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DETERMINATION OF SELECTED HEAVY METALS AND IRON CONCENTRATION IN LOCAL BREWS CONSUMED IN KERICHO AND BOMET COUNTIES IN SOUTH RIFT, KENYA.

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Abstract

Background: The concentrations of heavy metals namely; Cadmium, Lead, chromium, Zinc and (Cd, Cr and Pb) including Iron (Fe), were determined in traditionally fermented brews samples from Kericho and Bomet Counties in South Rift, Kenya in 2013.

METHODS: The levels of heavy metals were determined using a single beam Atomic Absorption Spectrophotometer (AAS). Ethanol was analysed using a gas chromatography (Varian3400cx) and a Refractometer (RFM 330 Bellingham Stanley limited) in Egerton University.

RESULTS: Concentrations of heavy metals in the brews samples analyzed in descending order of Zn > Cd > Pb> Cu were detected, but, the rest (Fe and Cr) were not detected. The highest concentration of Cadmium (0.086) was detected in changaa from kaplong while the lowest value (0.041) in changaa from Chepkuchun. The highest concentration of Pb (0.189 ppm), Zn (0.777 ppm) and Cu (0.0745 ppm) were detected in kinaro, kangarek and busaa respectively. The average ethanol content of the samples of kinaro was 33.65% Kangarek was 11.98% while in Changaa was 25%.

Key Words: Heavy metals Cadmium, Lead, chromium, Zinc, Iron, ethanol, local brews

1.1 Introduction

Traditional alcoholic brew is often made in homes and villages using seeds, grains, fruit, vegetables or palm sap, and is believed to make up the highest proportion of alcohol use in Africa (Willis 2002; McCall 1996), perhaps because it is typically less expensive than commercially brewed drink (World Health Organization 2004; Willis 2002). The production and drinking patterns accompanying the consumption of traditional brews is an integral part of many local cultures (Heath, 2000; Mateos, Paramo, Carrera, & Rodriguez Lopez, 2002). Although brewing and selling traditional drink is illegal in Kenya (Willis 2002), drinking traditional brew is a common activity during many social and religious ceremonies. For example, drinking busaa is integral to the custom of group genital circumcisions, weddings and funerals (Willis 2002). Once controlled by elder men, drinking of traditional brew has been largely transformed into a commercial enterprise that includes female and young consumers (Willis 2002; Papas et al. 2008) and is believed to be more frequently brewed and sold by women today (Holtzman 2001; McCall 1996; Obot 2007.

In a multi-country study by the World Health Organization of primary care attendees who reported at least one drink in the past year and no past alcohol treatment, Kenyans (78% men) reported the highest alcohol use across the six countries (U.S., Mexico, Norway, Australia, and Bulgaria), including binge drinking (72%), at least six drinks per week (49%), median alcohol consumption in 30 days (799 g) and alcohol dependence (20%). The percentage of drinkers who noted at least one alcohol problem in Kenya (47%) was second only to the U.S. (49%) (Hall et al. 1993; Saunders et al. 1993a'. Traditional drinks including homemade brews and distilled beverages accounts for 74% of the total alcohol consumption in Kenya. Cheap alcohol package in small quantities (250 milliliter) which have in the past being available in the Kenyan market has currently being prohibited by the new Alcoholic Drinks Control Act, 2010.

According to some studies carried out in some African countries there is considerable evidence that home produced alcohol drinks are known to have toxic components [Fite *et al*., 1991]. Many local brews are contaminated, toxic, and, thus, represent a health hazard (Mosha, Wangabo, & Mhinzi, 1996). For example, there have been reports of local brews brewed in old oil drums,

thereby introducing toxic contaminants. A traditional brew that is contaminated or in some way adulterated presents a serious risk to health (Holstege, Ferguson, Wolf, Baer, & Poklis, 2004). For example, methanol contamination can lead to blindness and even death, and there have been reports of bad batches of beverages contaminated by methanol, lead, and arsenic from countries around the world (Haworth & Simpson, 2004, pp. 6–7; Holstege et al., 2004; Hudson, Crecelius, & Gerhardt, 1980; Silverberg, Chu, & Nelson, 2001; Tonkabony, 1975). Because of their cheapness, low-income groups mostly consume them. Thus their handling and consumption often takes place under conditions of poor hygiene [Steinkraus,1983]. Similarly, high levels of liver cirrhosis have been reported among those who drink brews with the bacterial contamination, even when these individuals are not heavy or frequent drinkers (Lovelace & Nyathi, 1977). Similarly, the fermentation process of *pulque* often relies on the use of animal excrement that contributes to high levels of bacterial contamination, representing a significant health risk (Rosovsky, 2004). Several studies have documented a high rate of alcohol abuse in Kenya (Othieno et al. 2000; Hall et al. 1993; Saunders et al. 1993a, b).

In Kenya, alcohol consumption is highest in poor communities where potent home brewed alcohol is cheap and readily available. Quality control is weak; meaning ethanol **and heavy metals** content can at times be dangerously high. Examples of such homemade brews include, “muratina”, “mnazi”, “changaa”, “mbangari”, “busaa”, “kumi-kumi”Kinaro and kangarek. These are the illicit brews that the newly passed law (Alcohol Drinks Control Act) intends to make illicit and industrialize the production in attempt to protect the alcohol users from harmful effects of contaminated illicit brews (Kenya Gazette supplement, 2010).

There are several damaging effects of alcoholism such as mental problems, job trouble, frequent blockouts, loss of control etc [Olandiole, 2002]. These coupled with a reported increase in lifetime drinking among young, and use of drugs by females as a way to cope with current or past life stressors demands that quality control of alcoholic brews be instituted and enforced. These coupled with employment opportunities for people gives the alcohol industries a bargaining power when it comes to introduction, implementation and enforcement of alcohol policies in Africa, and Kenya in particular. Due to the effects of consumption of traditional brews on human health, this study attempted to investigate the level of ethanol and heavy metal composition of the brews traditionally fermented and consumed locally within kericho. The

control of composition of alcohol standard is done by the Kenya bureau of standards (KEBS). The Kenya Bureau of Standards recommends spirits, gin whisky and brandy to contain a minimum 37.5% of ethanol by volume, while beer should have 4% - 8%, fruit win 8% - 14% fortified wine 13% - 34% alcohol by volume. In this study it was found out that the overall ethanol content of the samples of busaa is 3.8% with a range of 2.2-5.3%

Materials and methods

3.1 Study area

The study was carried out in Kericho county, kabianga division located in south west of the county and lies within rift valley in Kenya. Different villages within the division including Cheptuyet, Chebirbei, Kapcheluch, Kaplutiet and Kapcheboiyo were selected.

Survey: To establish the types of local brews consumed in this region a guided questionnaire was used. The survey data indicated that in this study area, Busaa and chang'aa are the main brews produced locally and sold while kinaro is brought from Kisii and sold within the region. In Cheptuyet, the drinks consumed include Busaa, Chang'aa(Wirkik); in Chebirbei are Busaa, Chang'aa(Wirkik), in Kapcheluch is Chang'aa (Kinaro), Kaplutiet had Busaa, Chang'aa(Wirkik) while in Kapcheboiyo Busaa and Chang'aa(Wirkik) are consumed.
The health effects associated with their consumtion poverty and the increase of negative vices like gang raping among the youths. A recent case of a severe spread of syphilis was reported at least in two places (Kiptere and Kabianga) that the drugs were not available. The brew seem to be directly associated with the spread on the spread of H.I.V and AIDS. More studies need to be conducted to document this adequately. Other vices that impact directly on the well being of the families are, Murder, Wife beating; Cases where a spouse has killed another have not only been associated with the brew alone but also with other drugs such as Marijuana (bhangi), Family separations are likely to result in a family where there are constant fights, Stealing is also common especially for addicts who may not be able to work to maintain the habit, Fights and Domestic stress. It was reported that these have affected the families since the poverty levels have risen and hence the low economic level of the communities as well.

There are a number of health effects that have been observed amongst the consumers through the findings, however, further study for verification of the extent of these vices needs to be further investigated. They range from, Lack of appetite, Vomiting, Diarrhea, Infertility amongst both men and women, Low libido, blockage of the urinal tract, brain disturbances and throat cancer as gathered from the survey. According to a number of informers, the brew has negative effects on the consumer and is therefore not safe. These concerns range from those caused from drinking the brew while others are caused by the behavior of the drunkards once they take the brew. Those caused from drinking the brew as reported during the interviews included: Liver cirrhosis, Skin diseases, Lung problems, Hypoglycemia(low sugar in the body due to lack of appetite), Throat Cancer, Throat burns (especially when gulped), Blockage of the urethra, Loss of appetite, Vomiting after drinking having eaten food, Ulcers, damage the brain, Hangovers, Heart problems, Infertility, Addiction, Tuberculosis, High blood pressure, Stroke, Diarrhea, Stomachaches, Chest pains, Redden lips or burnt lips, Though rare may cause death.

From these findings it is apparent that the community does not really understand the causes of drinking and their effects and hence proper information need to be disseminated.

On food insecurity, it has been observed that most of the consumers are people of both genders but mostly the male mainly people above the age of eighteen years, locals from around, primary and secondary school dropouts, with a few who are totally illiterate. These is an age bracket that should be very productive to improve the food insecurity and also help improve the economy of the region, however this is not the case. Majorities is not employed and are farmers in their own fields. Others are casual laborers while their spouses are housewives. Majorities are married and have a number of dependants who are under the age of eighteen. According to most informers the consumption takes place at any time as long as the consumer can access the brew and especially during the high income times. This leaves the dependants with no income and hence economically disempowered with a diminished livelihood. Most consumers drink during the months of August up to December, mainly because this is when there are a number of festivals such as boys' circumcision, availability of food and increased flow of money due to tea bonuses or relatives coming from upcountry. It is this food that is sold also to cater for there drinking hence reduction in food security.The modes of preparation indicate the consumption of main food for the production of the brews. It is true to say that this brews are interdependent, this is

because the production of one brew can lead to the production of another brew. Ingredients for these brews range from Maize flour (either from good maize or from bad maize), to Millet (good millet that has just germinated), to water and sugar. An analysis of use of these food stuffs for brews instead of food is to be established. It is apparent that if these are the food stuffs produced in this region and yet not used for the food purpose then the eventuality is a malnourished society or otherwise poor livelihood.

Brewers described making busaa in an average of 6-7 days. Rotten maize flour is mixed with water and fermented for 2-3 days, then heated over a fire on a large pan or iron sheet. Yeast is added to the fermented mixture and it is fermented for another 3-4 days. The mixture is then filtered (by squeezing) through a cloth sack to produce the stronger Busaa. Adding hot water to the mixture and then filtering produces the weaker busaa. In order to make Kangarek brewers start with the mixture left over after the production of busaa. Sugar, water and sorghum are added to the mixture which is fermented for 3 days and the mixture is filtered. Changaa is made from mixture left overs of kangarek sugar and water is added to the mixture and fermented for 3-4 days. The mixture is then distilled by boiling over a flame with a pan cool of water to create condensation (the changaa), the first batches of condensation produce the stronger changaa while subsequent batches produce the weaker changaa.

3.2 sample collection, preparation and storage

Samples were collected in the month of January 2013 using randomized method. 100 ml samples were collected from the producers from ten (10) sampling areas as described above, into 100 ml plastic bottles and corked. The samples were transported to University of Kabianga laboratory and stored in a refrigerator under 4° C. Samples for analysis of ethanol in Kangarek and busaa were filtered using a filter paper (whatman paper NO 40) to give about 250 ml samples of each of the brews. Filtrate samples of Busaa, Kangarek (also on Kinaro) and Changaa were distilled at 95˚C to obtain 100 ml of each sample.

3.3 Sample Analysis

An analysis of heavy metals, lead, zinc, cadmium and chromium; and ethanol, hexane and methanol were done, (tables 3, 4 and 5). For preparation of samples for heavy metals analysis, the AOAC, 2000 chemical methods were used.

3.3.1 Heavy Metals

Analytical grade nitric acid (Analytical Rasayan, Nitric acid (1.42) AR, %purity 69.0-71.0, specific gravity 1.42 g/cm^3) was used in digesting the samples. Distilled water was used in rinsing apparatus and diluting digested samples. Brew samples were digested using the wet digestion method with 1:1 HCl: HNO_3 for 45 minutes at 150˚C, to obtain a clear solution, filtered using Whatman No. 40 filter into respective 50ml volumetric flasks and made up to the mark using distilled water. Standard solutions of metals (Cd, Cr, Fe and Pb) were used to obtain calibration curves. Samples were analysed as per the AOAC (1996) methods for the presence of selected heavy metals. Samples were analyzed for the concentration of heavy metals Cr, Cd, Fe, Zn and Pb using a Thermo Jarrell Ash S11 atomic absorption spectrophotometer.

3.3.2 Ethanol analysis

Pure standards of ethanol were prepared; 1µl of each standard was injected into a GC and their chromatograms recorded. A gas chromatography was performed using a gas chromatograph Varian star 3400 CX equipped with a flame ionisation detector(FID) A mixed standard of methanol, ethanol and hexane was also prepared in the ratio 1:1:1. 1 µl was injected into a GC and its chromatogram recorded. 5 ml of each sample was put in a clean, dry test tube. Anhydrous sodium sulphate (supplier-Mary and Baker ltd Batch 13462/20450, Dagem, Essex England) was used as a drying agent. 1µl of each sample was injected into a GC and their chromatograms recorded.

The chromatography was conducted under the following conditions:

Nitrogen was used as a carrier gas; Initial column temperature-75˚C; Final column temperature-190˚C; Injector temperature-200˚C; Injection volume-1 µl; Detector temperature-230˚C

After gas chromatography refractive index was carried in order to determine the concentration of the chemical components in each sample using 99.8% ethanol to prepare the standards. The standards were diluted with distilled water up to 50ml .1ml-5ml of ethanol was pipetted into a volumetric flask and diluted to 50ml using distilled water .Refractive index was carried out using a refractometer (RFM 330 Bellingham Stanley limited) onto which a water bath was attached. The function of water bath was to keep the temperature constant(22.2˚C).A teat pipette was used to transfer a small amount of the standards from the volumetric flask to the refractometer .The refractive index of each standard was recorded by the refractometer .A small amount of each sample was also transferred to the refractometer and the refractive index was measured .Before and after each measurement of the refractive index of each sample the refractometer was calibrated with distilled water .

Results and discussion

Table 3: Results of analysis of metals

Concentration of heavy metals in traditionally fermented drinks in mg/L						
sample region	Pb	Zn	Fe	Cd	Cu	Cr
B-kaplong	ND	0.1185	ND	0.075	0.0745	ND
B-kapkelek	ND	0.139	ND	0.064	0.036	ND
C-kaplong	ND	0.048	ND	0.086	0.036	ND
C-chepkuchun	ND	0.048	ND	0.041	ND	ND
C-chebirbei	ND	0.158	ND	0.064	ND	ND
KA-chepkuchun	0.047	0.777	ND	0.064	ND	ND
KI-kapkelek	0.189	0.046	ND	ND	ND	ND
KI-kiptere	0.047	0.103	ND	ND	ND	ND
KI-kaplong	0.189	0.066	ND	ND	ND	ND

B=busaa, C= changaa, KA= kangarek, KI= kinaro, ND= not detected.

The concentration of lead metal is highest in kinaro with kapkelek and kaplong samples having higher levels than kiptere sample; 0.189 ppm and 0.047 ppm respectively, while lead was undetected in the other brews. Cadmium was detected in

all samples except in kinaro brews, with changaa recording higher concentration than the others in concentration of 0.086 ppm. All types of brews samples recorded the presence of zinc. The of Zinc metal was highest in kangarek sample with 0.777 ppm . From the results in table 1, it is apparent that brews that showed presence of lead, did not record presence of copper while all samples did not show presence of iron and chromium which are required by the body as nutrients. Heavy metal contamination of Busaa is in the form of Cd>Cu >Zn>Pb, Fe and Cr.

Table 4: Average concentration of heavy metals in traditionally fermented drinks in mg/L

Average concentration of heavy metals in traditionally fermented drinks in mg/L						
sample region	Pb	Zn	Fe	Cd	Cu	Cr
Busaa	ND	0.129	ND	0.070	0.055	ND
changaa	ND	0.085	ND	0.064	0.012	ND
kangarek	0.047	0.777	ND	0.064	ND	ND
kinaro	0.1417	0.0717	ND	ND	ND	ND

Table 6: Percentage Ethanol concentration in the samples

SAMPLES	Refractive index(n)	Concentration of ethanol as (%)
Kinaro (kiptere)	**1.3370×5**	42.5
Kinaro (kapkelek)	**1.3358× 4**	24.8
Busaa(kapkelek)	**1.3336**	2.2
Busaa(kaplong HM1)	**1.3351**	5.1
Busaa(kaplong HM2)	**1.3342**	3.5
Kangarek (chepkuchun)	**1.3343 ×5/2**	9.25
Kangarek(kaplong)	**1.3350× 3**	14.7
Changaa(kaplong)	**1.3352× 4**	21.6
Changaa(chepkuchun)	**1.3360× 3**	19.8
Changaa(Chebirebei)	**1.3363× 5**	36

In table 1 there was a variation in colour from one traditional brew to the other, especially in Busaa and Kangarek. The colour of the brews may be varied because of the ingredients used. There are three types of sorghum varieties namely red, brown and white. The white varieties are mixed with red sorghum because consumers prefer to drink coloured brews which they believe to be healthy.

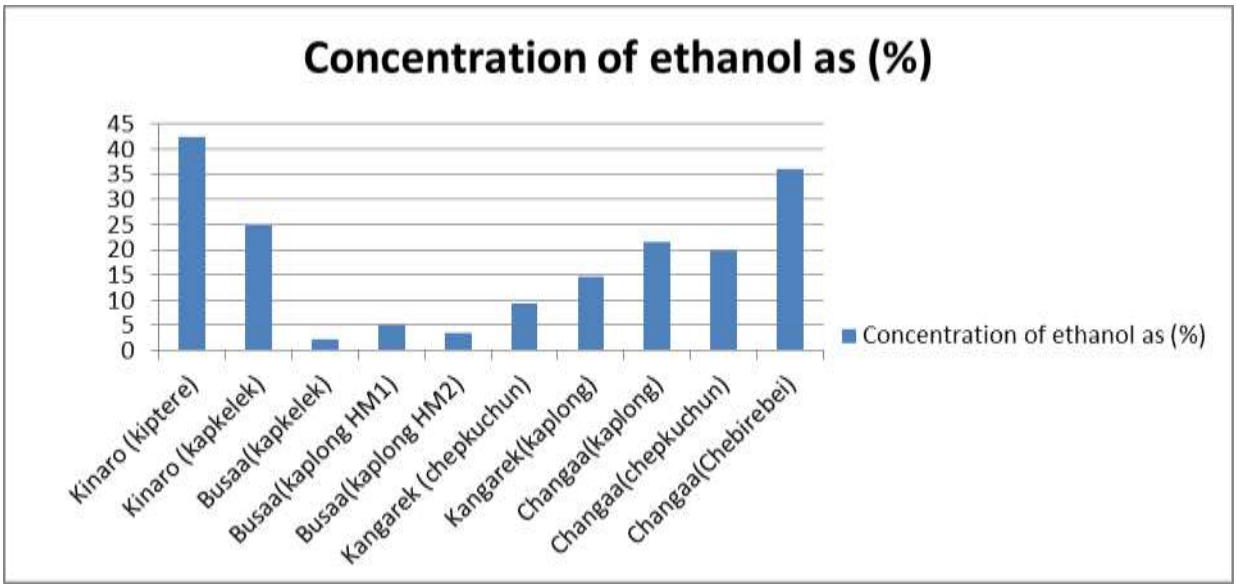

Figure 1: Ethanol concentration in different brews

In this study it was found out that the overall ethanol content of the samples of busaa is 3.8% with a range of 2.2-5.3%.The average alcohol content of the kinaro samples is 33.65% with a range of 24.8-42.5%.The average ethanol content of Kangarek is 11.98% with a range of 9.25-15%.The average ethanol content of Changaa is 25% with a range of 19.8-36%.The ethanol value of some samples of kinaro and changaa is higher than the control of composition of alcohol standards values recommended by KEBS. The Kenya Bureau of Standards recommends spirits, gin whisky and brandy to contain a minimum 37.5% of alcohol by volume, while beer should have 4% - 8%, fruit win 8% - 14% fortified wine 13% - 34% alcohol by volume.

There is a significant difference in ethanol content between the various traditional brews in Kabianga division. The variation in ethanol contents in the brews is due to the differences in methods of preparation and fermentation and the ingredients used. Conditions such as temperature, aeration, and strains of the microorganisms affect the level of the alcohols. Ethanol affects the central nervous system, gastro-intestinal tract,cardiovascular system, endocrine, liver, lipid metabolism, fetal development, and has immune suppression activities.

4.0 Conclusion

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