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Consumption pattern, heavy metal content and risk assessment of *Akpeteshie*-local gin in Ho municipality of Ghana

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ABSTRACT

Akpeteshie is a locally distilled alcoholic beverage produced by fermentation of palm wine and other substrates. This study investigated *akpeteshie* consumption patterns in Ho municipality and assessed the content of ethanol and contaminants (methanol, lead, copper and iron) in the *akpeteshie* samples. Alcohol consumption pattern of 140 participants was determined using the Daily Drinking Questionnaire in a cross-sectional study in Ho municipality, Ghana. The levels of ethanol and methanol in ten (10) samples of *akpeteshie* obtained from distillers across the municipality was determined using AOAC methods. Heavy metals were determined using atomic absorption spectrophotometer. The health risk associated with *akpeteshie* consumption was also assessed. About 67.86% of the respondents preferred *Akpeteshie* as their alcoholic beverage. Majority of respondents who consumed *akpeteshie* were males (93.6%), however the female participants (66.67%) exceeded the recommended number of drinks. Although methanol and lead were not detected, copper (1.39–4.12 mg/l) and iron (1.98 mg/l) were present and exceeded allowed standards. The study observed high *akpeteshie* consumption levels among males, but increased alcohol abuse among females beyond the recommended limits of 1–2 drinks/day. Although iron (1.98 mg/l) and copper (4.12 mg/l) levels in the *akpeteshie* samples were high, risk assessment of the consumed toxic metals through *akpeteshie* posed no adverse health effects on the populace of the various locations. However excessive consumption of *akpeteshie* could lead to incremental life cancer risk due to the minute accumulation of these toxic metals hence the need to intensify regulatory and health promotion efforts.

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Introduction

Akpeteshie is a locally distilled liquor in Ghana and other West African countries [1]. The local gin is known as "*Koutoukou*" in Ivory Coast [2] and "*ogogoro*" in Nigeria by Ohimain [3]. Alcoholic beverages are usually derived from fermentation and distillation of sugar-based crops. Some of these beverages such as beer and wines are universal and available across many cultures and geographic regions. *Akpeteshie* is an indigenous African alcoholic beverage which is either consumed in the original form as a colorless distillate, or aged and flavored with a variety of herbs to yield liquors known as "bitters" [2]. These "bitters" are commonly acclaimed by consumers to have several benefits such as medicinal and aphrodisiac effects [2].

Akpeteshie is produced via distillation of the end product of microbial fermentation of a variety of substrates. The substrates commonly used are palm wine, sugarcane, and a mixture of sugar, water and yeast [2]. The production process is done using relatively simple distillation setups, making the alcoholic drink relatively cheaper [4]. The active component of alcoholic beverages is ethanol, but during fermentation other compounds (methanol and isopropanol) are produced. Due to the nature of the metal contraptions used in the distillation procedure, there are possible heavy metal contamination [5]. Atomic absorption spectrophotometer (AAS) had been used for the detection of heavy metals in consumable samples such as water and fish [6]. Methanol contamination can lead to critical health conditions such as respiratory distress, vision impairment, permanent blindness, coma and death [7]. In addition, the ingestion of heavy metals causes alterations in the functionality of several human organs [8]. Due to possible health risks linked to alcohol abuse and limited information on *akpeteshie* consumption and contamination levels, this study investigated consumption pattern, level of methanol and heavy metal contaminants of *akpeteshie* in the Ho municipality, Volta Region, Ghana.

Materials and methods

Ethical permission

Ethical permission was obtained from the University of Health and Allied Sciences (UHAS) Ethical Review Committee (Protocol ID.: UHAS-REC A.4 (275) 18–19). The participants in the study granted permission by means of written consent.

Sampling and experimental design

A cross-sectional study was done in Ho, Volta Region of Ghana. The survey component examined the independent variables of participants such as age, gender, educational level and occupation against dependent variables which consisted of types of alcoholic beverages consumed, the frequency of *akpeteshie* consumption as well as the volume of *akpeteshie* consumed. The experimental component determined the levels of ethanol, methanol and heavy metals (iron, copper and lead) in *akpeteshie*.

Survey sampling method

The survey was conducted using simple random sampling of 140 participants in various drinking spots/bars in the Ho municipality. The volume, quantity and frequency of *akpeteshie* consumption were assessed using the Daily Drinking Questionnaire [9]. *Akpeteshie* is sold using glass 'tots' with varying volumes and hence a pictographic aid of these various 'tots' (Fig. 1) was used to elicit the exact volumes of *akpeteshie* consumed by respondents.

Sampling and sample preparation

Ten (10) artisanal distillers within the Ho municipality were selected by a simple random sampling technique. Five (5) zones (North, South, East, West and Central zone) were created and two distillers from each zone were recruited. The *akpeteshie* was sampled and labelled. Samples were collected in triplicates and the sampling was done in February 2020.

Ethanol and methanol content

The ethanol content of the *akpeteshie* was determined by methods described by the AOAC [10]. For methanol determination, the sample was distilled and 0.1 ml of the distillate was pipetted into a test tube and 0.9 ml trichloroacetic acid was added. Potassium permanganate (0.1 ml; 5%) was added and the mixture was left to stand for 5 min. Sodium bisulphite was added to decolorize potassium permanganate. Chromotropic acid (0.2 ml) was then added, followed by 6 ml of concentrated sulphuric acid. The same procedure was conducted for a blank (0.1 ml of 10% alcohol) and a standard methanol solution (0.1 ml of 0.03% methanol). The presence of methanol in the sample was qualitatively determined by a purple color change.

Fig. 1. Pictographic aids used to elicit "*akpeteshie*" drinks consumed. A. 44 ml container (1 drink; Ghc 0.50), B. 50 ml container (1.2 drinks; Ghc 0.60), C. 60 ml container (1.4 drinks; Ghc 0.80), A. 100 ml container (2.4 drinks; Ghc 1.20).

Heavy metals determination

The heavy metal (Cu, Fe and Pb) concentration was determined with an atomic mass spectrophotometer (AAS) (Varian AA 240). Standard solutions of the metals were prepared at concentrations of 0.5–4.0 mg/l alongside a blank solution using deionized water. A standard curve was derived for each solution after aspiration unto oxygen-acetylene flame of the AAS. Quantities of the toxic metals (Cu, Fe, and Pb) in the sampled products were then determined [6].

Risk assessment

Estimated daily intake

The estimated daily intake (EDI) and its link with body weight, food consumption, and metal content were determined. In order to calculate the risk of heavy metal from severe akpeteshie consumption, the assumptions made include: the swallowed dose was equal to the absorbed pollutant dose [11], food processing had no impact on the pollutants [12], and the average adult (men and women) weight in Ghana as 75 kg [13].The average daily consumption of local gin (akpeteshie) in Ghana is 25 g/day suggested by Obeng-Dwamena [14], equivalent to 0.025 litres/day (1 g/day= 0.0010 litres/day).

The EDI was calculated using the formula (in Eq. (1)):

$$EDI = \frac{CxCcons}{Bw} \tag{1}$$

where C is the concentration of heavy metals in *akpeteshie* (mg/kg wet weight), $C\ cons$ is the average daily consumption of *akpeteshie* (25 g/day Bw = 0.025 kg/day Bw), and Bw is the body weight (75 kg). The guideline for each heavy metal is shown in Table 2.

Determination of target hazard quotient (THQ)

The risk of side effects other than cancer is indicated by the THQ, which is calculated as the exposure dosage divided by the reference dose (RfD). The dosage calculations were carried out utilizing common assumptions from the combined and USEPA risk analysis [15] methods. The THQ was estimated using the formula (in Eq. (2); Chien et al. [12]).

$$THQ = \frac{EFrxEDtotxFIRxC}{RfDoxBwxATn} x10^{-3} \tag{2}$$

Where;

Table 1
Exposure metrics used to calculate the health risks associated with consuming akpeteshie (US EPA, 2012).

Parameter	Unit	Child	Adult
Body Weight (BW)	Kg	15	75
Exposure Frequency (EF)	Days/ years	365	365
Exposure Duration	Years	6	30
Ingestion Rate ($IR_{akpeteshie}$)	mg/day	50	25
Average Time (AT)	Days/years		
Carcinogenic		365 × 70	366 × 70
Non-carcinogenic		365x ED	365x ED

Table 2
Reference doses and cancer slope factors of some heavy metals.

Heavy metals	Reference Doses (mg/Kg)	Cancer slope factor	References
Copper	4.0×10^{-2}	1.50	WHO (2012)
Iron	0.7	N/A	USEPA (2012)
Lead	3.5×10^{-3}	8.5×10^{-3}	USEPA (2012)

*NA- Not Available at the time of study.

The exposure frequency is EFr (350 days/year), the exposure duration is EDtot (30 years), the food intake rate is FIR (g/day), and the unit conversion factor is 10^{-3}; RfDo - oral RfD (mg/kg day^{-1}), Bw is body weight (75 kg), and ATn is the average exposure time for non-carcinogens (365 days/year multiplied by number of exposure years, 30 yr). C is the heavy metal content in akpeteshie (mg/kg).

Estimation of hazard quotient (HQ)

$$HQ = \frac{EDI}{RfD} \tag{3}$$

where RfD is the reference dose and HQ is the hazard quotient (mg kg^{-1} day^{-1}). A potential detrimental health effect is indicated by HQ values greater than 1, whereas HQ values less than 1 imply an unlikely adverse health effect.

Risk estimation for carcinogenicity

According to USEPA [16], a lifetime's worth of exposure to a suspected carcinogen is used to determine a person's chance of developing cancer (Table 1).

In our calculations, a cancer slope factor was employed to relate the lifetime exposure dose index (EDI) of heavy metals to the chance of a person getting cancer [16].

$$\text{Risk} = \sum \text{n, I} = 1 \quad \text{EDIxCSF}$$

CSF= Cancer Slope Factor

Estimation of total target hazard quotient (TTHQ)

In this investigation, the total THQ was calculated using the Chien et al. [12] technique as the arithmetic sum of the individual metal THQ values:

$$TotalTHQ(TTHQ) = THQ(toxicant1) + THQ(toxicant2) + THQ(toxicantn) \tag{4}$$

Determination of incremental lifetime cancer risk (ILCR)

The incremental lifetime cancer risk (ILCR) as a result of dietary exposure was calculated using Eq. (5) [17].

$$ILCR = \frac{\text{Ed} \times EF \times ED \times SF \times CF}{BW \times AT} \tag{5}$$

Where
Ed: daily *akpeteshie* exposure dose (μg/day)
EF: exposure frequency, 365 d/yr [18]
ED: exposure duration, 63 years for Ghanaian as life expentancy [19]
SF: oral cancer slope factor for toxic metal (geographic mean of 7.3 mg/kg/day)$^{-1}$]
CF: conversion factor, 10^{-6} kg/mg
BW: body weight, 75 kg [13]
AT = average lifespan for carcinogens (365 d/yr * exposure duration)

Table 3
Socio-demographic characteristics of *akpeteshie* consumers ($n = 140$).

Variable	Frequency (Percent)
*Gender*MaleFemale	131 (93.60)9 (6.40)
Age/years	
18–29	20 (14.30)
30–39	41 (29.30)
40–49	51 (36.40)
50–59	16 (11.40)
≥60	12 (8.60)
Marital status	
Single	23 (16.40)
Married	98 (70.00)
Divorced	12 (8.60)
Widowed	7 (5.00)
Educational status	
No Education	8 (5.70)
Primary	21 (15.00)
[1]JHS/MSLC	58 (41.40)
[2]SHS/GCE OL	30 (21.40)
[3]GCE AL (6th Form)	5 (3.60)
Tertiary	18 (12.90)
Occupation	
Unemployed	4 (2.90)
Trader	9 (6.40)
Artisan	63 (45.00)
Civil Servant	5 (3.60)
Professional	11 (7.90)
Driver	28 (20.00)
Farming	20 (14.30)
Income/GHC	
<300	29 (20.70)
300–599	63 (45.00)
600–899	20 (14.30)
900–1199	6 (4.30)
>1200	22 (15.70)
Total	140 (100.00)

[1] JHS/MSLC - indicates Junior High School/Middle School Leavers Certificate.
[2] SHS/GCE OL- indicates Senior High School/ General Certificate Examination Ordinary level.
[3] GCE AL – indicates General Certificate Examination Advanced Level.

Data analysis

Version 22 of SPSS statistical software was used to analyze the data. ANOVA was used to compare the experimental data, and LSD at 5% significance level was used to identify mean differences.

Results

Socio-demographic characteristics and consumption patterns

Information on the demographic characteristics of 140 participants who met the inclusion criteria which included being above the legal age (18 years and above), being a consumer of *akpeteshie* and providing consent to partake in the study revealed that majority of the participants were males (93.6%) and between the ages of 40–49 years (36.4%). In addition, most of the respondents were artisans (40%) and had Junior High School education (41.4%) as the highest level of education (Table 3).

Majority of the respondents (67.86%) opted for *akpeteshie* as their alcoholic beverage of preference (Fig. 2). Most participants consumed *akpeteshie* every day (53.57%) whilst others consumed it occasionally (8.57%), 1–2 times in a week (9.29%), 3–4 times per week (22.86%) and 5–6 times in a typical week (5.71%) (Fig. 3). However, 9.29% of the respondents could not adequately estimate the quantity of drinks consumed in a day, due to increased consumption frequencies (Fig. 4). The respondents had a mean *akpeteshie* consumption of 205.93 ml/day which translated to 4.94 drinks of alcohol (pure ethanol)/day. Men on the average, had greater consumption frequencies (5.11 drinks) relative to females (2.51 drinks) (Table 4). When the mean *akpeteshie* consumption of males and females was compared to guidelines for alcohol consump-

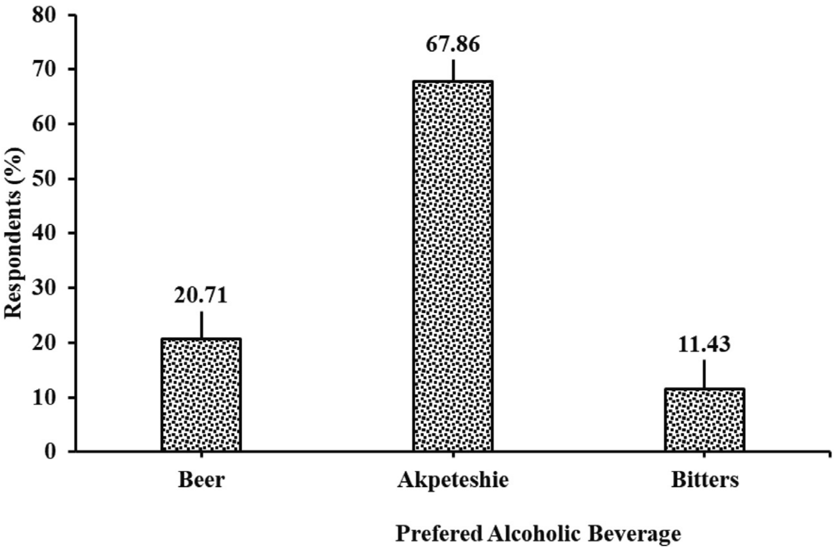

Fig. 2. Alcoholic beverages most preferred by respondents.

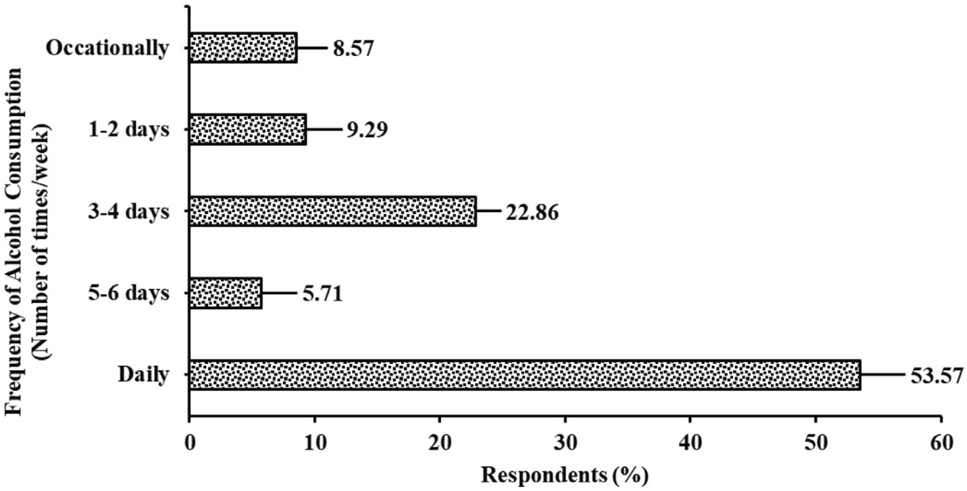

Fig. 3. Frequency of *akpeteshie* consumption by respondents.

tion, 51.15% of the males consumed normal quantities of the drink (2–3 drinks per day; Fig. 5) whilst majority of females (66.7%) consumed *akpeteshie* beyond recommended quantities (1–2 drinks/day; Fig. 5).

Ethanol, methanol and heavy metal concentrations

Ethanol concentration was significantly different ($p<0.05$), and between 44% - 50%, with a mean of 47% (Table 3). Methanol was absent in all the samples at a threshold concentration of 0.003%. As regards heavy metal concentrations, although Pb was not detected in the samples, Fe and Cu concentrations were high and significantly different ($p < 0.05$). *Akpeteshie* samples from Ho-Dome recorded the highest iron concentration (1.98 mg/l) whereas samples from Trafalgar recorded the highest concentration of copper (4.12 mg/l) (Table 6).

Risk assessment

The range of values recorded for EDI, HQ, THQ, TTHQ and ILCR were 7.10×10^{-8} - 3.90×10^{-12}, 1.78×10^{-6} - 9.75×10^{-11}, 1.47×10^{-4} - 4.52×10^{-9}, 1.47×10^{-4} - 3.29×10^{-5} and 4.52×10^{-9} - 8.4×10^{-6} respectively for all the toxic metals studies in the various locations investigated (Table 7).

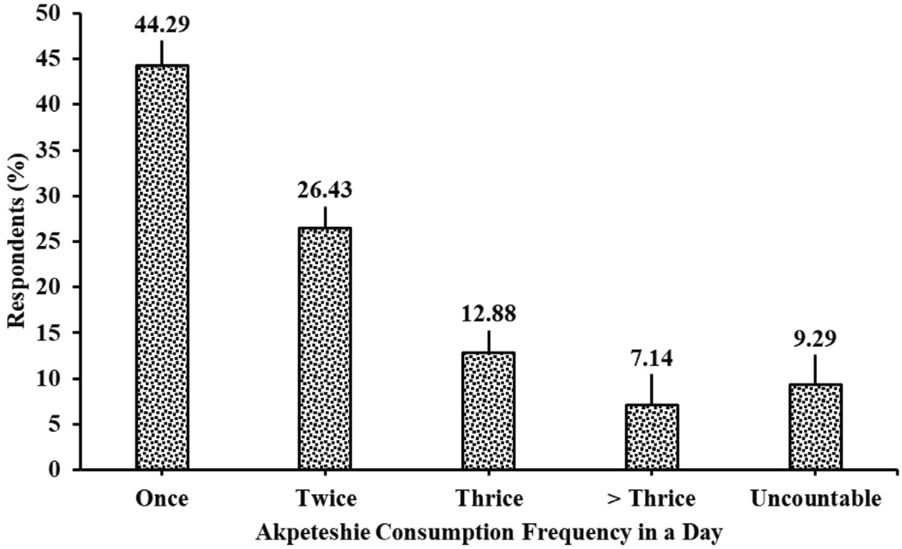

Fig. 4. Daily rate of *akpeteshie* consumption.

Table 4
Average *akpeteshie* consumption of respondents.

Respondents	Drinks of alcohol (pure ethanol)	Quantity of *akpeteshie* (ml)
All respondents		
Mean	4.94	205.93
Std. Deviation	4.81	200.45
Mode	2.40	100.00
Median	2.72	113.33
Minimum	1.06	44.00
Maximum	27.36	1140
Males		
Mean	5.11	212.88
Std. Deviation	4.92	205.07
Minimum	1.06	44.00
Maximum	27.36	113.33
N	131.00	131.00
Females		
Mean	2.52	104.79
Std. Deviation	1.20	50.04
Minimum	1.06	44.00
Maximum	4.32	180.00
N	9.00	9.00

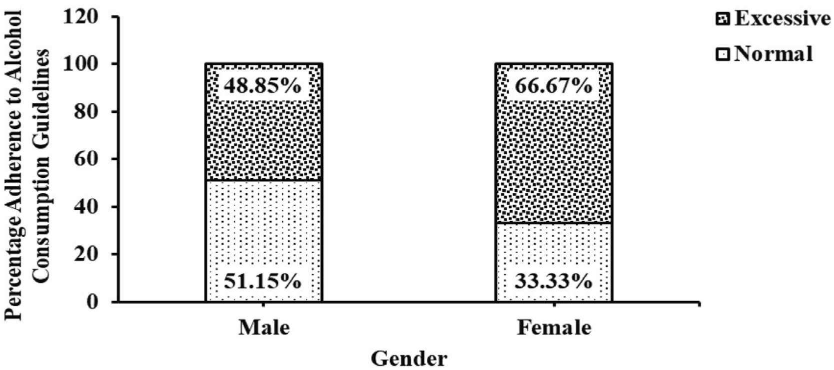

Fig. 5. Adherence to alcohol consumption guidelines (Males: 2–3 drinks/day; Females: 1–2 drinks/day).

Discussion

Akpeteshie consumption pattern among participants

The study observed a high prevalence of *akpeteshie* consumption among males (93.6%) as compared to females (6.4%). Also, the youth were much more indulgent in *akpeteshie* consumption as compared to the elderly (participants >60 years). A*kpeteshie* consumption thus, increased steadily from young adulthood till middle age (40–49 years) and then declined as consumers aged. It has been shown that the highest prevalence of alcohol consumption was 46%, and among men in their early 40 s [20]. The least *akpeteshie* consumption rate was observed among those who had no formal education. This reflection is similar to the findings of Osei-bonsu et al. [21] that pointed at a high alcohol intake rate among individuals with relatively higher education. Persons with higher education have improved socioeconomic status and can afford an alcoholic lifestyle.

Akpeteshie was a commonly consumed alcoholic beverage among the study participants. Although a majority of the participants consumed all alcoholic beverages such as beer, spirits, and wines (50.71%), *akpeteshie* was the favored alcoholic drink (67.86%), trailed by beer (20.71%) and bitters (11.43%). A study by Frimpong-Mansoh et al. [22], however reported that beer rather than spirits and wine was the most desired choice of alcoholic beverage among Tema adult residents in Ghana. This variations in alcohol consumption patterns could be attributable to geographic factors and individual preferences. Several factors influence alcohol consumption and this include culture, religion, education, cost, and type of alcoholic beverage [22]. *Akpeteshie* is comparatively cheaper and easily accessible than beer hence has high patronage in the rural areas of Ghana.

Alcohol has an addictive effect on consumers, hence most participants consumed *akpeteshie* daily (53.57%), and these finding is consistent with reports by Osei-bonsu et al. [21]. Although majority of participants consumed the drink once daily (44.29%), some participants (9.29%) could not track the number/quantities of drinks consumed daily.

The average *akpeteshie* intake was 205.93 ml/day (4.94 drinks of alcohol per day) and males on average consumed approximately twice the quantity (5.11 drinks) of *akpeteshie* consumed by females (2.51 drinks). Females tend to consume small quantities of alcohol because of a relatively lower blood and fluid volume which is more vulnerable to the adverse outcomes of alcohol [23]. Additionally, societal norms and traditional gender role attitudes had contributed to reduced alcohol consumption among females [23]. In Ghana, *Akpeteshie* is considered a “hard” drink and a preserve of men, hence females have high preference for beer and wine [22]. The mean *akpeteshie* consumption of males and females was compared to guidelines for alcohol consumption (2–3 drinks/day for males and 1–2 drinks/day for females), and this study showed that alcohol consumption quantities of the male participants (51.15%) were within recommended quantities, whilst a greater proportion of the females (66.67%) consumed *akpeteshie* above the limits prescribed (1–2 drinks/day).

Ethanol concentration of the drinks were within ranges established by the Ghana Standards Authority (GSA). According to GSA, *akpeteshie* should have concentrations of ethanol not less than 40% and not above 50% [24]. Studies have shown *akpeteshie* sampled in the Ashanti Region of Ghana and Ivory Coast to be 20.5–20.8% ethanol [24] and 15.6–42.5% ethanol [2], respectively. These variations in ethanol concentrations is due to different production methods. In addition, varied substrates are used to produce *akpeteshie* and this significantly influence ethanol concentration [2].

Ethanol, methanol and heavy metal content of akpeteshie

The samples tested negative for methanol, and other studies have reported similar results [2,24]. However, Tulashie et al. [5] reported high methanol concentration (0.16%) in *akpeteshie*. These differences could be attributed to variations in distillation practices. Most distillers collect the initial distillate separately from the *akpeteshie*, and this could account for the absence of methanol in the sampled *akpeteshie*.

Significant quantities of Fe were found in *akpeteshie* samples and 20% of samples studied exceeded the set iron standards of 0.300 mg/l (GSA). Koffi et al. [2] and Zakpaa et al. [24] reported significant quantities of iron in *akpeteshie*. The presence of iron in *akpeteshie* is due to the process and equipment used. Iron tanks usually used in the processing of *akpeteshie* can leach iron contaminants into the beverage [8]. Copper contamination was high and greater than the MAC limit of 1.0 mg/l. This high copper contamination is due to the use of copper tubes in the condensation process. The recommended daily allowance for copper for adults is 10 mg per day and intakes above this could result in toxicity [25]. Hence, excessive consumption of *akpeteshie*; as high as the maximum consumption of 1140 ml as reported by respondents could result in copper toxicity. The study did not detect the presence of lead in samples because lead (Pb) tanks were not utilized for alcohol production.

Risk assessment of akpeteshie

The outcomes of a risk assessment could be used to evaluate and prioritize pollutants and to build a strategy for preventing exposure. Risk assessment is presently an important subject extensively researched due to contaminants above suitable or background values that are within tolerance ranges. Risk is defined as the relationship between severity and venomousness [26,27]. Therefore, several water-dependent exposure pathways have been developed to study the impact of human-based exposures [28]. According to the degree of toxicity, which was previously discussed in relation to average daily intake or chronic daily intake from a number of factors invariably can result in adverse health problems or the opposite [29–31].

Table 5
Alcoholic strength of the various samples of *akpeteshie.*

Sample	Means ± SD
Dzolo	44.94 ± 0.05^{a}
Sokode	46.63 ± 0.03^{d}
Ho 50/50	49.43 ± 0.03 g
Trafalgar	47.52 ± 0.00^{e}
Tsito Site A	45.67 ± 0.04^{bc}
Tsito Site B	45.96 ± 0.00^{c}
Adaklu Site A	46.01 ± 0.01^{c}
Adaklu Site B	48.26 ± 0.08^{f}
Ho Dave	45.29 ± 0.13^{ab}
Ho Dome	44.85 ± 0.23^{a}

Means with different superscript indicates a significant difference (p<0.05) between the samples.

Table 6
Heavy metal contamination of *akpeteshie* (mg/l).

Samples	Copper (mg/l)	Iron (mg/l)	Lead (mg/l)
Dzolo	1.82±0.04^{b}	ND	ND
Sokode	1.39±0.02^{a}	0.09 ± 0.01^{ab}	ND
Ho 50/50	3.33±0.06^{c}	0.14 ± 0.02^{ab}	ND
Trafalgar	4.12±0.05^{f}	0.05 ± 0.00^{ab}	ND
Tsito Site A	1.45±0.03^{a}	0.04 ± 0.00^{ab}	ND
Tsito Site B	1.83±0.01^{b}	0.01 ± 0.05^{a}	ND
Adaklu Site A	1.74±0.02^{b}	1.29 ± 0.10^{c}	ND
Adaklu Site B	4.05±0.20^{ef}	ND	ND
Ho Dave	3.79±0.01^{de}	0.20 ± 0.01^{b}	ND
Ho Dome	3.70±0.05^{d}	1.98 ± 0.12^{d}	ND

Means with different superscript indicates a significant difference (p<0.05) between the samples.
ND- indicates "Not Detected".

The EDI of heavy metals was assessed in relation to the quantity consumed by the participants in the Ho metropolis, Southern Ghana, as shown in Table 7. This was done in order to determine the potential daily intake of each heavy metal from both a non-carcinogenic and a carcinogenic standpoint, resulting in a likely health effect or cancer risk.

According to Udota and Umoudofia [8], who looked into the heavy metal contents of "ufofop," a local gin in Nigeria, the range of values obtained in this work were less than the range of values for copper (Cu) between 3.1625 and 6.2125 mg/L, lead (Pb) 3.000 to 6.750 mg/L, and iron (Fe) 6.000 to 28.500 mg/L. The amount of iron obtained in the present study was less than that reported by Van-Wyk et al. [32] in 2021 (19.167–632.361 g/l) and Okareh et al. [33] in 2018 (720–4220 g/l), but it was still within the MPL limit of 0.30 mg/l [34]. Fe can enter the beverage through leaching from the process container and, in sufficiently high amounts, can provide a disagreeable flavor. Iron is necessary for the formation of blood and the transfer of oxygen throughout the body, but an excess amount or poisoning from accumulation in the body can result in hepatic/multiple organ breakdown, and death [21,32,35]. It can also cause nausea, diarrhea, and other gastrointestinal symptoms [35]. As observed, Pb was present in MPL, but Pb is a non-essential element with no positive effects and is regarded as a carcinogen with a risk to the general public's health due to its potential to cause adverse health issues. Pb could enter products through handling, storage equipment, soil, irrigation, and vehicle emissions [21].

In this investigation, the metals in akpeteshie had HQ and HI values that were less than 1.0, indicating no negative health consequences. The target hazard quotient (THQ) values of metals less than 1.0 were found in local beverages (Raffia palm wine, oil-palm wine, Pito, and "Burukutu") according to a prior study by Iwegbue et al. [36]. However, the total amount of metals (THQ) was more than what was permitted for "Burukutu" and Raffia palm wine. The Pb, Cu, and Fe HQs found in the akpeteshie were comparable to those previously reported by Li et al. [17]. Towle et al. [37] also demonstrated non-carcinogenic effects of Pb in a number of domestic and foreign wines offered for sale in the US. According to Wongsasuluk et al. [38], drinking water from Thailand had high HQ for Zn, Pb and Cu that above the permitted HQ limit of 1.0.

According to Bonic et al. [39], the average concentrations of these metals in plum brandies were 3.3 (Cu) and 0.4 (Fe) mg/liter. Once more, Ibanez et al. [40] discovered that the Cu and Fe concentrations in brandy, whiskey, and vodka were 0.1–14.6 and 0.0–2.3 mg/L, respectively. The outcomes of our research (Table 5) are similar to those of existing investigations [38,39]. Since THQ were less than 1, these trials also had no negative health consequences on the study population. The results of Pal et al. [41] recorded higher concentrations in the ranges of 0.13–2.0 and 0.0–5.51 mg/L for Fe and Cu, respectively. For ordinary, frequent, and chronic heavy drinkers (version A), combined exposure to heavy metals in spirits offered no health risk, while the risk associated with intake of recorded spirits was higher for chronic heavy drinkers (version B). But linked to the health risk brought on by ingesting too much ethanol, the threat was negligible.

Table 7
Risk assessment of toxic metals through the consumption of *akpeteshie* in the Ho municipal.

Location	Toxic Metal	Concentration (mg/l)	EDI (Adult)	HQ (Adult)	THQ (Adult)	TTHQ (Adult)	ILCR (Adult)
Dzolo	Cu	1.82±0.04	7.10×10^{-8}	1.78×10^{-6}	1.47×10^{-4}	1.47×10^{-4}	8.39×10^{-10}
	Fe	ND					
	Pb	ND					
Sokode	Cu	1.39±0.02	5.42×10^{-10}	1.36×10^{-8}	1.11×10^{-5}	1.11×10^{-5}	8.40×10^{-6}
	Fe	0.09 ± 0.01	3.5×10^{-11}	5.00×10^{-11}	4.17×10^{-8}		1.47×10^{-4}
	Pb	ND					
Ho	Cu	3.33±0.06	1.29×10^{-9}	3.23×10^{-8}	2.66×10^{-5}	2.67×10^{-5}	8.40×10^{-6}
	Fe	0.14 ± 0.02	5.46×10^{-11}	7.8×10^{-11}	6.44×10^{-8}		1.47×10^{-4}
	Pb	ND					
Trafalgar	Cu	4.12±0.05	1.61×10^{-9}	4.03×10^{-8}	3.29×10^{-5}	3.29×10^{-5}	8.40×10^{-6}
	Fe	0.05 ± 0.00	1.95×10^{-11}	2.79×10^{-11}	2.28×10^{-8}		1.47×10^{-4}
	Pb	ND					
Tsito A	Cu	1.45±0.03	5.66×10^{-10}	1.42×10^{-8}	1.16×10^{-5}	1.16×10^{-5}	8.40×10^{-6}
	Fe	0.04 ± 0.00	1.56×10^{-11}	2.22×10^{-11}	1.74×10^{-8}		1.47×10^{-4}
	Pb	ND					
Tsito B	Cu	1.83±0.01	7.13×10^{-10}	1.78×10^{-8}	1.46×10^{-5}	1.46×10^{-5}	8.40×10^{-6}
	Fe	0.01 ± 0.05	3.90×10^{-12}	9.75×10^{-11}	4.52×10^{-9}		1.47×10^{-4}
	Pb	ND					
Adaklu A	Cu	1.74±0.02	6.78×10^{-10}	1.69×10^{-8}	1.39×10^{-5}	1.45×10^{-5}	8.40×10^{-6}
	Fe	1.29 ± 0.10	5.04×10^{-10}	7.2×10^{-10}	5.89×10^{-7}		1.47×10^{-4}
	Pb	ND					
Adaklu B	Cu	4.05±0.20	1.58×10^{-9}	3.95×10^{-8}	3.23×10^{-5}	3.23×10^{-5}	8.40×10^{-6}
	Fe	ND					
	Pb	ND					
Ho Dave	Cu	3.79±0.01	1.48×10^{-9}	3.95×10^{-8}	3.01×10^{-5}	3.02×10^{-5}	8.40×10^{-6}
	Fe	0.20 ± 0.01	7.80×10^{-11}	1.11×10^{-10}	9.13×10^{-8}		1.47×10^{-4}
	Pb	ND					
Ho Dome	Cu	3.70±0.05	1.44×10^{-9}	3.7×10^{-8}	2.96×10^{-5}	3.05×10^{-5}	8.40×10^{-6}
	Fe	1.98 ± 0.12	7.72×10^{-10}	1.10×10^{-9}	9.04×10^{-7}		1.47×10^{-4}
	Pb	ND					

*ND- indicates "Not Detected".

Conclusion

This study showed that *akpeteshie* was consumed by most respondents and more males consumed the alcoholic beverage. Female alcoholics consumed *akpeteshie* beyond the recommended limits of 1–2 drinks/day. The study also detected high levels of the heavy metals iron and copper in *akpeteshie* samples, although methanol and lead (Pb) were absent. Excessive consumption of *akpeteshie* could result in iron and copper toxicity. Risk assessment of this consumed toxic metal through *akpeteshie* posed no adverse health effects on the populace of the various locations since all were less than 1. Notwithstanding, minute accumulation of these toxic metals could be detrimental to health.

Data availability statement

The supporting data of the findings are presented in the article and are also available upon request.

Declaration of Competing Interest

The authors declare no conflict of interest.

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