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Chemical compositions of traditional alcoholic beverages and consumers' characteristics, Ethiopia

Dersehilign Awegichew Teshome[1], Matthias Rainer[2], Jean-Christophe Noel[2] Gerhard Schüßler[3] Dietmar Fuchs[4], Harald R. Bliem[3] and Bonn K. Günther[2]

[1]Institute of Neuroscience, Medical University of Innsbruck, Austria
[2]Institute of Analytical Chemistry and Radiochemistry, University of Innsbruck, Austria
[3]Department of Medical Psychology, Medical University of Innsbruck, Austria
[4]Department of Biological Chemistry, Medical university of Innsbruck, Austria
[5]Department of Psychology, University of Innsbruck, Austria

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Commercially available home brewed alcoholic beverages of *Areki and Tej* from Addis Ababa and other regional cities of Ethiopia were analysed for alcohol concentration, methanol level and other additives. Surveys were also carried out on the rate of alcoholism and the socio-demographic characteristics of the consumers. The chemical properties of the sampled beverages showed that home distilled *Areki* and fermented *Tej* drinks can pose health threats due to their high alcoholic strength and undesirable additives. Methanol concentration was found significantly below the highest limit to causing harm to human health. Close to a third of the observed *Tej and Areki* users have exhibited symptoms of alcoholism. Factors related to gender and reasons for drinking were significantly associated with alcohol abuse. The introduction of community-based intervention to reduce the rate of alcoholism in Addis Ababa is strongly suggested. Commercial vending houses should be subjected to acceptable regulations in their mode of production and delivery mechanisms. Applicable strategies for effective management and supervision of traditional alcohol consumption and to reduce alcoholism and risks of health menace are recommended. Further studies on other health influencing substrates deserve supporting.

Key words: Homemade alcohols, *Tej* and *Areki*, community survey, alcoholism, chemical compositions, Ethiopia.

INTRODUCTION

Background

There are numerous traditional alcoholic beverages which are locally produced and consumed among native peoples of many countries around the world. Such types of drinks are very commonly produced in a variety of

*Corresponding author. E-mail: dersehilign.teshome@student.i-med.ac.at. Tel: 0664 4674 902.

ways as home-made beverages in many African countries (WHO, 2004). Home-brewed beverages have several names mostly reflecting the areas where they are produced but most of them are produced in almost similar ways by distillation and fermentation of grain cereals, fruits and/or vegetables (Shale et al., 2014). Distillation is a more complex time consuming method requiring specialized equipments to produce potent alcoholic beverages. Some of the most culturally important traditional beverages in Africa are: `tella` in Ethiopia (Shale et al., 2014) ` thobwa` in Malawi (Matumba et al., 2011), `burukutu` in Nigeria (Sawadogo-Lingani et al., 2010) `tonto` in Uganda (Mwesigye et al., 1995) and `muratina` in Kenya (Aka et al., 2014). These drinks are very popular, perhaps the most widely consumed beverage types because of the nutritional, therapeutic, social and religious values attached to them (Solange, 2014). Indeed, studies also confirmed that fermented products in general can improve sensory qualities and nutritional values by enriching the product with essential proteins and vitamins (Steinkraus, 1986).

Like in other parts of the world, alcohol has been used in Africa for centuries and played an important role in the culture and local economy. Given the abundance of raw materials, varieties of fermented drinks are produced and consumed for various reasons including component of standard diet, a means to settle disputes, facilitating marriages, to hold festivities after a successful hunt or harvest, and for hygienic or medicinal reasons (Platt, 1955). Furthermore, home brewed beverage production and local trade have also provided livelihood for many urban and rural poor, particularly women, for whom it is often the primary means of supporting their families (Adelekan et al., 2008). Despite all these significant economic and cultural importance traditional alcohol drinks have in common in many African societies, there are growing concerns on hygienic handling of raw materials, production procedures and qualities of the final products and rise of alcoholism. Considerable evidences demonstrate that some of the popular traditional alcohol drinks produced in Africa are contaminated with bacteria (Holzapfel, 2002) and contain harmful impurities and adulterants (Sanni, 1993). For example, member of the bacteria types such as Staphylococcus, Escherichia, and Salmonella have been reported to be present in a number of traditional food products and beverage drinks in Africa (Lues et al., 2011). In extreme cases, death might result as well, as the case in Kenya in November 2000 where 140 people died and many went blind and hospitalized after consuming the traditional drink called Kumi Kumi. These drinks are very popular among Kenyan poor neighborhoods and contain harmful substances such as car battery solution, methanol and other dangerous additives (Mureithi, 2002). Similar alcohol poisoning cases have also been reported from Zimbabwe and Somalia (Riley et al., 1999).

The other concerning aspect in many African countries is, the rapidly changing drinking culture. In traditional African society drinking alcohol has been an occasional and communal activity, associated with particular communal festivals (Room, 2014; Room et al., 2002). People do not drink alone or for the sake of drinking only, but these days this values are changing due to expansions of urbanization together with income inequality, along with the tendency to drink excessively inexpensive illegal and/or homemade high alcoholic beverages to alleviate their stress and have good time (Room et al., 2002). According to the latest WHO (2014) global status report on alcohol consumption showed that about 30% of all alcohol consumed globally is unrecorded. This rate, however, is much higher in Eastern Mediterranean, South East Asia and Africa (56, 69 and 31%).

Ethiopia is a country rich in history, ethnicity, and cultural and crop genetic diversity. Traditional alcohol beverages are widely consumed among different ethnic groups of the country as a prominent part of the local traditions of major social events including public holidays, wedding, funerals and other forms of festivities. Some of the most widely consumed home-brewed beverages are Tella, Shamita, Tej, Borde, and Areki. Of these traditionally fermented beverages of Tej, Tella and Areki are the most preferred drinks for big festive occasions.

The WHO global status report on alcohol and health released in 2014 showed that in Ethiopia the volume of unrecorded alcohol consumption is estimated to be 3.5 L of pure alcohol per capita indicating the highest consumption rate compared to other African countries such as Nigeria (1 L),Uganda(1.5 L) and Angola (1.6 L) (WHO, 2014).

As impurities and adulterations are the case in many African countries (Mureithi, 2002; Riley et al., 1999) there are some complaints from regular customers in the study cities that some vending houses use certain plant roots and cement to increase the alcoholic potency of beverages (Yohannes et al., 2013). Such kind of complaint is much more pronounced in the drinks of Areki and Tej, essentially in major cities such as Addis Ababa. Correspondingly, since Areki and Tej drinks are inexpensive compared to industrially produced beer or wine drinks, there is a tendency among the public that those who drink Tej and Areki are considered as alcoholics.

Ethiopian traditional fermented produces are not sufficiently studied.There are quite few works on Ethiopian traditional fermented beverages including data on fusel oil and alcohol content of Tej (Bekele, 2001).The ethanol level,pH and sensory,evaluation of Tej,Areki and Tella were also reported by Yohannes et al. (2013).These studies have, however, methodological drawbacks while quantifying the level of ethanol in Tej and Areki. More

Table 1. Sample allocation.

Characteristics of districts	Total number of districts	Total number of households (as of 2011 census)	Sample size
Low income areas	222 (65%)	35,520	704/54,720*35,520 = 457
Mid-High income areas	120 (35 %)	19,200	704/54,720*19,200 = 247

importantly, they lack information on health relevant substrates such as methanol or other additives with respect to human health. Consequently, there is limited comprehensive and reliable data on the quality of Ethiopian traditional alcoholic beverages in the literatures.

The overall goal of this study is thus to describe the current traditional alcohol consumers' characters in *Kirkos* sub city of Addis Ababa through the analyses of alcohol strength, methanol level and other additives in Tej and Areki beverages from human health perspective. The specific objectives of the study are to:

1. Examine the concentration of ethanol, methanol and other additives of *Tej* and *Areki* drinks.
2. Characterize users of traditional alcohol drinks in *Kirkos* sub city of Addis Ababa, and
3. To determine the rate of alcoholism and the associated factors among observed consumers of *Tej* and *Areki.*

MATERIALS AND METHODS

Study design

The study is quantitative and cross sectional in design. The survey is designed to examine toxicological relevant substrates and characterize current consumers.

Study area and sampling methodology for community survey

The community survey was conducted in *Kirkos* sub city of Addis Ababa. The sub city was selected based on the availability of vending houses and composition of varying socio-economic classes. A stratified and simple random sampling design was employed. Districts were designated as Mid-High and Low income areas based on local knowledge and using Probability Proportional to Size (PPS) and random selection of households.

Sampling frame

The sampling frame of the study was obtained from Ethiopian Statistical Agency 2010/11 census and stratified as districts. Since there was no complete income distribution data in the country, the lead investigator decided to use the aggregate housing appearances of the districts as an alternative way to stratify households. For instance, in area where there are many houses built from mud, woods, plastic and old government built houses, , would be considered as low income areas.

Sample size and allocation

In computation of the sample size, it was estimated 20% of adults living in *Kirkos* sub city have had traditional alcohol beverages in recent time, with 10% margin of error, at 95% level of confidence, design effect of 2, non-response adjustment of 10% and an average household size of 6 is incorporated (Table 1). Based on the above assumptions, a total of 704 households were studied.

Inclusion/exclusion criteria

The exclusion criteria have been age and mental or physical illness. Upon entry to household any member of the household (aged above 18 and mentally aware) who had consumed traditional alcoholic beverages such as *Tej* and/or *Areki* at least once in the past 12 months were requested to fill up the survey form.

Data collection method and instruments

A face to face self-administered questionnaire was utilized. The household data obtained through two structured questionnaires, that is, (1) CAGE was employed to identify symptoms of alcoholism and (2) other questionnaires based on literature reviews such as socio-demographic characteristics, income status, motives and drinking behavior were used to identify relevant variables.

Methods of analysis

The Statistical Package for Social Science (SPSS) version 21 was applied for the entire analyses. Particularly, frequencies and percentages were used to summarize the socio-demographic characteristics and prevalence of alcoholism. Multiple logistic regression analysis was used to identify factors associated with alcoholism. As the dependent variable (alcoholism) is a categorical variable, application of such analysis is appropriate. A series of Chi-square test were also used to examine the crude association of predictor variables with the outcome variable.

Ethical approval

An approval for this study has been granted by Addis Ababa Regional Health Bureau prior to survey implementation.

Survey of sample alcoholic beverages

Samples and sampling sites

A total of four *Tej* and five *Areki* alcohol drinks were collected from

Table 2. Characteristics of *Areki* samples.

***Areki* samples**	**Color**	**Notation**	**Odor/taste**
Terra Areki1	Clear	A1	Alcoholic, earthy
Terra Areki2	Clear	A2	Alcoholic, earthy
Terra Areki3	Clear	A3	Alcoholic, earthy
Terra Areki4	Clear	A4	Alcoholic, earthy
Yekosso Areki5	Amber	A5	Sweet, strong, earthy

Table 3. Characteristics of *Tej* samples.

***Tej* samples**	**Color**	**Notation**	**Odor/taste**
Tej Sample1	Light yellow	T1	Fruity, strongly fermented
Tej Sample2	Yellow brownish	T2	Fermented, whey, acid
Tej Sample3	Dark yellow brownish	T3	Sweet, acid, whey
Tej Sample4	Green yellow brownish	T4	Sweet, pineapple, acid

Addis Ababa city, Sululuta town and regional cities of Gojam, and Debre Birhan. The samples of each drink were collected by sterilized plastic bottles, screw-caped and then the *Tej* drinks were separately kept in a refrigerator until analyses were conducted. The vending houses were selected randomly.

Areki is locally found often as colourless and clear distilled alcoholic beverage, which is made from fermented product of *Yereki-tinsis*. *Yereki-tinsis* is a mixture of pounded *Gesho* leaves (*Rhamnus prinoides*) and cereal flours of sorghum, wheat or maize.

Areki A1 to A4 have similar colour and odour. *Areki* A5 is a bit amber in colour and smells earthier than the others (Table 2).

Tej is home-brewed fermented honey wine (mead). It is prepared by mixing honey, water, and leaves of *Gesho* (*Rhamnus prinoides*).

Tej samples T1 to T4 have different shades of yellow color and all the samples have residue at the bottom of the bottle which could be from the raw material used for production (Table 3).

Used chemicals

Ethanol and methanol standard (purity higher 99.9%), acetonitrile (HPLC grad) hexane and ethylacetate (both purity above 99.8%) were purchased from Sigma Aldrich.

Methods

GC/FID measurements were undertaken with an Agilent 6890 series GC/MS with an DB-WAXETR thin-film capillary column (30 m* 0.25 µm). 1 µl was injected with a split of 30:1, T(injection) = 200°C. Helium as mobile phase had a flow of 1 ml/min. T(detector) = 250°C. Temperature gradient: 60°C hold for 0.5 min to 85°C with 4.5°C/min. GC/MS characterisation was undertaken with an Agilent 6890 N coupled with an Agilent MS 5973 inert. A HP5-MS column (30 m, 0.25 µm, 0.25 micron) was used as stationary phase. 1 µl was injected at a split of 10:1. Injection temperature was 200°C, Helium was used with 1 ml/min as mobile phase. Temperature gradient: 50°C hold for 1 min with 5°C/min to 200°C(hold for 1 min).

Experiments

Samples were centrifuged for 1 min by 12000 rpm to remove residues. The *Areki* samples were stored in PET bottles for some weeks in a dark room. The *Tej* samples were stored in PET bottles in the refrigerator protected by light for some weeks. pH measurements were performed with a single-rod measuring cell at standard conditions.

For GC/FID quantification the samples were mixed with acetonitrile as internal standard and measured directly. Standards with different concentrations for ethanol and methanol quantification were produced and acetonitrile was added to as internal standard.

For GC/MS identification à 350 µl of each sample was extracted with 350 µl hexane. And second extraction was made with 350 µl sample and 350 µl acetic acid ethyl ester. The mixture was shaken at room temperature for 10 min at 1500 rpm. The organic upper phase was transferred into a vial for measurement.

RESULTS AND DISCUSSION

Response rates

Initially, a representative sample size for the study was estimated 704. Of the 704 approached, 665 residents responded correctly, having an overall response rate of 94%.

Socio-demographic characteristics of current consumers

The study consisted of all permanent residents of *Kirkos* sub city, whose ages were 18 years and above, had consumed traditional alcoholic drinks at least once in the past 12 months. Nearly forty percent of the consumers' age ranges between 25 and 39 year and were not married. Majority of the respondents were male, living in less affluent area, having a regular income for their living. Close to half of the participants have already completed their primary school education (Table 4).

Table 4. Demographic and socioeconomic characteristics of observed consumers.

Characteristics	Number (%)
Age groups	
18- 24	63 (9.6)
25 - 39	258 (39.2)
40 - 54	166 (25.2)
>55	172 (26.1)
Gender	
Male	492 (74.3)
Female	170 (25.7)
Marital status	
Single	264 (40)
Married	241 (36.5)
Divorced	79 (11.9)
Widowed	76 (11.4)
Living area	
HighMid housing	241(36.3)
Low housing	422(63.7)
Educational BG	
No education	104 (15.8)
Primary school education	299 (45.4)
Secondary school education	125 (22)
University/college	111 (16.8)
Income status	
Has regular income	456 (71)
Has no regular income	186 (29)
Free time activities	
Has health benefits	486 (75.8)
Has no health benefits	155 (24.2)
Reasons for drinking Alc.	
Helps me interact with others	98 (14.8)
Low selling price	51 (7.7)
For health benefits	99 (15)
Cultural/religious ceremonies	128 (19.3)
Helps me cope with stress	118 (17.8)
Uses as food appetizer	47 (7.1)
For enjoyment	121 (18.3)
# **Alcohol dependence**	
Yes	187 (28.3%)
No	473 (71.7%)

Alcohol abuse prevalence rate

Assessing the rate of alcoholism among the current users in *Kirkos* sub city of Addis Ababa was attempted using CAGE questionnaire (Ewing, 1984), as a result, close to a third (28.3%) of the respondents have indicated symptoms of alcoholism. The result is comparable with previous findings on hazardous alcohol uses in regional cities of Butajira and Soddo (Kebede, 1999; Tefera, 2016) in Ethiopia. Compared to previous report on hazardous alcohol use from Addis Ababa, however, the rate was much higher (Kebede, 1999). It should be noted that different devices could have contributed to differing results: The study by Kebede (1999) in Addis Ababa utilized Composite International Diagnostic Interview (CIDI) to identify cases with alcohol dependence whereas in the current study CAGE was used for identification. It could also be due to a huge time gap between the two studies year of implementation. Since late 1990`s Ethiopia particular Addis Ababa has under gone through a serious of demographic, economic and socio-political changes. Above all there is an ever increasing income inequality, high unemployment and poverty alongside with high availability of cheap home brewed alcoholic drinks and locally grown stimulant Khat/Chat (Catha edulis) may have exacerbated the level of substance abuse. Similar literatures from various countries have indicated that both production and consumption of unrecorded beverages tend to flourish during economic crisis, high unemployment, corruption and lack of social or economic stability (Moskalewicz, 2000; Tomkins, 2007). In this study we also found out that all Areki sample drinks contained very high alcohol strength consequently contributing to high levels of alcoholism.

Model building for alcoholism

To help us identify factors associated with hazardous alcohol use, we developed a model specific to the population. This objective is fulfilled using a model building procedure described by Hosmer and Lemeshow (Bursac et al., 2008).

The screening for alcoholism was carried out using cross culturally validated CAGE questionnaire. The acronym stands for 4 yes/no questions consisting (1) have you ever felt that you need to Cut down on your drinking? (2) Have people Annoyed you by criticizing your drinking? (3) Have you ever felt bad or Guilty about your drinking? (4) Have you ever had a drink first thing in the morning to steady your nerves or to get rid of a hangover (Eye-opener)? The total score can range from 0 up to 4: Four being “yes” to all items. The recommended cut-off for CAGE is ≥2 to screen for alcohol abuse (Ewing, 1984). In addition, the questions have gone through several adjustments to ensure its cultural and content validity.

Bivariate analysis and variables for multivariate analysis

Initially, all socio-demographic and remaining behavioural variables were defined as potential predictors of alcoholism. The results of chi-square have showed that all the variables included have met the specified

Table 5. Bivariate analysis.

Characteristics	CAGE		Total (%)	*p*- value
	No	Yes		
Age groups				
18- 24	39 (61.9%)	24 (38.1%)	63 (100%)	
25 - 39	165 (64.2%)	92 (35.8%)	257 (100%)	
40 - 54	125 (76.2%	39 (23.8%)	164 (100%)	0.000*
>55	142 (83.5%)	28 (16.5%)	170 (100%)	
Gender				
Male	328 (67.2%)	160 (32.8%	488 (100%)	0.000*
Female	142 (84%)	27 (16%)	169 (100%)	
Marital status				
Single	168 (64.1%)	94 (35.9%)	262 (100%)	
Married	175 (73.2%)	64 (26.8%)	239 (100%)	0.000*
Divorced	58 (73.4%)	21(26.6%)	79 (100%)	
Widowed	69 (92%)	6 (8%)	75 (100%)	
Living area				
HighMid housing	187 (78.9%)	50 (21.1%)	237 (100%)	
Low housing	285 (67.7 %%)	136 (32.3%)	421 (100%)	0.002*
Educational BG				
No education	75 (72.1%)	29 (27.9%)	104 (100%)	
Primary education	199 (67.5%	96 (32.5%)	295 (100%)	
Secondary education	110 (76.4%)	34 (23.6%)	144 (100%)	0.11*
University/college	86 (77.5%)	25 (22.5%)	111(100%)	
Income status				
Has regular income	348 (77%)	104 (23 %)	452 (100%)	
Has no regular income	107 (57.8%)	78 (42.2%)	185 (100%)	0.000*
Free time activities				
Has health benefits	370 (76.8%)	112 (23.2%)	482 (100%)	
Has no health benefits	89 (57.8%)	65 (42.2%)	154 (100%)	0.000*
Reasons for alcohol use				
Helps me interact	64 (66.7%)	32 (33.3%)	96 (100%)	
Low selling price	27 (54%)	23 (46%)	50 (100%)	
For healthy benefits	89 (90.8%)	9 (9.2%)	98 (100%)	
Cultural/religious Re.	111 (86.7%)	17 (13.3%)	128 (100%)	0.000*
Helps me cope with stress	63 (53.4%)	55 (46.6%)	118 (100%)	
Uses as food appetizer	37 (78.7%)	10 (21.3%)	47 (100%)	
For enjoyment	79 (65.8%)	41 (34.2%)	121 (100%)	

statistical criteria, *p*-value <0.25 (Table 5).

Factors associated with alcoholism

One of the objectives of this study was to identify factors associated with hazardous alcohol use. Accordingly, the result of the study identified four factors that were significantly associated with alcoholism. Gender particularly males were 2.4 times more likely than females to abuse alcoholic drinks (OR = 2.4, 95% CI: 1.296 - 3.618, p < 0.005). This finding is in consistent with previous literatures which show the association between being male and alcohol abuse (Alem, 1999; Razvodovsky, 2013; Tefera, 2016). Besides, in present survey majority of the respondents were males in their early adulthoods. Consequently, there is a higher vulnerability to chew locally found stimulant such as Khat/Chat (Catha edulis); alongside to consume a potent alcoholic drinks such as Areki in order to relieve from temporary depressive feelings created by chewing the Khat. According to recent reports some 80-90 and 10-60% East African males and females, respectively, chew Khat on daily basis (Odenwald et al., 2005).

Table 6. Main effects.

Variable	Odds ratio	95% confidence interval	*p*-values
Sex	2.165	1.296 - 3.618	0.003
Reasons for alcohol use	3.741	2.214 - 6.322	0.000
Income status	0.625	.407 - .960	0.032
Free time activities	0.615	3.98 - .951	0.029

Table 7. pH measuring.

Sample	pH	Sample	pH
A1	4.00	**T1**	3.60
A2	3.70	**T2**	3.40
A3	3.90	**T3**	3.50
A4	4.10	**T4**	3.40
A5	5.30		

Individuals' motives for consuming traditional alcoholic drinks were the second major risk factor associated with alcohol misuse. Those respondents who responded that they prefer drinking homemade alcoholic drinks because of their relative cheap prices were 3.7 times more likely than those who have not given similar reasons to suffer from alcohol use related problems such as alcoholism (OR = 3.741, 95% CI: 2.214 - 6.322, p < 0.005). Given this result, it is possible to infer that cheap homemade alcoholic drinks have contributed to the rise of alcoholism in the community. Literatures in similar topic have also indicated that availability of unrecorded alcohol in many countries have been linked to people of lower socio-economic strata and alcohol dependence (Adelekan et al., 2008; Gamburd, 2008).

Factors such as income status and free time activities are identified as protective factors against alcoholism. The percentages of individuals who reported that they have had some kind of regular monthly income source for their livelihood were less likely to abuse alcohol drinks, in comparison with those who do not have reliable income source (OR = 0.625, 95% CI: .407 - .960, P< 0.005). This finding could be related to the fact of being unemployed and employed; being unemployed is often associated with greater alcohol consumption and drinking surrogate alcohol drinks (Razvodovsky, 2013; Tomkins, 2007). In other words, individuals without fixed income source are related feelings of boredom and lack of economical means to satisfy one's basic needs may cause them to have a grief and sorrow feelings, leading to increased alcohol use to help them cope with the unpleasant situations. In contrast, employed people are those likely with some kind of responsibilities as such, they may drink less often because of tight time schedule or to avoid potential job loss (Peirce et al., 1994). In connection with, majority of the respondents surveyed in this study were employed and choose to pass their spare time in healthy beneficial ways such as reading books, doing physical exercise, spending time with family and visiting cultural and historical sites etc. Similarly, individuals who reported spending their free time by engaging in activities which could enhance either mental or physical health were 0.615 time or 61.5% less likely to become an alcoholic person than those who have not indicated health benefiting activities as their hobby (OR = 0.615, 95% CI: 3.98 - .951, P<0.005). This finding shows a potential intervention strategy against the widespread substance use problem in the city in general (Table 6).

Chemical analysis of the sampled drinks

The aim was to quantify ethanol and methanol of two different homebrewed alcoholic beverages produced in Ethiopia via gas chromatography flame ionization detection (GC-FID). *Tej* is a fermented honey wine with an expected ethanol concentration of around 8% (v/v). *Areki* is distilled liquor with an expected concentration of circa 40%. In addition, the pH is measured and additional volatile components are determined via gas chromatography mass spectrometry (GC/MS).

pH

The pH is more acidic than expected for the *Areki* samples. A1-A4 are in the same pH range, the dark A5 alcohol is the less acidic of all the samples.

T1 to T4 are also in the similar pH range and more acidic than the strong *Areki* liquor. It was supposed that T1 was over fermented, but the pH did not indicate it, maybe the high carbon dioxide content is typical for some of these products (Table 7).

GC/MS identification

Table 8 shows the main volatile components of the different samples. The MS spectrum was compared with the National Institutes of Standards and Technology (NIST) databank. Only when the measured spectrum had a match over 90% with the databank, the found molecule will be listed in Table 8. The results of the extraction with hexane and acetic acid ethyl ester were combined to get the whole volatile molecules composition.

In every sample phenylethanol was found. It is a flavour component which occurs in Rosaceae, Asparagaceae and Caryophyllaceae. In this case the yeast can be the source of this molecule. It decomposes through light and

Table 8. Characterization of aroma components in alcoholic beverages (Range, 2009).

Sample	Molecule	CAS	Smell[1]
A1	2-Phenylethanol	60-12-8	Rose
	Hexanoic acid ethyl ester	123-66-0	Fruity
	Octanoic acid ethyl ester	106-32-1	Fruity, sweet, pineapple
	Decanoic acid ethyl ester	110-38-3	Sweet waxy apple
	Palmitic acid ethyl ester	628-97-7	Mild waxy fruity creamy
	Stearic acid ethyl ester	111-61-5	Mild waxy
	Isoamylacetate	123-92-2	Sweet, banana
	Dodecanoic acid ethyl ester	106-33-2	-
A2	Isoamylacetate	123-92-2	Sweet, banana
	Hexanoic acid ethyl ester	123-66-0	Fruity , produced at fermentation
	Phenylethanol	60-12-8	Rose , Decomposition under air/light
	Octanoic acid ethyl ester	106-32-1	Fruity, sweet
	Decanoic acid ethyl ester	110-38-3	Sweet waxy apple
	Dodecanoic acid ethyl ester	106-33-2	-
	Palmitic acid ethyl ester	628-97-7	Mild waxy fruity creamy
	Stearic acid ethyl ester	111-61-5	Mild waxy
A3	Phenylethanol	60-12-8	Rose , Decomposition under air/light
	Octanoic acid ethyl ester	106-32-1	Fruity, sweet
	Dodecanoic acid ethyl ester	106-33-2	-
	Palmitic acid ethyl ester	628-97-7	Mild waxy fruity creamy
	Decanioc acid ethyl ester	110-38-3	Sweet waxy apple
	Isoamylacetate	123-92-2	Sweet, banana
	Butanoic acid ethyl ester	105-54-4	Fruity juicy
A4	Phenylethanol	60-12-8	Rose, decomposition under air/light
	Butanoic acid ethyl ester	105-54-4	Fruity juicy
	Isoamylacetate	123-92-2	Sweet, banana
	Hexanoic ethyl ester	123-66-0	Fruity, produced at fermentation
	Decanoic acid ethyl ester	110-38-3	Sweet waxy apple
	Octanoic acid ethyl ester	106-32-1	Fruity, sweet
	Palmitic acid ethyl ester	628-97-7	Mild waxy fruity creamy
	Dodecanoic acid ethyl ester	106-33-2	-
A5	α-Pinen	80-56-8	Fresh camphor pine
	Phenylethanol	60-12-8	Rose, Decomposition under air/light
	Octanoic acid ethyl ester	106-32-1	Fruity, sweet
	α-Guaiene	3691-12	Sweet woody peppery
	Aromadendrene	14682-34-9	-
	Caffeine	58-08-2	-
	Palmitic acid ethyl ester	628-97-7	Mild waxy fruity creamy
	d-Limonene	5989-54-8	Pine herbal terpene
	Decanoic acid ethyl ester	110-38-3	Sweet waxy apple
	Linolic acid butyl ester	2634-45-9	-
T1	Butandiole		
	Phenylethanol	60-12-8	Rose, decomposition under air/light
	Butandioic acid monoethyl ester		
	Caffeine	58-08-2	-
	Palmitic acid ethyl ester	628-97-7	Mild waxy fruity creamy

Table 8. Contd.

T2	Butandiole	584-03-2	-
	Phenylethanol	60-12-8	Rose, decomposition under air/light
T3	Butandiole	584-03-2	-
	Phenylethanol	60-12-8	Rose, decomposition under air/light
	(4-Hydroxy)Phenyl ethanol	501-94-0	Mild sweet floral taste
	Palmitic acid ethyl ester	628-97-7	Mild waxy fruity creamy
	Butandioic acid ethyl ester	105-54-4	Fruity juicy
T4	Butandiole	584-03-2	-
	Phenylethanol	60-12-8	Rose, decomposition under air/light
	(4Hydroxy) Phenyl ethanol	501-94-0	Mild sweet floral taste
	Palmitic acid ethyl ester	628-97-7	Mild waxy fruity creamy

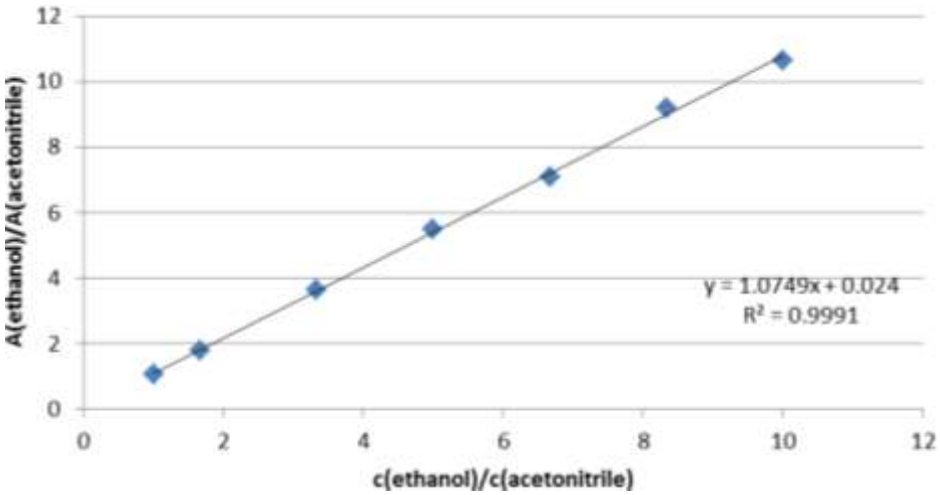

Figure 1. GCFID calibration of ethanol quantification with acetonitrile as internal standard; A = peak area.

oxygen so that the taste of the product can be influenced by storing conditions. In *Areki* liquor (A1-A4) many long-chain esters are found which can be produced at fermentation. They all taste fruity and give the product a fuller bouquet. Even though the samples are the same sort of product, they have a different odour composition which is caused by different raw-products and different producers. *Areki* A5 which has a dark colour has as some terpenes in it, mainly limonene and α-pinene, found in nearly every essential oil. The *Tej* alcohols also have some esters in them which smell fruity which also are produced during fermentation of the organic raw-material. Surprisingly, in A5 und T1 caffeine was found as principal component. The experimenters were not able to elicit why it has been used. Through further investigations it could also be possible to find even more flavour components.

Ethanol quantification

As homemade alcoholic beverages are produced at home without standardized procedures, thus the alcohol concentrations differ among samples significantly. Although there are some easy methods to measure the ethanol concentration via density as reported by Yohannes et al. (2013) which was not accurate. The experimenter chose GCFID to determine via internal standard the ethanol concentration in % (v/v). Standards between 3 and 30% (v/v) were prepared. The *Areki* samples A1 to A5 were diluted 1:1 with water due to the high ethanol concentration. *Tej* T1 to T4 were centrifuged and measured directly (Figure 1)(Table 9).

As expected *Areki* A1 to A4 have high ethanol content but it varies from producer to producer. *Areki* A5 has the highest concentration of 51.1% (v/v).*Tej* T1 to T4 have

Table 9. Ethanol concentration in different alcoholic beverages used calibration results of Figure 1.

Sample	c(ethanol)/ % (v/v)	Practical limit of error (f= 5, 99.5%)
A_1	44.9	±0.5
A_2	48.9	±0.5
A_3	48.1	±0.5
A_4	51.1	±0.5
A_5	44.8	±0.5
T_1	12.4	±0.5
T_2	12.3	±0.5
T_3	12.1	±0.5
T_4	13.0	±0.5

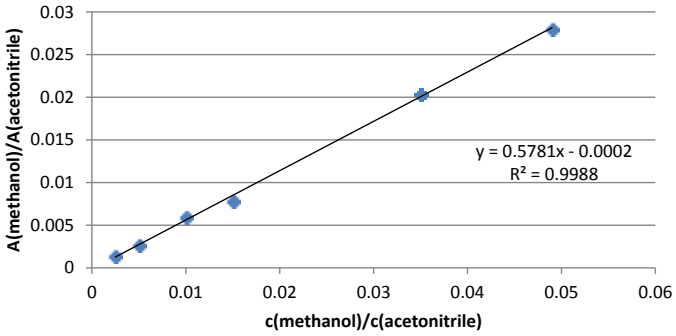

Figure 2. GCFID calibration of methanol standards with acetonitrile as internal standard.

Table 10. Results of methanol quantification with results of calibration in Figure 2.

Sample	c(methanol) /% (v/v)	Practical limit of error (f= 5, 99.5%)
A_1	0.187	±0.004
A_2	0.150	±0.004
A_3	0.167	±0.004
A_4	0.062	±0.004
A_5	0.021	±0.004
T_1	0.020	±0.004
T_2	0.008	±0.004
T_3	0.010	±0.004
T_4	0.006	±0.004

lower ethanol concentration by reasons of production. They vary not so much as the *Areki* liquors. The alcoholic strength of *Areki* samples showed much more variations than that of the *Tej* drinks. The greater variation in alcoholic strength in *Areki* samples might be due to the specific ingredients and methods of preparation of the source locality. Previously, similar research also observed significant variations in pH and alcohol contents among the samples considered (Yohannes et al., 2013). In addition, in this study, *Areki* drinks contained an average alcoholic strength of 47.56% which is higher than previously reported between 33.95 and 39.9% v/v (Yohannes et al., 2013) and even much higher than the maximum allowable limits for similar spirit drinks in Europe (Regulation, 1989). High alcoholic drinks such as *Areki* have a great potential to cause detrimental health effects through the huge increment of alcoholism, as it was identified in this study third of current consumer showed symptoms of alcoholism. On other hand, the *Tej* drinks had an alcoholic strength between 12.1 and 13% v/v which corresponds to the previous reports (Bekele, 2001; Yohannes et al., 2013) however, in *Tej* sample drinks caffeine was also identified which raises the possibility for the presence of other undesirable additives if further investigation is carried out.

Methanol quantification

Sometimes it is possible that methanol and other higher alcohols could be present in the final product of homemade alcoholic drinks. Methanol can be highly concentrated in the first fractions of distillation. It is normal to throw away the first fractions to avoid severe health risk due to methanol intoxication. Higher alcohols like glycols and long chained alcohols can be present in distillation fractions after the ethanol one. When high concentrated alcoholic beverages are produced and more fractions are used as usual, the final product can be contaminated with potential toxics.

In the samples methanol concentrations were determined with the same method as for ethanol. Standards staggered with acetonitrile are made with a concentration range between 0.1 and 0.005% (v/v) (Figure 2)(Table 10).

Methanol was found in all samples. The distilled beverage samples have relatively higher concentrations than that of *Tej* beverages. Methanol concentration for *Areki* beverages ranged between 0.021 and 0.187 % (v/v) whereas in *Tej* drinks concentration of 0.006 and 0.020% (v/v) were identified. The detected methanol both in *Tej* and *Areki* samples drinks were considerably below the maximum limit suggested by European Union for methanol concentration (Regulation, 1989). Nevertheless, the *Areki* sample beverages on average contain higher methanol concentration which speaks for the possibility that producers might have used the first fractions at the distillations. The GCFID and MS measurements have shown the possible presence of other alcohols which can also lead to health risks in high

concentrations. With further investigation these possible dangerous alcohols can be identified and quantified.

Although many more contaminates remained to be investigated, this finding at least confirmed slightly that Ethiopian homebrewed beverages of *Tej* and *Areki* have no serious threat to human health .

Although our results did not demonstrate a serious health threats to the consumers, we strongly recommend that the Ethiopian public health authorities introduce control on vending houses by examining regularly the qualities of the drinks and hygiene practices to ensuring safe consumption of the beverages. Such approach would at least help to reduce public health problems related to homemade alcoholic beverages.

Conclusion

The study has attempted to provide a comprehensive insight into the qualities of Ethiopian home-brewed drinks along with the characteristics of consumers from human health perspective. The qualities of homebrewed *Tej* and *Areki* samples were relatively safe except for high ethanol contents in *Areki* drinks, and an additive of caffeine that was also detected in *Tej* and *Areki* beverages, call for further investigations. To protect the public from alcohol related contaminants concerned government organs must put in place policies to ensure qualities and safety of traditional alcoholic drinks at least in selected vending houses in major cities of the country.

Overall, *Tej* and *Areki* drinks are mainly consumed by low socioeconomic class of the society. The prevalence rate of alcoholism among the studied consumers calls for some kind of interventions. Being male and using homebrewed alcoholic drinks because of its relative cheap price were predictor factors of alcoholism while having a regular monthly income and passing spare times with health beneficial activities were protective factors against alcohol abuse.

There are several methodological limitations to this study. First of all, the prevalence of alcoholism in *Kirkos* sub city shows just a portion of the situation and cannot be generalized to the entire Addis Ababa city and the country Ethiopia as a whole. Although the findings reflect the experiences of the specific part of the city of Addis, future inclusive research results could be obtained by working on larger sample sizes across the entire capital city shading light into alcohol consumption and its impacts on the health of city residents. Additional data could be collected and analysed across the nation toportray trends of alcoholism in the different regions ofEthiopia. Similarly, the chemical analysis of the sample drinks were performed from very small samples that may lack the representativeness of home brewed alcoholic drinks qualities in Addis Ababa and in Ethiopia as a whole.

We believe that our study has provided the basis for future research on the prevalence of alcoholism by addressing the basic concerns regarding the qualities of home brewed alcoholic beverages in Ethiopia. As there is inadequate information in the country on home brewed alcoholic drinks in relation to health outcomes, our findings would serve a basis for further investigation in the near future.

It is highly recommend that future research should focus on other health relevant quality parameters such as level of lead, acetaldehyde and bisphenol on representative sample from cross-sections of rural and urban regions of Ethiopia.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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