials (crop varieties), process conditions, volatile compounds, storage time and additives can cause the differences among the electrical conductivity values (Lachenmeier *et al.*, 2008). Compared to distilled beverages, fermented beverages had highest salinity value. Salinity of Shameta and Bordie were highest compared to others. Fermented beverages of Tella, Shameta, Korefie and Bordie had a high content of salinity because in the fermentation process no distillation is performed.

Ethanol content of alcoholic beverages

The recovery test was done for all the samples since all the samples had different matrices and the percentage recoveries were calculated by spiking known concentration of ethanol into the traditional alcoholic beverage samples. The efficiency of the fractional distillation method used for the determination of ethanol in alcoholic beverages was checked by adding known concentration of ethanol to the 50 mL different kind of alcoholic beverage sample. The amount of ethanol spiked was 20% to 30% the amount of ethanol determined in samples. The different known spiked concentration of ethanol was prepared from absolute ethanol, its concentration was 99.99%. Each recovery test was performed in triplicates. Recovery test results for ethanol determination in samples of the traditional fermented, traditional distilled and factory alcoholic beverages are given Tables 5, 6 and 7, respectively. The percentage of the recovery was between 91 and 107% (Tables 5-7) which indicates that it was within the acceptable range (100±10%).

The ethanol contents of traditional fermented and distilled alcoholic beverage samples together with the literature values for comparison are given in Table 8. Conditions such as temperature, aeration and strains of the microorganisms obviously affect the level of alcohols. The ethanol content indicates the strength of alcohols. Table 8 shows the variations in the mean concentrations of ethanol of the various samples analyzed.

Ethanol concentration of the samples ranged between 2.80–51.2% (v/v). Among the samples that tested Bordie (traditional fermented beverage) recorded the lowest ethanol content 2.80% (v/v) while Dagim Areki (traditional distilled Areki) showed the highest ethanol content 51.2% (v/v). Ethanol content of factory produced, traditional fermented and traditional distilled beverage samples ranged from 30.0–41.0% (v/v), 2.80–12.8% (v/v) and 36.5–51.2% (v/v), respectively.

Table 5. Recovery test results for ethanol determination in samples of the traditional fermented alcoholic beverages.

Type of beverage	Concentration of ethanol in un spiked beverage sample% (v/v)	Amount of ethanol added% (v/v)	Concentration of ethanol in spiked beverage sample% (v/v)	Recovery% (v/v)
Tella	5.20	1.04	6.12 ± 0.1	98.0 ± 8
	5.20	1.30	6.37 ± 0.2	101± 3
	5.20	1.56	6.62 ± 0.3	103 ± 4
Shameta	3.20	0.64	3.76 ± 3	100 ± 5
	3.20	0.80	3.92 ± 3	99.0 ± 4
	3.20	0.96	4.08 ± 5	101 ± 3
Bordie	3.00	0.60	3.53 ± 8	103 ± 3
	3.00	0.75	3.68 ± 1	98.0 ± 3
	3.00	0.90	3.82 ± 1	105 ± 5
	6.00	1.20	7.06 ± 7	101 ± 8
Korfie	4.50	1.50	6.08 ± 9	105 ± 1
	4.50	1.80	6.26 ± 1	98.0 ± 1
Tej	12.0	2.40	14.1 ± 9	99.0 ± 7
	12.0	3.00	14.7 ± 9	100 ± 9
	12.0	3.60	15.6 ± 1	101 ± 1

Table 6. Recovery test results of ethanol determination in samples of the traditional distilled alcoholic beverages.

Type of beverage	Concentration of ethanol in un spiked beverage sample% (v/v)	Amount of ethanol added% (v/v)	Concentration of ethanol in spiked beverage sample% (v/v)	Recovery % (v/v)
	38.0	7.60	45.1 ± 0.01	99 ± 7
Yemar Areki	38.0	9.50	50.4 ± 0.01	106 ± 4
	38.0	11.4	52.9 ± 0.01	107 ± 2
	46.0	8.60	54.9 ± 0.05	103 ± 7
Gibto Areki	46.0	10.8	57.0 ± 0.03	102 ± 7
	46.0	12.9	58.6 ± 0.02	98.0 ± 2
	54.0	10.8	67.4 ± 0.15	104 ± 3
Dagim Areki	54.0	13.5	72.2 ± 0.15	107 ± 6
	54.0	16.2	67.4 ± 0.06	96.0 ± 3
	44.0	8.80	50.7 ± 0.04	96.0 ± 8
Wheat Aarfa Areki	44.0	11.0	51.2 ± 0.05	93.0 ± 3
	44.0	13.2	53.8 ± 0.04	94.0 ± 2
	36.0	7.20	43.2 ± 0.06	100 ± 1
Wheat Sharata Areki	36.0	9.00	47.3 ± 0.04	105 ± 2
	36.0	10.8	44.5 ± 0.02	95.0 ± 1
	48.0	9.60	58.8 ± 0.25	102 ± 1
Dagusa Arfa Areki	48.0	12.0	57.6 ± 0.05	96.0 ± 5
	48.0	14.4	61.8 ± 0.25	99.0 ± 1
	40.0	8.00	45.1 ± 0.15	94.0 ± 8
Dagusa Sharata Areki	40.0	10.0	46.5 ± 0.15	93.0 ± 4
	40.0	12.0	49.9 ± 0.06	96.0 ± 2
Wheat Berkrakie Areki	42.6	8.52	50.1 ± 0.12	98.0 ± 6
	42.6	10.7	50.1 ± 0.20	94.0 ± 2

	42.6	12.8	60.4 ± 0.15	109 ± 6
	39.5	7.90	51.2 ± 0.31	108 ± 3
Mixed Areki	39.5	9.88	52.3 ± 0.10	106 ± 4
	39.5	11.9	48.8 ± 0.15	95.0 ± 9
	46.0	9.20	50.2 ± 0.004	91.0 ± 3
Koso Areki	46.0	11.5	52.9 ± 0.01	92.0 ± 3
	46.0	13.8	59.2 ± 0.01	99.0 ± 5

Ethanol content of Tej was highest compared to others traditional fermented beverages where as Dagim and Ouzo Areki had the highest ethanol content from traditional distilled and factory produced beverages respectively. On the other hand Wheat Sharata Areki had lowest ethanol content compared to others traditional distilled beverages where as Bordie and Lomie Areki had lowest ethanol content from factory produced beverages, respectively. The results showed that low contentof ethanol were recorded in the traditional fermented beverages as compared to the traditional distilled and factory produced beverages. The oral lethal dose of ethanol is reported in the range 5 to 8 g/kg. Thus, for a 60 kg adult, 300 g (384 mL) of ethanol can be fatal (Tulashie *et al.*, 2017). Therefore, ethanol concentration of 39.0% (v/v) and higher amount in eleven of the analyzed beverages (Gibto Areki, Dagim Areki, Wheat Arefa Areki, Dagussa Arefa Areki, Dagussa Sharata Areki, Wheat Berkrakie Areki, Mixed Areki, Koso Areki, Vodka Areki, Ouzo Areki and Dry Gin Areki) imply that at least 390 mL of ethanol is contained in 1 L of the alcoholic drink and may all the same cause higher health risks when consumed excessively or without care. The wide variation in ethanol of different beverage brands is apparently related to the difference in sources raw materials (crop varieties), limit of standard procedures to produce traditional alcohols, alcohols process conditions and the difference in ferment ability behavior of the beverages (Tulashie *et al.*, 2017). Comparison of the ethanol content of traditional fermented and distilled alcoholic beverages is shown in Figure 5. As it can be seen in Figure 5, the ethanol content across the traditional distilled and traditional fermented beverage brands decreased in order of Dagim > Dagussa Arefa > Gibto > Wheat Arefa > Koso > Mixed > Wheat berkrakie > Dagussa Sharata > Yemar >Wheat Sharata> Tej > Tella > Korefie > Shameta > Bordie.

The ethanol contents of factory produced alcoholic beverages are given in Table 9. The amount of ethanol % (v/v) determined in the factory produced alcoholic beverages are in good agreement with the amount % (v/v) labeled in the containers by the factories.

Analysis of variance

In this study fifteen different brands of traditional fermented and distilled alcoholic beverages were collected from two areas of Addis Ababa. During the processes of sample preparation and analysis, a number of random errors might have been introduced in the alcoholic beverages. The variations in the mean ethanol contents of the analyzed beverages were tested by using analysis of variance (ANOVA) (Miller and Miller, 2005) to see whether the source of the variations were from the varieties of samples or/and due to areas of analyzed samples. The ANOVA results for all the fifteen brands of analyzed alcoholic beverage samples showed that statistically significant differences existed at the 95% confidence level in the mean ethanol content due to the difference in varieties of alcohols and significant difference due to the interaction effect of varieties of beverages and areas of sample collection whereas areas of alcoholic beverage sample collection was not significant effect at the 95% confidence level in the mean ethanol content for all the analyzed alcoholic beverage samples.

Table 7. Recovery test results of ethanol determination in samples of the factory produced alcoholic beverages.

Type of beverage	Concentration of ethanol in un spiked beverage sample% (v/v)	Amount of ethanol added% (v/v)	Concentration of ethanol in spiked beverage sample% (v/v)	Recovery% (v/v)
Vodka Areki	40.0	8.00	46.8 ± 0.15	97.5 ± 0.10
	40.0	10.0	51.2 ± 0.10	102 ± 0.09
	40.0	12.0	50.9 ± 0.31	97.9 ± 0.04
Lomie Areki	30.0	6.00	39.3 ± 0.15	109 ± 0.02
	30.0	7.50	39.6 ± 0.20	105 ± 0.03
	30.0	9.00	36.8± 0.12	94.4 ± 0.01
Ananas Areki	32.0	6.40	41.7 ± 0.25	108 ± 0.03
	32.0	8.00	39.0 ± 0.05	97.6 ± 0.04
	32.0	9.60	40.3 ± 0.05	96.9 ± 0.17
Ouzo Areki	40.0	8.00	46.8 ± 0.25	97.5 ± 0.06
	40.0	10.0	51.2 ± 0.04	102 ± 0.02
	40.0	12.0	50.9 ± 0.04	97.9 ± 0.02
Dry gin Areki	40.0	8.00	52.4 ± 0.05	107 ± 0.02
	40.0	10.0	52.8 ± 0.06	105 ± 0.05
	40.0	12.0	51.4 ± 0.04	97.6 ± 0.01

Table 8. The ethanol content of traditional fermented and distilled alcoholic beverage samples.

No.	Beverage type	Location	Ethanol content % (v/v)	Literature report % (v/v)	Reference
1	Yemar Areki	Kotebie	37.5 ± 0.5	-	-
		Kality	38.5 ± 0.5		
2	Gibto Areki	Kotebie	46.0 ± 0.5	46.8 - 50.3	(Ayalew Debebe *et al.*, 2017b)
		Kality	48.6 ± 0.6		
3	Dagim Areki	Kotebie	51.5 ± 0.5	51.1 - 54.0	(Belachew Desta, 1977; Ayalew Debebe *et al.*, 2017b)
		Kality	54.0 ± 0.5		
4	Wheat Arfa Areki	Kotebie	43.9 ± 0.4	34.0 - 40.0	(Belachew Desta, 1977)
		Kality	42.0 ± 0.5		
5	Wheat Sharata Areki	Kotebie	35.9 ± 0.4	34.0 - 40.0	(Tadele Yohannes *et al.*, 2013)
		Kality	37.0 ± 0.3		
6	Dagusa Arfa Areki	Kotebie	48.0 ± 0.5	-	-
		Kality	47.5 ± 0.5		
7	Dagusa Sharata Areki	Kotebie	39.9 ± 0.4	-	-
		Kality	40.9 ± 0.3	8.94 - 13.2	(Bekele Bahiru *et al.*, 2001; Tadele Yohannes *et al.*, 2013)
8	Tej	Kotebie	11.9 ± 0.4		
		Kality	13.3 ± 0.3		
9	Shameta	Kotebie	3.23 ± 0.3		
		Kality	3.50 ± 0.5	-	-
10	Bordie	Kotebie	3.00 ± 0.5	-	-
		Kality	2.60 ± 0.4		
11	Wheat Berkraki Areki	Kotebie	42.0 ± 0.6	34.0 - 40.0	(Ayalew Debebe *et al.*, 2017b)
		Kality	39.2 ± 0.8		
12	Mixed Areki	Kotebie	40.6 ± 0.6	34.0 - 40.0	(Ayalew Debebe *et al.*, 2017b)
		Kality	39.5 ± 1		
13	Koso Areki	Kotebie	46.4± 0.5	42.8 - 56.0	(Ayalew Debebe *et al.*, 2017b)
		Kality	45.1 ± 0.4		
14	Tella	Kotebie	5.57 ± 0.4	3.50 - 4.50	(Tadele Yohannes *et al.*, 2013; Admas Berhanu, 2014; Teklu *et al.*, 2015)
		Kality	5.20 ± 0.5		
15	Korefie	Kotebie	4.43 ± 0.4	2.70 - 2.77	(Belay Getnet and Admas Berhanu, 2016)
		Kality	4.50 ± 0.5		

Table 9. Average ethanol content of factory produced alcoholic beverages.

S. No.	Sample type	Amount of ethanol % (v/v) determined	Labeled amount % (v/v)
1	Vodka	39.7± 0.02	40.0
2	Lomie	30.0 ± 0.01	30.0
3	Ananas	32.0 ±0.09	32.0
4	Ouzo	41.0 ±0.01	40.0
5	Dry gin	39.2 ± 0.03	40.0

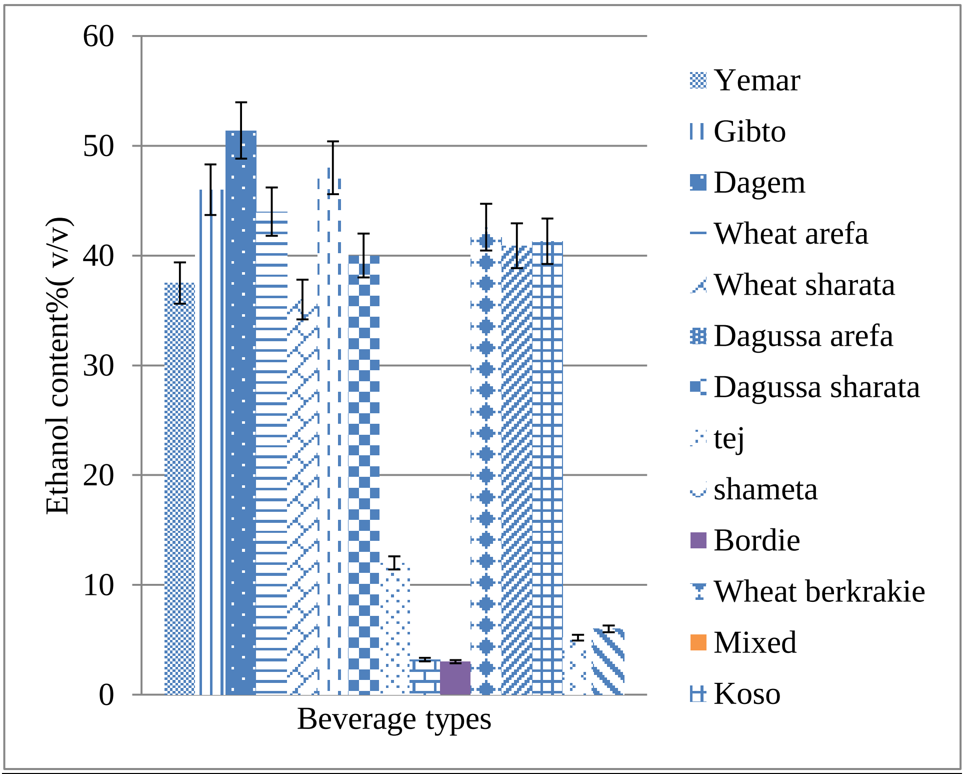

Figure 5. Comparison of the ethanol content of traditional fermented and distilled alcoholic beverages.

CONCLUSION

Quantification of methanol concentration in the alcoholic beverages showed the presence of some amounts of methanol between the ranges of "not detectable" to 7735 mg/L, however below the minimum oral lethal dose 0.3–1.0 g/kg (20 to 60 g or 25–75 mL/person in a 60 kg adult). The results indicated that the contents of ethanol in beverage samples was ranged from 2.80–51.2% (v/v) and there was no significant difference in the ethanol content obtained from the two areas where as there was significant difference in different brands of beverages. The study indicated that the alcoholic content of Ethiopian traditional beverages vary considerably. The alcoholic content variability of local beverages might be due to the spontaneous fermentation, raw materials used and method of producing. pH values of alcoholic beverage samples ranged from 3.50–7.50 but most samples have pH values around 4. Among the twenty brands of beverages Shameta, Tej, Bordie, Tella and Korfie had highest acid content, solid content, electrical conductivity and salinity, while they had lowest pH, ethanol and methanol contents than other beverages. Based on qualitative data all fermented beverages had only ethanol whereas distilled beverages had ethanol and other volatile components.

The levels of methanol found in the fermented beverages are well below the lethal dose and do not pose any health threat to the human health when consumed. However, the normal alcohol health risk associated with high consumption remains a problem. Thus control in the production and supervision with the development of comprehensive national alcohol policy is necessary.

ACKNOWLEDGMENTS

The authors are thankful to the Department of Chemistry, Addis Ababa University, Addis Ababa, Ethiopia, for providing laboratory facilities. Seferu Tadesse is thankful to the Ethiopian Agricultural Research Institute for sponsoring his graduate studies.

REFERENCES

1. Admas Berhanu (2014). Microbial profile of Tella and the role of gesho (*Rhamnus prinoides*) as bittering and antimicrobial agent in traditional Tella (Beer) production. *Int. Food Res. J.* **21**:357–365.
2. Carreon-Alvarez, A. ;Suárez-Gómez, A.; Zurita, F.; Gómez-Salazar, S.; Soltero, J. F. A.; Barcena-Soto, M.; Casillas, N.; Porfirio-Gutierrez and Moreno-Medrano, E. D. (2016). Assessment of physicochemical properties of Tequila brands: authentication and quality. *J. Chem.* **2016**: 1−13, Article ID 6254942. http://dx.doi.org/ 10.1155/2016/6254942.
3. AOAC (2010a). AOAC Official Methods of Aanalysis 945.08, 950.15, 962.12 (17th Ed) (2010). List of methods of analysis for beverage Alcohol http://www.ttb.gov/ssd/pdf/list of beverage methods.pdf (Accessed October, 2018).
4. AOAC (2010b). AOAC Official Methods of Analysis 920.47, 940.09, 950.27 (17th Ed) (2010). List of methods of analysis for beverage Alcohol http://www.ttb.gov/ssd/pdf/ list of beverage methods.pdf (Accessed October, 2018).
5. AOAC (2010c). AOAC Official Methods of Aanalysis 920.47, 942.06, 945.07, 982.10, 983.12 (17th Ed); ASBC official method Beer-4; 27 CFR part 30 (2010). List of methods of analysis for beverage Alcohol http://www.ttb.gov/ssd/pdf/ list of beverage methods. pdf (Accessed October, 2018).
6. Ayalew Debebe; Abel Anberbir; Mesfin Redi-Abshiro; Chandravanshi, B. S.; Araya Asfaw; Negist Asfaw; Nigussie Retta (2017b). Alcohol determination in distilled alcoholic beverages by liquid phase Fourier transform mid-infrared and near-infrared spectrophotometries. *Food Anal. Methods* **10**:172–179.
7. Ayalew Debebe; Chandravanshi, B. S. and Mesfin Redi-Abshiro (2016). Total contents of phenolics, flavonoids, tannins and antioxidant capacity of selected traditional Ethiopian alcoholic beverages. *Bull. Chem. Soc. Ethiop.* **30**:27–37.
8. Ayalew Debebe; Chandravanshi, B. S. and Mesfin Redi-Abshiro (2017a). Assessment of essential and non-essential metals in Ethiopian traditional fermented alcoholic beverages. *Bull. Chem. Soc. Ethiop.* **31**:17-30.
9. Ayalew Debebe; Shibru Temesgen; Mesfin Redi-Abshiro and Chandravanshi, B. S. (2017c). Partial least square-ultra violet near infrared spectrometric determination of ethanol in distilled alcoholic beverages and its comparison with reference method, gas chromatography. *Bull. Chem. Soc. Ethiop.* **31**:201-209.
10. Ayelew Debebe; Mesfin Redi-Abshiro and Chandravanshi, B. S. (2017d). Non-destructive determination of ethanol levels in fermented alcoholic beverages using Fourier transform mid-infrared spectrometry, *Chem. Cent. J.* **11**:27. DOI 10.1186/s13065-017–0257-5.
11. Ayelew Debebe; Shibru Temesgen; Mesfin Redi-Abshiro; Chandravanshi, B. S. and Estifanos Ele (2018). Improvement in analytical methods for determination of sugars in fermented alcoholic beverages. *J. Anal. Methods Chem.* **2018**:4010298. DOI: https://doi.org/10.1155/2018/4010298.
12. Bekele Bahiru; Tetemke Mehari and Mogessie Ashenafi (2001). Chemical and nutritional properties of '*Tej*' an indigenous Ethiopian honey wine variations within and between production unit. *J. Food Technol. Afr.* **6**:104–108.
13. Belachew Desta (1977). A survey of the alcoholic contents of traditional beverages. *Ethiop. Med. J.* **15**:65–68.
14. Belay Getnet and Admas Berhanu (2016). Microbial dynamics, roles and physico-chemical properties of Korefe, a traditional fermented Ethiopian beverage. *Biotechnol. Int.* **9**:156–175.
15. Canaroglu, T. and Yilmaztekin, M. (2011). Methanol and major volatile compounds of Turkish raki and effect of distillate source. *J. Inst. Brew.* **117**:98–105.
16. Daniel Minilu Woldemariam and Chandra- vanshi, B. S. (2011). Concentration levels of essential and non-essential elements in selected Ethiopian wines. *Bull. Chem. Soc. Ethiop.* **25**:169–180.
17. Dereje Bekele and Chandravanshi, B. S. (2012). Levels of essential and non-essential metals in Ethiopian Ouzo. *SINET: Ethiop. J. Sci.* **35**:19-28.
18. Getachew Tafere (2015). A review on traditional fermented beverages of Ethiopia. *J. Nat. Sci. Res.* **5**:94–102.
19. Guesh Mulaw and Anteneh Tesfaye (2017). Technology and microbiology of traditional fermented food and beverage products of Ethiopia. *Afr. J. Microbiol. Res.* **11**:825–844.
20. Jahagirdar, S. S.; Patki, V. K. and Thavare, R. M. (2015). Comparative study of water quality parameters of different brands of soft drinks. *J. Mech. Civil Eng.* **2**:142–149.

21. Katema Bacha; Tetemke Mehari and Mogessie Ashenafi (1999). Microbiology of the fermentation of shamita, a traditional Ethiopian fermented beverage. *SINET: Ethiop. J. Sci.* **22**:113–126.

22. Kebede Abegaz; Fekadu Beyene, Langsrud, T. and Narvhus, J. A. (2002). Indigenous processing methods and raw materials of Bordie, an Ethiopian traditional fermented beverage. *J. Food Technol. Afr.* **7**:59–64.

23. Kofi, S.; Preko, A.; Dzidefo, G.; Yaw, A. and Wiredu, A. (2017). Determination of methanol and ethanol concentrations in local and foreign alcoholic drinks and food products (Banku, Gakenkey, Fantekenkey and Hausakoko) in Ghana. *Int. J. Food Contam.* **4**:1–5.

24. Lachenmeier, D. W. (2007). Rapid quality control of spirit drinks and beer using multivariate data analysis of fourier transform infrared spectra. *Food Chem.* **101**:825–832.

25. Lachenmeier, D. W.; Schmidt, B. and Bretschneider, T. (2008). Rapid and mobile brand authentication of vodka using conductivity measurement. *Microchim. Acta* **160**:283–289.

26. Miller, J. N. and Miller, J. C. (2005). *Statistics and Chemometrics for Analytical Chemistry*, 5th ed., Pearson Practice Hall: England; 2005; pp 55–72.

27. Oladeinde, F. O.; Nwankwo, E. I; Moronkola, O. A; Amosu, M. A. and Farayola, B. (2002). Determination of indigenous and foreign alcoholic beverages levels in urine by quantitative infrared spectroscopy. *Afr. J. Biomed. Res.* **5**:73–76.

28. Paine, A. and Dayan, A. (2001). Defining a tolerable concentration of methanol in alcoholic drinks. *Human Exp. Toxicol.* **20**:563–568.

29. Pinu, F. and Villas-Boas, S. (2017). Rapid quantification of major volatile metabolites in fermented food and beverages using gas chromatography-mass spectrometry. *J. Mol. Diver.Preserv. Int. Multidiscipl. Dig. Publ. Inst.* 7:1–13.

30. Rajković, M.; Ivana D. Novaković, I. and Petrović, A. (2007). Determination of titratable acidity in white wine. *J. Agric. Sci.* **52**:169–184.

31. Shewakena, S.; Chandravanshi, B. S. and Debebe, A. (2017). Levels of total polyphenol, flavonoid, tannin and antioxidant activity of selected Ethiopian fermented traditional beverages, *Int. Food Res. J.* **24**:2033-–2040.

32. Tadele Yohannes; Fekadu Melak and Khalid Siraj (2013). Preparation and physicochemical analysis of some Ethiopian traditional alcoholic beverages. *Afr. J. Food Sci.* **7**:399–403.

33. Teklu, B.; Gebremariam, G.; Aregai, T. and Saripalli, H. (2015). Determination of alcoholic content and other parameters of local alcoholic beverage (Tella) at different stages in Gondar, Ethiopia. *Int. J. IT Eng. Appl. Sci. Res.* **4**:2319–4413.

34. Tulashie, S. K.; Appiah, A. P.; Torku, G. D.; Darko, A. Y. and Wiredu, A. (2017). Determination of methanol and ethanol concentrations in local and foreign alcoholic drinks and food products (Banku, Ga Kenkey, Fante Kenkey And Hausa Koko) in Ghana. *Int. J. Food Contam.* 4:1-–5.

35. Wang, M. L.; Choong, Y. M.; Su, N. W. and Lee, M. H. (2003). A rapid method for determination of ethanol in alcoholic beverages using capillary gas chromatography. *J. Food Drug Anal.* **11**:133–140.

36. WHO (2014). Global status report on alcohol and health. Available at: http://apps.who.int/iris/bitstream/10665/112736/1/9789240692763_eng. pdf (Accessed November, 2018).

37. Yohannes Belete; Chandravanshi, B. S. and Feleke Zewge (2017). Levels of the fluoride ion in six traditional alcoholic fermented beverages commonly consumed in Ethiopia. *Fluoride* **5**0: 79–96.

38. Yücesoy, D. (2011). Authentication and prediction of some quality parameters of alcoholic beverage araki with infrared spectroscopy. MSc Thesis, İzmir University, İzmir, Turkey.