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Original Research Article

Polyaromatic hydrocarbons concentrations and Potential risk associated with popular beer brands consumed within Southeastern Nigeria

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Abstract

That alcohol sale is now a very big business in Nigeria and consumption has continued to rise remains a fact. But how much health effects or risk is associated with the lucrative trade is yet to be properly studied. In this study the physicochemical characteristics of beer samples were determined by common methods according to Food Compliance Laboratory Unit of National Agency for Food and Drug Administration and Control. Using hexane for extraction and gas chromatography equipped with flame ionization detector (GC-FID) for quantitative analysis, the concentrations of 8 polycyclic aromatic hydrocarbons (PAHs) were determined in 9 different beer brands. Results revealed that %Al ranged between 4.5 -5.6, all other parameters were within permissible limits except for EC (0.18-3.8µS/m) indicating presence of ionic substances. PAHs concentrations ranged between (ND- 0.0413, ND - 0.049, ND - 0.0372, ND - 0.0175, ND -0.0214, ND - 0.0224, ND - 0.0224, ND - 0.0632, ND - 0.0632) mg/mL for La, Lb, Lc, Ha, Hb, Hc, Ga, Gb, and Gc as popular commercial beer beverages sold in the city of Owerri Nigeria. The concentration of the 8 Polycyclic aromatic hydrocarbons (PAHs) in were all higher than PAHs maximum allowed limits of (0.0002, 0.00001 and 0.00003) for drinking water set by USEPA and EC. PAHs profiles indicated the dominance of about 4-three member rings and about four carcinogenic PAHs were detected in these beer as follows: chrysene, benzo (a)pyrene, benzo(g_h_i)perylene, and 1_2 benzanthracene and the Carcinogenicity ratio was 2.0 %, while Carcinogenicity was 64.27 %, and non-carcinogenicity was 35.90 % respectively. The carcinogenic risk assessment code (CRAC) was accessed in these beer and based of CRAC benzo (g_h_i)perylene was of medium risk of 5 and 5.5% in Gc and Gb beer samples which shows that daily consumers of this beer in the city of Owerri have high risk of cancer, tumor and mutation.

Keywords: Assessment, Alcoholic, Beverages, Carcinogenic, Cancer risk, Drinks, Persistent organic pollutants.

INTRODUCTION

Recently, Polycyclic aromatic hydrocarbon (PAHs) a group of organic compounds with carbon and hydrogen structure, having 2 or more fussed rings is major cause to the increased cancer death occurrence in Nigeria [1][2]. These compounds are highly of public interest as a result of their carcinogenic, mutagenic and teratogenic properties [3] and because of these harmful properties that is life threatening to humans the United States Environmental Protection Agency (US EPA) has included 16 of these PAHs as major pollutants, that requires proper monitoring in food and other environmental samples.[4] These compounds are classified as lower molecular and high molecular weight PAHs, the lower ones contains not more than four (4) aromatic rings and it associated with mobile or gaseous phase which makes it a little toxic, soluble and relatively volatile in the environment[5-6]. Heavy PAHs are those compounds with 5 or more rings known to be carcinogenic, toxic and stable.[7] These unique properties make these compounds different on how they affect the human body.

PAHs are formed primarily through natural processes like forest fires, volcanic eruptions, and carbonization processes.[8–10] there are several ways by which the general population is be exposed to PAHs, they includes: breathing of contaminated ambient air, improper waste incineration, constant eating of foods such as barbecues, road side suya, or smoked meat and fish, roasted, fried and baked foods,[11-13] smoking of cigarettes, or inhaling smoke from fire places, incomplete combustion or thermal decomposition from fossil fuels used in driving of cars, cooking of food, warming of homes, and fueling our industries also contributes greatly to PAHs deposit.[14] PAHs could be present in agricultural crops which probes a means of humans to get exposed through the dietary means.[15] Occupational exposure of workers to PAHs is certainly a means to which humans get exposed too, it often occurs during coke production, roofing of buildings using bituminous products, oil refining, and coal gasification inhaling smokes from exhaust fumes commonly found among road side mechanics, street vendors, and people involved in metal and iron works. [16-17]

Besides 2-12 % inhalation that leads to PAHs exposure, dietary exposure is the main route because it contributes about 88-98 % of PAHs uptake by the human body[18] most especially through beer beverages which has shown to be the third most popularly consumed international beverage after water and tea.[19] this is found among young people owing greatly to its pleasant and health attribute.[20] [21] Beer being a refreshing carbonated beverage brewed from malt (germinated barley), hop, water, and yeast, in which the malt is sometimes substituted with starch rich adjuncts like rice, corn and wheat [22] is rich in group B vitamins such as Niacin, Riboflavin, B_6, B_{12}, Calories, thiamine, nicotinic acid, folic acid and other essential amino acid like lysine which contribute greatly to a healthy diet [23][24]. Globally, in 2004 nearly 148 billion liters of beer were produced with an average estimate of 72.9 liters consumed annually,[25] cities like Owerri are often associated with large consumption of beer and this is attributed to the increasing number of hotels, bars, night and social clubs situated in such environment. An estimate of 78.4% of beer consumption was recorded among students in Owerri [26]. Despite the health attributes and pleasure got from drinking beer, when contaminated with PAHs beer may outweigh all benefits derived from it.

PAHs enrichment into beer occurs through various processes of beer production such as aging, high temperature heat treatment during decolorization, charring methods and smoke released during the drying of germinated barley.[27-30] Raw materials like germinated barley and other starch rich adjunct such as corn and wheat used in beer production can also absorb deposits of PAHs present in contaminated soil, air and water during germination,[31-33]although PAHs are lipophilic in nature but several reports of PAHs deposits in water, smoked foods and agricultural crops has been recorded. Ciecierska and Obiedzinski[34] reported PAHs concentrations of 8.64–112.43 μgkg^{-1} in fruit and herbal teas in Poland. The concentrations of PAHs were also determined in smoked and non-smoked black tea, In the smoked tea, the concentration of benzo(b)fluoranthene varied from 1.2–125.0μg kg $^{-1}$while that of benzo(b)anthracene varied from 0.6–1.2 μg L $^{-1}$. In the non-smoked tea, the concentration varied from 0.6 μg kg^{-1}for benzo(a)anthracene to 10.8 μg kg^{-1} for benzo(b)fluoranthene.[35] Chukwujindu et *al* in one of his experiments to assess the concentration of 16 priority Polycyclic aromatic hydrocarbons in tea infusion made of local alcoholic gin revealed that the concentrations of PAHs ranged between 36.8-438.3 μg kg^{-1}.[36] Studies by Olabemiwoo et *al* also revealed that PAHs content present in 2 smoked fish species sold in Western Nigeria ranged between 0.497-0.814 and 0.519-0.772 μg kg^{-1} was associated with intense heat applied during smoking.[37] therefore the objective of this present study is to determine the concentration of PAHs in beer with a view to providing information regarding PAHs deposit in beer in other help solve health problems related to cancer.

There are many models to assess the occurrence of PAH in a food. The EU, 2006 established regulatory limits beazo[a]pyrene in food, with the argument that it could be used to characterize PAHs as a marker in foods. The use of toxic equivalent factors (TEFs) (AFESSA, 2003) was once used but it is now discouraged as a result of lack of data involving concentrations of PAH in oral carcinogenicity studies and the low the level of predictivity of the approach. EFSA, 2008 proposed risk characterization by margins of exposure based on lower limit of confidence interval of benchmark close of incidence of 10 % induced tumors a value which stands at 0.34 mg/kg bw/ day. The 2008 EFSA proposed that the PAH4 i.e. sum of benzo[a]pyrene, chrysene benzo[b]flourenthene and Benz[a]anthracene could be a suitable indicator of PAH risk occurrence associated with food, the PAHs are the most suitable indicator of PAH in foods (PAH8 = PAH4 +benzo[k]flowrenthene, benzo[g,h,i]perylene, dibenz[a,h]anthracene and indeno[1,2,3-c,d] pyrene, the PAH8 do not furnish more data value than PAH4. Therefore, the EU, 2011 amended their regulation to introduce new maximum levels of PAH4 and requested a separate maximum concentration level of benzo[a]pyrene, so as to ensure more efficient risk assessment [Bnetro et al., 2013].

The significance and importance of this studies lies in the fact that the consumption of beer is very high in Ngeria (Okafor, Uche and Abaiilim, 2020) and Owerri is considered the enjoyment capital of south Eastern Nigeria. Despite these assertions studies on PAHs in beverages especially beer is lacking in Nigeria. There are equally no standards to use in regulating PAHs in beer so many of such studies will pave way for development standards and for awareness of the cancer dangers that lurk behind the chilled bottles of beers in thousands of drinking spots and refreshment centers within Owerri town. In the current study, only 8 PAHs were determined in a total 27 samples of beer bottles into nine brands of beers.

MATERIALS AND METHODS

The concentrations of 8 individual PAHs were determined in samples of commercially sold brand of beer samples. Sample extraction was done at chemistry Laboratory Imo State University while GC-FID quantitative analysis was done at Springboard laboratory opposite 17 Udoka housing estates Awka, Anambra State.

2.1. Materials

Separator funnel, Whatman filter paper, Spatula, Weighing balance, n-Hexane (C_6H_{14}), Sodium chloride (NaCl), Sodium Hydroxide (NaOH), Distilled water, Buffer 7 and buffer 4 Tablet, Glass beaker (0-500) Ml, Conical flask (0-500) ml, 250 ml Glass measuring cylinder, Volumetric flask, Universal bottles, Oven, dessicator, Anhydrous sodium sulphate (Na_2SO_4), Florisil (Magnesium silicate), glass wool, Pasture pippette, Stop clock, pH meter (JENWAY 3510), AID Agilent technology 200 GC -FID Spectroscopy.

2.2. Sterilization of apparatus

All standard laboratory glassware were cleaned by scrubbing with a nylon brush in a detergent solution in a wash basin, rinsed with tap water until no more soap was observed. They were rinsed with distilled water.

2.3. Sample collection

Three batches of three types of commonly consumed beer samples sold in Nigeria added up to nine samples were purchased from nine most popular outlets in Owerri, Imo, state. The collected samples were stored in the dark until the analysis. All necessary chemicals and reagents used were of high analytical grade and were purchased from Chemi science lab. and Fin lab. Owerri, Nigeria.

Physicochemical properties: Distillation method was used to determine alcohol content as described in Ceirwyn [32]. Colour was determined by spectroscopic technique according to European Brewing Convention (EBC) method 4.7.1 [36]. Absorbance of distilled water was recorded from a spectrophotometer and the absorbance was adjusted to 0.00. The cuvette was rinsed with brighter beer sample and was filled with the beer sample. Absorbance of beer was recorded at 430 nm and the colour of the sample in EBC was calculated from the relation:

Colour = 25Af.....1

Where A is the absorbance at 430 nm in a 1ml cuvette, f is dilution factor.

PH was determined using Jenway 310 pH meter and as described by Food Compliance Laboratory Unit of National Agency for Food and Drug Administration and Control (NAFDAC SOP Code: FC:06.5) [34] Electrical conductivity was determined by a Jenway conductivity meter in same sample used for pH. Bitterness was determined as par ASBC Beer 23A method [33]. De Clerk [35] method was modified and adopted to determine the specific gravity of beer sample.

2.4 Sample extraction

Beer samples were properly agitated and filtered through a filter paper in other to remove impurities present in the beer samples. After filtration, 15 ml of the solvent (n-hexane) is added to 10 ml of beer sample in a separating funnel and the mixture was shaken and allowed to stand for an hour to enable it separate completely, the aqueous layer is discarded and the organic extract is collected in a sample bottle. This process was repeated for the nine beer samples.

2.5. Clean-up

For the clean-up procedure, magnesium silicate was used as the stationary phase and n-hexane as the mobile phase. Little quantity of glass wool was used as a plug to prevent the loss of the stationary phase at the bottom of the column before the addition of magnesium silicate. A 0.5g anhydrous sodium sulphate was added on top of the magnesium silicate and the packed column was first washed with n-hexane to preclude any interference from trace organics. The clean-up procedure was meant to reduce to the barest minimum all forms of impurities which might be present in the eluate. The collected eluate was left to evaporate to dryness and the dried eluate was dissolved in 1ml n-hexane and stored in glass for PAHs chromatographic analysis.

2.6. GC-FID Analysis

The quantitative analysis for PAHs in the extracted solvent were done using AID Agilent Technology 200 GC-FID with A RESTEK 15METER MXT-1 column and the LC is usually estimated by integrating the areas of the resolved and unresolved, Helium was the carrier gas and a pressure 5 PSI was used for column elution. Sample injection was carried out using a syringe. The GC oven temperature was programmed first from 50ºC (hold 1 min), ramped at 10ºC to a final temperature of 110ºC (1 min).

Data Analysis: Mean for triplicate analysis were reported and overall mean of individual PAH in beer sample was reported as well. Standard deviations were determined using SPSS 18. Variability of PAHs amongst beer samples and amongst PAHs levels were calculated according to Verla et al 2020 and were characterized as: little variation if CV % <

20, if moderate variation the CV is 20 – 50 % and for high variation the CV is > 50%. Differences in PAHS concentrations in various beers were assessed and bar chats plotted to display the results. Some carcinogenic indices were calculated as follows:

$$\text{Carcinogenic ratio} = \frac{[Concentration\ of\ carcinogenic\ PAH]}{[Cocentration\ of\ non{-}carcinogenic\ PAH]} \text{……..2}$$

$$\%\ \text{Carcinogenicity} = \frac{[Concentration\ of\ carcinogenic\ PAH]}{[Sum\ \ of\ concentration\ for\ PAH\ detemined]} \times 100 \text{ ....3}$$

The estimated daily intake (EDI) was calculated using equation 4. The C_{PAH} is the concentration of individual PAH, I_D is average daily consumption of beer in Nigeria (33.64 mL) and BW is the average body weight of adult in Nigeria (70 kg).

$$\text{EDI} = \frac{C_{PAH} x I_D}{B_W} \quad \text{…….....4}$$

3.0. Results and Discussion

Table 1: Physicochemical characteristics of beer samples

	La	Lb	LC	Ha	Hb	Hc	Ga	Gb	Gc
%Al	4.6	4.5	4.6	5.2	5.2	5.4	4.6	4.5	4.8
Color	7.5	7.6	7.8	5.6	5.8	5.8	8.2	7.4	6.8
pH	4.1	3.8	3.6	4.25	4.6	4.6	3.6	3.8	3.8
EC(µS/m)	0.35	0.28	0.30	0.25	0.26	0.25	0.18	0.22	0.20
SG	10.0	10.05	10.4	11.0	10.7	10.8	10.06	10.05	10.0
IBU	0.58	0.60	0.60	0.60	0.64	0.64	1.56	1.48	1.45

Table.2: Showing concentrations of PAHs in the beer samples

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)												
Beer Sample	nc/L Phe 3 rings	nc/L Ant 3 rings	c/H 1-2 Benz 5 rings	c/H chy 4 rings	c/H Bgp 6 rings	nc/L Ace 3 rings	nc/L Flu 4 ring	c/H Bap 5 rings	TBEP	MEAN 1	SD 1	CV
La	0.003	0.018	0.0135	0.0060	0.009	Nd	Nd	Nd	0.041	0.008	0.005	61.4
Lb	0.030	0.012	0.0135	0.0060	0.016	Nd	Nd	Nd	0.049	0.090	0.006	65.3
Lc	0.003	0.012	0.003	0.0060	0.013	Nd	Nd	0	0.037	0.006	0.005	85.5
Ha	Nd	0.013	Nd	Nd	0.001	0.0010	0.0021	0.0020	0.018	0.004	0.005	111.4
Hb	Nd	0.019	Nd	Nd	0.006	0.0070	0.0021	0.0020	0.021	0.004	0.005	90.7
Hc	Nd	0.018	Nd	Nd	0.001	0.0070	0.0021	0.0020	0.0220	0.004	0.006	126.7
Ga	Nd	0.019	Nd	Nd	0.005	0.0010	0.0021	0.0040	0.0220	0.004	0.008	84.4
Gb	Nd	Nd	Nd	Nd	0.050	0.0070	0.0020	0.0110	0.0630	0.016	0.018	110.7
Gc	Nd	0.018	Nd	Nd	0.055	0.0070	0.0020	0.0030	0.0728	0.015	0.019	117.7
TPAB	0.009	0.097	0.0280	0.0170	0.156	0.0110	0.0090	0.0240	-	-	-	-
MEAN2	0.030	0.013	0.0090	0.0060	0.017	0.0029	0.0026	0.0030	-	-	-	-
SD2	0.002	0.004	0.0054	0.0030	0.021	0.0020	0.0087	0.0030	-	-	-	-
CV	50	36	57.4	50	123.53	115.8	112.5	97.14	-			

nc/L: non-carcinogenic with low molecular mass, c/H: carcinogenic and high molecular mass, Nd=Not detected, phe= phenanthrene, Ant= Anthracene, 1_2 Benz = 1_2benzanthracene, Chy= chrysene, Bgp = Benzo(g_h_i)perylene , Ace= Acenaphthylene, Flu= fluoranthene, BaP= Benzo(a)pyrene , TPEB= Total Sum of PAHs in each beer samples, TPAB =total Sum of each PAHs in all beer samples, Mean 1 = mean of total PAHs in each beer samples, Mean 2= mean of each PAHs in all beer samples, SD 1(Standard deviation of TBEP), SD 2 (standard deviation of TBAP)

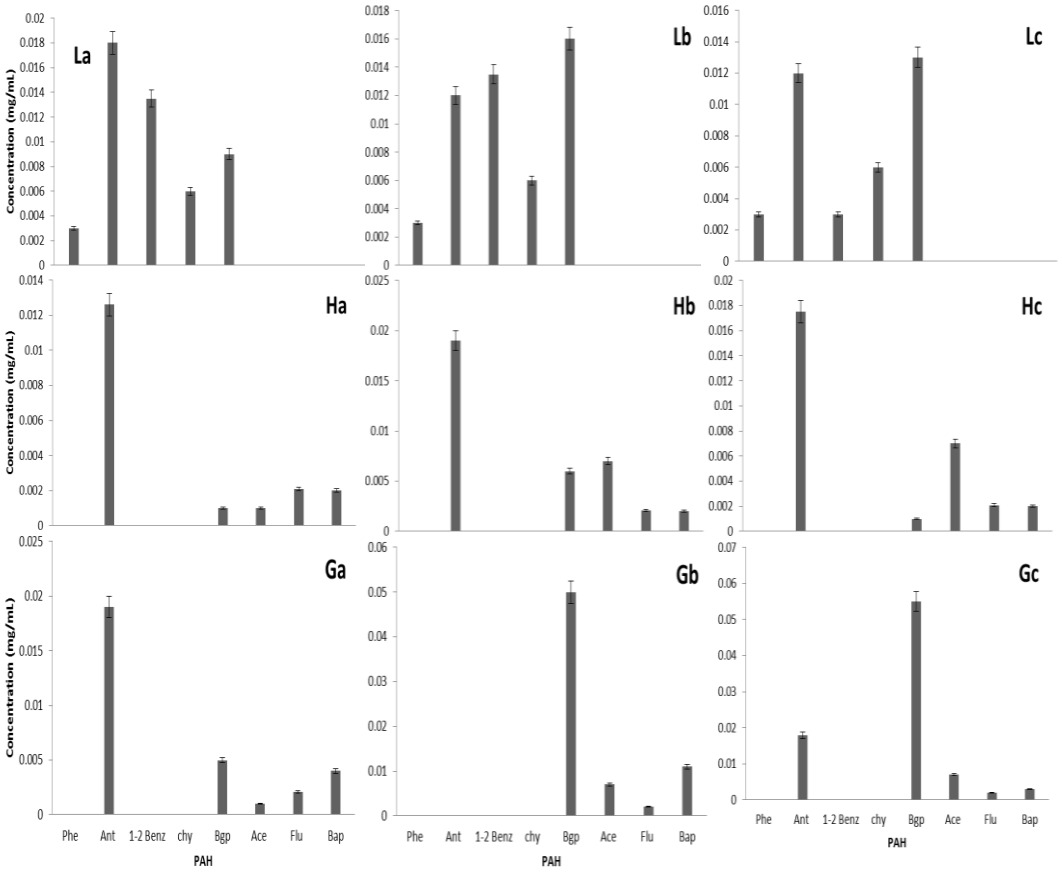

Figure_1: Representation of concentration of the PAHs in the beer samples.

PAHs standard in drinking water by Richard [39] reveal Maximum contaminant level (MCL) in mg/Ml (USEPA) and MCL in mg/mL (EC) to be 0.0001 to 0.0003 for 8 PAHs studied. If not, properly treated water could be a veritable source of PAHs for these beers.

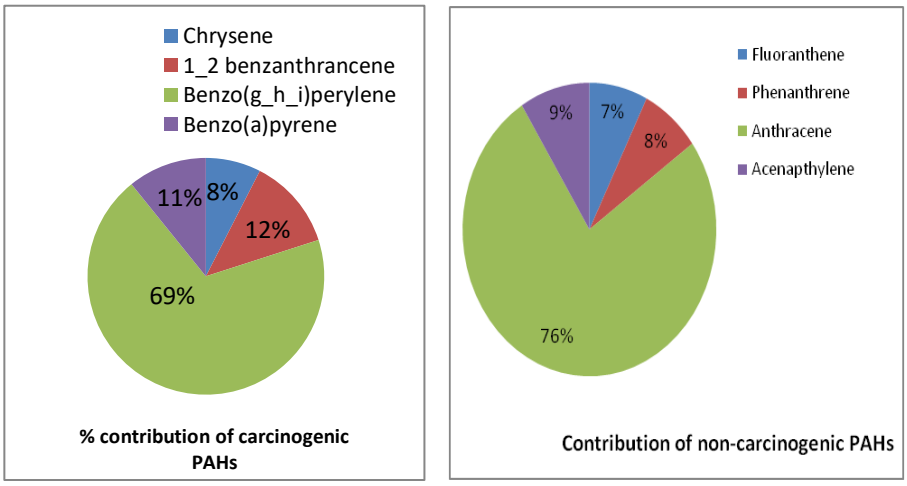

Fig 2: Pie charts comparing % contribution of carcinogenic PAHs and non-carcinogenic PAHs

Table_3: Concentration of Carcinogenic PAHs and calculated Carcinogenic risk of various beer samples in percentage of total PAH.

	La	Lb	Lc	Ha	Hb	Hc	Ga	Gb	Gc	∑CRA
Carcin. PAH										
Chrysene	0.60	0.60	0.60	0	0	0	0	0	0	1.8
1_2 Benz	1.25	1.25	1.25	0	0	0	0	0	0	3.75
B[g]p	0.90	1.6	1.3	0.10	0.60	0.10	0.50	5.0	5.0	11.2
B[a]p	0	0	0	0.23	0.23	0.23	0.38	1.09	2.8	4.96
∑ carcin.	2.75	3.35	3.15	0.33	0.83	0.33	0.88	6.09	8.3	
% B[a]p	0	0	0	69.71	27.7	69.7	43.2	17.9	33.7	
% B[g]p	33.3	47.8	41.3	30.3	72.2	43.5	56.8	82.1	66.3	

Carcin: carcinogenic, % B[a]p: relative proportion

Table_4: Estimated daily intake of PAH through beer consumption

	Phe	Ant	1-2 Benz	Chy	Bgp	Ace	Flu	Bap
La	0.101	8.658E-3	6.494E-3	2.886E-3	4.329E-3	0	0	0
Lb	0.101	5.772E-3	6.494E-3	2.886E-3	7.696E-3	0	0	0
Lc	0.101	5.772E-3	1.443E-3	2.886E-3	6.253E-3	0	0	0
Ha	0	6.061E-3	0	0	4.810E-4	4.810E-4	1.010E-3	9.62E-4
Hb	0	9.139E-3	0	0	2.886E-3	3.367E-3	1.010E-3	9.62E-4
Hc	0	8.418E-3	0	0	4.810E-4	3.367E-3	1.010E-3	9.62E-4
Ga	0	9.139E-3	0	0	2.405E-3	4.810E-4	1.010E-3	1.924E-3
Gb	0	0	0	0	0.024	3.367E-3	9.62E-4	5.291E-3
Gc	0	8.658E-3	0	0	0.026	3.367E-3	9.62E-4	1.443E-4

DISCUSSIONS

Physicochemical properties

Concentration of PAHs from Table 2 a total number of 8 PAHs was present in the nine beer samples analyzed in this study with concentrations ranged between ND -0.3516 mg/mL. a quick view on the total concentrations of PAHs in each beer samples showed that phenanthrene was detected only in La, Lb and Lc beer samples at concentration range of 0.0032 mg/mL while being absent in remaining beer samples which is far above the MCL of 0.0002 in drinking water set by USEPA, but this concentration range was below permissible limits of 0.0514 mg/mL in Industrial water as reported by Wujy et *al*,[38]Anthracene was present all beer samples with the exception to Gb beer sample, its concentration ranged from nd in Gb to 0.0165 in Hc which was still far above permissible limits set by EC and USEPA. 1_2 benzanthracene followed the same trend as phenanthrene and chrysene. Benzo(g_h_I)perylene was virtually present in all beer samples while the rest which includes acenapthylene, fluorene and benzo(a)pyrene followed similar trend of being present in La, Lb, and Lc while being detected in the rest of the beer samples. In comparison with USEPA and EC limits of PAHs in mg/mL it is deduced the all PAHs in the selected beer samples were above the maximum allowed limits of 0.0002, 0.00003 and 0.0001 mg/mL for water, although water constituting about 75% of the ingredient used in beer production seem not to be the major such of PAHs deposit from the research conducted but to the best of our knowledge there's no reports of MCL of PAHs deposits found in beer. From the graphical representation in fig 1, benzo(g_h_i)perylene was the highest at percentage of 0.055±0.01 in Gc beer while acepnapthene was lowest in Hc beer at concentration of 0.0007 mg/Ml

Carcinogenic Profile of beer

Ring structure distribution of PAHs concentrations in beer sample showed that sum of mean for 3 rings compounds was 0.0169 mg/l, medium (4 rings) was (0.0075 mg/l), while the 5-6 rings structures had a sum of mean concentrations valued at (0.0299 mg/l). Note that the 5-6 rings of PAHs is considered the most toxic and this structural size has B[a]p which is used as a maker for total carcinogenic potential assessment in foods (). The contribution of B[a]P to the 5–6-member ring is 56 % a value within the range 51-64 % as respired by [Ohura et al. 2014]. The 3 rings PAHs and 4-rings are usually low molecular weight and non-gynogenic whereas the 5-6 rings are considered heavy molecular weight. The danger in B[a]P is that it has the required ring structured which increased enzyme reactivity and often it is absorbed into the blood from organic so events like alcohol. The fears about pyrene compounds lies in the fact that the degradation product pyrenediol epoxide is capable of disrupting the process of producing DNA in a way that induces mutations. Thus after exposure to B[a]P or B[g,h,i]P there are usually occur of cancer [Grung et al., 2016]. Researchers have proved that indicated that pyrenediol epoxide in particular can targets and destroys the gene responsible for protection thereby causing cell to become cancerous [Pfeifer et al., 2002 and Kazerouni et al., 2002]. According to International Agency for Research on Cancer (IARC), the metabolites of pyrene compounds exhibit both mutagenic and carcinogenic characteristics and thus B[a]P is listed as Group 1 carcinogen. Hence the likely hood of B[a]P being absorbed from beer and cause harmful effects to consumers of beer. These fears are further exacerbated by the presence of B[g]P in all beer sample while in levels that are up to 2. Variability amongst PAHs revealed that B[a]P (123.53 %) was the most variable PAHs amongst all eight PAHs detected in beer samples, while Ant (36 %) was the least variable. Variability with most non-carcinogenic PAH, and low variably to highest variability was found to range from low variability to highest variability with most none carcinogenic PAHs, and low molecular weights exhibiting low or medium variability 36-50 % except Ace with variability of 115.8 %. Amongst beer samples variability ranged from La (61.4 %) Hc (126.7 %). Variability amongst beer samples was characterized as very high (>50 %) for all 9 beer samples. The sum of PAH4 in beer samples are (benzo[a]pyrene, benzo[g,h,i] perylene, 1-2 benzanthracene and chrysene) was as follows Ge (8.3); Gb (6.09); Lb (3.35); Lc (3.15); La(2.75); Ga (0.88); Hb (0.83); Ha and Hc (0.33). This implies that the carcinogenicity is likely to follow the trend in the decreasing order as the sum of PAH4 the contribution of B[a]p in La, Lb and was 0, meaning that carcinogenicity in terms of B[a]p is 0. 66.6 % of beer samples, the carcinogenicity in terms of B[a]p was significant, ranging from Gb (17.9 %) to 69.7 % in Ha and Hc at 69.7 % carcinogenicity there is a serious call for concern. It is suggested that Ha and Hc should not be consumed at all. The contribution of benzo [g, h, c] pyrene ranged from Ha (30.3 %) to 82.1 % in Gb. The percent carcinogenicity due to this congener followed the decreasing order. Gb (82.1); Hb (72.2); Ge (66.3); Ga (56.8); Lb (47.8); He (43.5); Le (41.3); La (33.3); Ha (30.3). There is need for attention regarding the sources of these PAH in beer. Most beer samples had carcinogenic ratios above 1 and this could mean cancer potentials of all beers are greater than 1. Over all carcinogenic ratios were 2 and could be considered an emergency situation for consumers of beer from this region. Carcinogenic ratios of less than 1 show that there may be no cancer arising from consuming the food in the short run.

Carcinogenic Risk

This is to show that PAHs detected in La, Lb and Lc beer samples were of low risk, same also applies to Ha, Hb, and Hc beer samples while Ga, Gb, Gc was also of low risk except benzo(a)pyrene which was of medium risk in beer samples Gb and Gc. Considering the tenets of CRAC in (table 4) Benzo (g_h_i) perylene was of medium risk and its contribution to carcinogenicity was significant. Therefore, it is suggested that consumption of Gb and Gc beer in the city of Owerri is most likely to be exposed to life time risk of cancer, tumor and mutation. [40] The 2020- 2025 Dietary Guidelines for Americans recommended that in order to reduce risk of alcohol related harm, men of drinking age should limit their beer consumption to two drinks or less a day while women stay at 1 drink on a day when alcohol is consumed.

Conclusion

The overall percent carcinogenicity was 64.27 %. Again, this percentage is high and calls for attention from both consumers and manufacturers of beers samples. When considered, the source of the PAHs responsible for such a high percent carcinogenicity has been characterized using a simple PAH index. The balance of this value was non-carcinogenicity and overall value was 35.9 %. By using benzo[a]pyrene the carcinogenic potential risk of beer samples has been characterized. Therefore, in conclusion, the beer samples revealed a potential carcinogenic danger in overall. It is hoped that consumers and producers alike will hide the call to check the associated danger and do something positive in time

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COMPETING INTERESTS

We declare that there no competing interests.

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