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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

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Abstract

Background: It is believed that higher methanol content may be present in some alcoholic drinks produced by traditional distilleries or some alcohol brewing companies. As a result of this, there could be a higher risk of methanol concentration in products. Therefore, this research focused on quantifying the amount of methanol in some fermented foods and alcoholic drinks by Gas Chromatography. The method was validated for limit of detection, limit of quantification, and recovery.

Results: The results showed some level of methanol in some of the studied local and foreign alcoholic drinks between the ranges of 0.003-0.161% Vol. whereas no methanol was observed in any of the analyzed food products.

Conclusions: The results showed that the levels of methanol observed in the analyzed drinks do not pose any health threat to the human body when consumed, contrary to the general assumptions that it does. However, the normal alcohol health risk associated with high consumption still remains a problem.

Keywords: Akpeteshie, Methanol, Hausa koko, Kenkey, Banku

Background

Alcohol can be described as a psychoactive drug which has extensive applications in both industries and households. Alcohol can be produced locally or industrially in large or small quantities based on the available resources across the world (ePURE, 2017). Most farmers engage in alcohol production not only as a means to generate income to earn a living, but also due to the high level of demand and use in diverse ways by consumers across the globe (Glithero et al. 2013). The sources of raw materials for the production of alcohol can be obtained from fruits, cassava, palm wine, sugar cane, etc. The basic method for the production of alcohol is by fermentation or decomposition and simple distillation (Manoel, Teresa, José, & Cássia, 2014). It is assumed that most traditional alcohol manufacturers are ignorant about the basic chemical compositions of the alcohol they produce and hence may end up producing alcoholic drinks with higher methanol content and other potential health threatening components (Jurgen, et al., 2014). Dangerous chemical compositions such as lead and methanol present in alcohol pose a threat to human health. Ethanol and methanol have similar physicochemical properties and are present as by-products after distillation (Jurgen, Fotis, & Dirk, 2010). According to World Health Organization (WHO), the harmful use of alcohol causes an estimated 2.5 million deaths every year, of which a significant proportion occurs in the young. There is also emerging evidence that the harmful use of alcohol contributes to the health burden caused

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by communicable diseases such as tuberculosis and HIV/AIDS (WHO, 2004).

The quality of alcoholic beverages in Ghana (especially the traditionally brewed) has been a source of concern for some time (Luginaah and Dakubo 2003). It is believed that methanol may be generated in alcoholic drinks during the fermentation process. The lack of proper fermentation and distillation techniques by traditional or artisanal distilleries and some commercial operators may be a factor to high risk of methanol content in the products (Elijah 2016). Also, the complications and chronic diseases or ill health such as blindness, dizziness, respiratory diseases etc., associated with drunkenness suggested that there may be the presence of methanol and other toxic substance in the drink that affects the health of the people (Lachenmeier 2007). Methanol is a chemical solvent, widely used in products such as paints, gasoline, and photocopying fluid. Methanol occurs naturally in food, notably in fresh fruits, vegetables and their juices. It occurs as free methanol, methyl esters of fatty acids or methoxy groups on polysaccharides such as pectin from which it can be released by digestion. Pectin is broken down during digestion in the colon, from where methanol can be absorbed. This means that the potential methanol intake from the diet is higher than analysis of the free methanol content of individual foodstuffs (Lang et al. 2006). The ingestion of as little as 10 ml of methanol can cause permanent blindness and 30 ml can be fatal (Lal et al. 2001). Methanol is metabolized by alcohol dehydrogenase that converts it to formaldehyde and finally to formic acid, the metabolite responsible for its toxicity. Folate is necessary to metabolize and excrete formic acid (Lal et al. 2001). Observed human oral lethal dosage of methanol via ingestion ranges from 15 to 250 g (Gibel et al. 1969).

This work focuses on quantifying the concentrations of methanol in both local and foreign alcoholic drinks and some fermented food products (Banku, Ga kenkey, Fante kenkey and Hausa koko) in Ghana by using Gas Chromatography with thermal conductivity detector (GC-TCD) as an analytical method.

Methods

Sampling

Twenty samples of most commonly used local and foreign alcoholic beverages in Ghana were randomly purchased from various shops in the Greater Accra and Volta regions of Ghana. The selected alcoholic beverages were in the categories of spirits, wines and herbal bitters. The raw materials for the foreign beverages differed from one another, but were mostly cereals and fruits as well as selected herbs which were fermented and distilled industrially. However, all samples of the locally made spirit (Akpeteshie) were produced by artisanal (traditional) brewery. The selected local food products (Banku, Ga kenkey, Fante kenkey and Hausa koko) were purchased from the University of Cape Coast, UCC (science market) in the central region of Ghana. These food products with the exception of Hausa koko were all produced from fermented corn dough. Hausa koko on the other hand was produced from milled millet grains that were allowed to stand and ferment for some days. The purchased samples were then given unique serial numbers.

Reagents

Analytical grade reagents were utilized. Standard reference solutions of Methanol, Isopropyl alcohol and distilled water were used for the development of the GC calibration curve for this work.

Sample preparation

2.5 ml of each alcoholic beverage sample was measured into a measuring cylinder and topped up with de-ionized water to the mark. The food samples were prepared by measuring the mass, 154.75 g, 210.00 g, 214.91 g and 245.55 g of Banku, Hausa koko, Ga kenkey and Fante kenkey respectively and were dissolved separately in de--ionized water. Filtration was done to obtain a clear solution for GC analyses. A portion of the prepared sample was then used for the GC analysis.

Table 1 Detailed description of the operating conditions of the GC

Parameter	Value
Injector temperature set point	120 °C
Injector flow rate	21 ml/min
Type of column	Packed Column
FFAP	15% Chromosorb which is highly polar
Column flow rate	20 ml/min
Initial oven temperature	60 °C on hold for 5 min
Final oven temperature	120 °C on hold for 5 min
Temperature increases interval	at 10 °C/min interval
Detector temperature	250 °C
Reference flow rate	50 ml
Limit Of detection (Methanol)	1.43×10^{-4}%Vol
Limit of detection (Ethanol)	1.54×10^{-4}%Vol
Limit of quantification (Methanol)	4.77×10^{-4}%Vol
Limit of quantification (Ethanol)	5.12×10^{-4}%Vol
Recovery Range %	80%–100%

Table 2 Summary of the mean concentrations of methanol and ethanol in the analyzed alcoholic drinks

Drinking spot	Location	Alcohol type	Origin	Code	Methanol (%vol)	Ethanol (%vol)
Maxi spot	Mafi Asiekpe	Spirit	Local	S2	–	37
Home	Osu-Nyaneba Est.	Wine	Foreign	S3	0.009	12
Home	Osu- Nyaneba Est.	Whisky/spirit	Foreign	S4	0.007	40
Home	Osu- Nyaneba Est.	Wine	Foreign	S5	0.007	17
Maxi spot	Mafi Asiekpe	Bitters/spirit	Local	S6		40
Distillation point	Mafi Mankukope	Akpeteshie/spirit	Local	S7	0.052	45
Maxi spot	Mafi Asiekpe	bitters/spirit	Local	S8	–	29
Maxi spot	Mafi Asiekpe	bitters/spirit, med. Alcohol	Local	S9	–	32
Home	Osu-Nyaneba Est.	Wine	Foreign	S10	0.003	8
Maxi spot	Mafi Asiekpe	dry gin/spirit	Local	S11	–	37
Desiadenyo spot	Mafi Asiekpe	Spirit	Local	S12	–	31
Desiadenyo spot	Mafi Asiekpe	spirit, med. Alcohol	Local	S13	–	37
Desiadenyo spot	Mafi Asiekpe	bitters/spirit	Local	S14	0.063	38
Maxi spot	Mafi Asiekpe	spirit, med. Alcohol	Local	S15	0.112	22
TOR Bush Canteen	Tema-Accra	Akpeteshie/spirit	Local	S16	–	36
Original Auntie BB	Osu-Nyaneba Est.	Akpeteshie/spirit	Local	S17	0.126	42
VYKISS spot	Osu-Ako-Adjei	spirit, med. Alcohol	Local	S18	0.142	43
Auntie Afi's Enterprise	Osu-Ako-Adjei	Akpeteshie/spirit	Local	S19	0.141	39
Jomens Enterprise	Osu-Ako-Adjei	Akpeteshie/spirit	Local	S20	0.161	39

Note that the brand names of these alcoholic beverages have been withheld for security reasons

Instrumentation

For the quantification of the methanol and ethanol content in the prepared samples, a GC model of Agilent US 6890 N Series (California, USA) equipped with a thermal conductivity detector purchased from Agilent Technology was used. The GC was calibrated using prepared mixtures of analytical grade ethanol, methanol and water. A (3.0 μl) portion of each prepared sample was introduced into the injector port and the analysis was carried out in operation conditions stated below in Table 1.

Results and discussion

The Table 2 depicts a summary of the mean concentrations of two replicates each for ethanol and methanol analyzed in the alcoholic drinks in each case.

Table 2 shows the variations in the concentrations of methanol and ethanol of the various samples analyzed. Ethanol concentration of the samples ranged between 7 and 46% whereas that of methanol ranged from "not detectable" to 0.161%. Akpeteshie recorded the highest amount of methanol and ethanol concentrations among the analyzed samples in all cases. From Table 2, it was also observed that eight of the alcoholic drinks (sample codes; S2, S6, S8, S9, S11, S12, S13 and S16) recorded no amount of methanol concentration whereas twelve of the analyzed samples (sample codes; S3, S4, S5, S7, S10, S14, S15, S17, S18, S19 and S20) showed traces of methanol at different concentrations. Among the samples that tested positive for methanol content, sample S10 (a foreign wine) recorded the lowest amount of methanol concentration (0.003%) while sample S20 (Akpeteshie) showed the highest methanol concentration (0.161%).The results show that low amounts of methanol were recorded in the foreign drinks as compared to the local drinks.

Whereas WHO reported oral lethal dose of methanol between 0.3–1 g/kg (20 to 60 g or 25–75 ml/person in a 60 kg adult) (WHO 1997), a 0.161% methanol level as seen in the analysis implies that 1.61 ml of methanol may be realized in 1 L of the alcoholic drink (Akpeteshie) and hence possesses no potential health threat

Table 3 Ethanol and methanol concentration in the analyzed local fermented food products

Food vendor	Location	Sample name	Methanol(%vol)	Ethanol (%vol)
Emmanuel chop bar	Science market, UCC	Banku extract	–	0.0297
	Science market, UCC	Ga Kenkey extract	–	0.007
	Market entrance, UCC	Hausa koko extract	–	0.0141
	Amamoma	Fante kenkey extract	–	0.139

when consumed. However, the oral lethal dose of ethanol had been reported in the range 5 to 8 g/kg. Thus, for a 60 kg adult, 300 g (384 ml) of ethanol can be fatal (Alcohol.org.nz), therefore, ethanol concentrations of 39% and above as seen in some of the analyzed drinks (S4, S6, S7, S17, S18, S19 and S20) implies 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.

Table 3 shows a summary of methanol and ethanol concentrations found in the fermented food products.

All these food products were produced from corn dough with the exception of Hausa koko, which was produced from millet grains. To make corn into dough, it was first soaked in water for about 3 days and then drained off the water after which it was milled into fine powder. The obtained powder was mixed with a small amount of water and made into dough. The dough was then left for some days to ferment before being used to prepare the desire food product (Ga Kenkey, Fante Kenkey and Banku). The millet grains were also treated in the same way to obtain millet dough from which Hausa koko was produced.

No amount of methanol was observed in the food products. Fante kenkey recorded the highest amount of ethanol concentration. The concentration of ethanol in Ga kenkey was insignificant as compared to that of Fante kenkey.

Conclusions

Determination and quantification of methanol and ethanol concentration in alcoholic drinks and some local fermented food products showed that some amounts of methanol between the ranges of “not detectable” to 0.161% were found in most of the alcoholic drinks that were investigated, but were however below the minimum oral lethal dose 0.3–1 g/kg (20 to 60 g or 25–75 ml/person in a 60 kg adult). The food products recorded no amount of methanol but contained small quantities of ethanol between the ranges of 0.006–0.140% which are not harmful to the body. The concentration of ethanol in most of the alcoholic drinks was below the suggested lethal dose of 5 to 8 g/kg for a 60 kg adult, 300 g (384 ml) of ethanol. However, Akpeteshie seemed to contain 40–45%Vol of ethanol implying that at least 400 ml of ethanol is contained in 1 L of the drink and hence may cause higher health risks when consumed excessively or without care.

This research work suggests that despite the fact that methanol was found to be present in most of the analyzed alcoholic drinks, the levels observed do not pose any health threat to the human body when consumed, contrary to the general assumptions that it does. However, the normal alcohol health risk associated with high consumption still remains a problem and therefore, it is recommended that typical alcohol policy responses such as increases of sales prices via taxation especially for the locally made spirit (Akpeteshie) which appears to be cheaper on the market as well as restrictions of availability of such beverages be implemented, alongside sensitization campaigns to educate the national populace on the dangers of excess alcohol intake.

Additional files

Additional file 1: Validation data. (XLSX 32 kb)

Additional file 2: Chromatograms of the analyzed food and drink samples. (PDF 8503 kb)

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Availability of data and materials
All the data, including chromatograms with respect to measurements made in this manuscript are available in the manuscript and as Additional files 1 and 2 to support this manuscript.

Authors’ contributions
All the authors contributed significantly to this manuscript. SKT was the chief supervisor of the entire process from the experimental work to the writing of the manuscript. AYD and AW did the laboratory analyses/experimental work of the local and foreign drinks respectively. APA and GDT did all the sampling, undertook the experimental work/laboratory analyses of the local fermented food products, and drafted the entire manuscript. All authors read and approved the final manuscript.

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Not applicable.

Consent for publication
All the authors have consented to the publication of this manuscript.

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The authors declare that they have no competing interests.

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