Journal of Basic Physical Research ISSN: 2141-8403 Prints, 2141-8411 Online
Vol.8, No.2 pp. 55- 64, July, 2018. Available online at www.jbasicphyres-unizik.org

PHYSICOCHEMICAL ANALYSIS OF SOME PACKAGED FOODS AND DRINKS CONSUMED IN ENUGU METROPOLIS

J.O. Nwerem and P.N. Ekemezie
Department of Pure and Industrial Chemistry, Nnamdi Azikiwe University, Awka.
Email: pn.ekemezie@unizik.edu.ng/Phone No: 08034054808

Abstract
The analysis of Volatile Organic Compounds(VOCs), proximate and heavy metal contents in food and drinks packaged with plastic/polymer materials were studied. The volatile organic compounds were analysed using the Gas Chromatograph interfaced with Mass Spectrometer(GC-MS). The heavy metals were analysed using atomic absorption spectrometry and flame photometry while the proximate analyses were done using standard methods. The results revealed different percentage content for ash, moisture, crude fibre, fats, carbohydrate and protein for the samples. The alcoholic drinks had no detectable content of ash, crude fibre, fats, carbohydrate and protein. The results also showed the presence of different heavy metals, with cadmium below the detection limit (0.001ppm). Chromium and zinc were detected in all samples. However their concentrations were below the World Health Organization maximum contaminant levels of 0.05ppm and tolerable upper level intakes. The results also revealed the presence of toluene, ethylbenzene, p-xylene, 1-methylethyl-benzene, propyl-benzene, 1,2,4-trimethyl-benzene, α-methylstyrene, tert-butyl-benzene, hexachloro ethane, pentyltetratriacontyl, 1-butoxy-2-methyl-2-butene,5-ethenyl-2-methyl-pyridine, 3,5-dimethylbenzenamine, 2-methyl-N-propylbenzamide, and 3-methylbut-2-yl-neopentyglutaric acid at different concentration levels in most of the samples. 1-butoxy-2-methyl-2-butene had the highest concentrations of 26.93 ppm, while benzenamine, 3,5-dimethyl and pentyltetratriacontyl are the most dominant. 1-methylethyl-benzene was not detected in any of the samples. In cases where the volatile organic compounds were detected and quantified, their concentrations were below the World Health Organisation guideline values. Thus, the results confirmed the safety of the samples for human consumption.

Introduction

In this research, analysis of some processed foods and drinks packaged with plastic materials were done. These foods and drinks are usually subjected to heat during processing and packaging, and the heat can aid in the emission of Volatile Organic Compounds (VOCs) and subsequent migration into the food (McNeal and Hollifield, 1993., Gorna-Blinkul *et al*., 1996., Lachenmeier et al., 2010). Apart from the processes involved in producing these foods, their storage conditions can also affect the VOCs profile in the food. More so, the ingredients used in processing and producing these foods and drinks can affect the level of VOCs and heavy metal contents (Dauneau and Perez, 1997., Salako *et al*., 2016). VOCs and other substances migrating into foodstuffs are of concern if they present a possible health hazard to the consumer, or cause unacceptable changes to the organoleptic properties of the food or beverages. Monitoring the VOCs and heavy metals present in the packaged foods will improve food safety and give an insight on the possible intake by humans and any possible health implications. Therefore, it is necessary to continuously test these foods to monitor the level of volatile organic compounds (VOCs) and heavy metals in them in order to provide assurance to consumers about the safety of the products.

Materials and Methods

Sample Collection

Twenty samples (20) covering different food products packaged in different materials were purchased from markets in and around Enugu metropolis. The items selected for analysis were based on their popularity among local consumers and availability at the time of sampling. The data for the samples are presented in Table 1. The samples were analysed for proximate composition, heavy metals and volatile organic compounds (VOCs).

Table 1: Sample Information

S/N	Sample Name	Sample ID	Batch Number	Man. Date	Expiry Date
1	Maltina classical bottle	A			
2	Rapha classical bottle	B	14ACLT20013		02/17
3	Fresh yo drinking yoghurt	C	66024		10/16
4	5-alive pulpy orange fruit drink	D			
5	Mirinda orange	E	P39783	03/16	09/16
6	Boyic orange flavoured yohurt	F			08/16
7	3 crown milk	G	18:21:52		10/16
8	Wish bone thousands island dressing	H	83232087		08/16
9	Bamaeal mayonnaise	I	15286M-15		04/17
10	Mini caramel swiss roll	J			
11	Pringles (sour cream and onion)	K	L5316035740 1909		
12	Torto magic stick + chocohazelmt	L	E241		02/17
13	Chocolate cookies (merbe)	M	L152/302-14		11/16
14	Gala sausage rolls	N	19/3A15111		05/16
15	Mcvities the original digestive	O	074D		03/17
16	Brandy special quality	P			
17	Squadron bleeded dark rum	Q			
18	Royal eagle premium gin	R	004		
19	Mc'dowell reserve whisky	S			
20	Seaman's schnapps (sachet 30mL)	T	4364		

Proximate Composition

After bringing the samples to uniform size of 600μm, they were analysed for moisture, protein, fat, ash, fiber and nitrogen free extract. The analyses were conducted in the Graduate Laboratory of University of Lagos.

Determination of Moisture Content

Moisture content of each sample was determined by oven drying method. Well-mixed (1.5 g) sample was accurately weighed in clean, dried crucible (W_1). The crucible was allowed in an oven at 105°C for 12 hours until a constant weight was obtained. Then the crucible was placed in the desiccator for 30 minutes to cool. After cooling, it was reweighed (W_2). The percent moisture was calculated by using the following formula:

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_1} \times \frac{100}{1} \qquad (1)$$

Where

W_1 = Initial weight of crucible + Sample

W_2 = Final weight of crucible + Sample

Note: Moisture free samples were used for further analysis.

For the alcoholic beverages and other drinks, the Karl Fisher method was used to determine the moisture content. The prepared test portion (0.01 g) was weighed accurately into a titration vessel, and was dissolved in anhydrous chloroform–methanol solution. It was titrated with dilute

(1:1) Karl Fisher reagent to electrometric end point. Blank test was carried out using same amounts of reagent, diluent and solvents. The blank titre was then subtracted (AOAC, 2005).

$$\text{Moisture \%} = \frac{\text{mL of reagent x C}}{\text{weight of test portion x 10}} \quad (2)$$

Where C = concentration of Fisher reagent

Determination of Ash Content

For the determination of ash, clean empty crucible was placed in a muffle furnace at 600°C for an hour, cooled in a desiccator and then weight of empty crucible was noted (W_1). One gram of each of the sample was placed in the crucible (W_2). The sample was ignited over a burner with the help of blowpipe, until it charred. Then the crucible was placed in muffle furnace at 550°C for 2hours. The appearances of gray white ash indicate complete oxidation of all organic matter in the sample. After ashing, the furnace was switched off. The crucible was cooled and weighed (W_3). Percent ash was calculated by following formula:

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2 - W_1} \text{ x } \frac{100}{1} \quad (3)$$

Crude Protein Determination

Protein in the sample was determined by Kjeldahl method. Each sample was dried in a furnace at 100°C. Dried 1.0 g samples were placed in a digestion flask. Concentrated H_2SO_4, (15 mL) and digestion mixture i.e. K_2SO_4: $CuSO_4$ (8: 2), 8 g were added. The flask was swirled in order to mix the contents thoroughly then placed on heater to start digestion till the mixture became clear (blue green in color). It took 2 hours to complete. The digest was cooled and transferred to 100 mL volumetric flask and volume was made up to mark by the addition of distilled water. Distillation of the digest was performed in Markam Still Distillation Apparatus. Ten milliliters of digest was introduced into the distillation tube then 10 mL of 0.5M NaOH was gradually added through the same way. Distillation was continued for at least 10 min and NH_3 produced was collected as NH_4OH in a conical flask containing 20 mL of 4% boric acid solution with few drops of modified methyl red indicator. During distillation yellowish color appeared due to NH_4OH. The distillate was then titrated against standard 0.1M HCl solution till the appearance of pink color. A blank was also run through all steps as above. Percent crude protein content of the sample was calculated by using the following formula:

$$\% \text{ Crude Protein} = \%N \text{ x } 6.60 \quad (4)$$

The nitrogen content %N of the sample is given by the formula below:

$$\%N = \frac{T_v \times N_a \times 0.014 \times V_1}{G \times V_2} \times 100 \quad (5)$$

Where: T_v = Titre value of acid (cm^3)

N_a = Concentration or normality of acid

V_1 = Volume of distilled water used for distilling the digest ($50cm^3$).

V_2 = Volume of aliquot used for distillation ($10cm^3$)

G = Original weight of sample used in gram

Determination of Crude Fat

Crude fat determination was done accorging to AOAC, 2005. It consisted of extracting dry sample with some organic solvent, since all the fat materials e.g. fats, phospholipids, sterols, fatty acids, carotenoids, pigments, chlorophyll etc. are extracted together therefore, the results are frequently referred to as crude fat. Crude fat was determined by ether extract method using Soxhlet apparatus. Approximately 1 g of moisture free sample was wrapped in filter paper, placed in fat free thimble and then introduced in the extraction tube. Weighed, cleaned and dried, the receiving beaker was filled with petroleum ether and fitted into the apparatus. The water and

heater were turned onto start the extraction process. After 4-6 siphoning, the ether was allowed to evaporate and then the beaker was disconnected before the last siphoning. The extract was transferred into a clean glass dish with ether washing and the ether was evaporated on water bath. The dish was then placed in an oven at 105°C for 2 hours and cooled in desiccators. The percentage crude fat was determined by using the following formula:

$$\% \text{ Crude Fat} = \frac{\text{weiht of ether}}{\text{weight of sample}} \text{x } 100 \qquad (6)$$

Determination of Crude Fiber:
A moisture free and ether extracted sample of crude fiber made of cellulose was first digested with dilute H_2SO_4 and then with dilute KOH solution. The undigested residue collected after digestion was ignited and loss in weight after ignition was registered as crude fiber.

Sample 0.153 g (W_0) was weighed and transferred to a porous crucible. The crucible was placed into a Dosi-fiber unit and the valve was kept in an "OFF" position. 150 mL of preheated H_2SO_4 solution and some drops of foam-suppresser were added to each column. The cooling circuit was opened and the heating elements turned on (power at 90%). When it started boiling, the power was reduced to 30% and left for 30 minutes. Valves were opened for drainage of acid and rinsed with distilled water thrice to completely ensure the removal of acid from sample. The same procedure was used for alkali digestion by using KOH instead of H_2SO_4. The sample was dried in an oven at 150°C for 1 hour. Then the sample was allowed to cool in adesiccators and weighed (W_1). The sample crucible was kept in muffle furnace at 55°C for 4 hours. The sample was cooled in desiccator and weighed again (W_2). Calculations were done by using the formula (AOAC, 2005)

$$\% \text{ Crude Fiber} = \frac{W_1 - W_2}{W_0} \text{ x } 100 \qquad (7)$$

Determination of Carbohydrate
Total carbohydrate content was determined by subtracting the sum of the percentage moisture, ash, crude protein, crude fibre from 100% (AOAC, 2005).

Heavy Metal Determination:
0.5g of the sample was weighed into a quartz beaker with 10mL of HNO_3 added and gently heated on a hot plate. Heating was then continued until the brown fumes turned to white. The beaker was allowed to cool to room temperature. The mixture was rinsed with 20mL of deionised water and filtered into a standard 25mL volumetric flask and made up to mark in readiness for Atomic Absorption Spectrophotometry.

Volatile Organic Compound (VOC) Analysis
VOC analysis was done according to AOAC, 2005. The samples for VOCs analyses were extracted in dichloromethane using a separating funnel. 2.0g of each of the samples was weighed into the funnel and 20mL of the organic solvent was added. The mixture was shaken vigorously and the two components were allowed to stand using a retort stand to hold the separating funnel. The organic solvent with extract was collected by filtering into a quartz beaker, the process was repeatedly carried out for two more consecutive times and the aliquot was collected and mixed which was further concentrated on a steam bath to 5mL. This was purified by passing through a pasture pipette packed with anhydrous sodium sulphate on cotton wool in form of a membrane. It was further air dried to 2mL which was taken for gas chromatographic analysis.

The extracts of the samples were subjected to Gas Chromatography-Mass Spectrometry analysis, this powerful instruments helped to characterize the various composition. The gas chromatography (GC) analysis was performed on an Agilent Technologies interfaced with Mass

Selective Detector (MSD). The electron ionisation was at a 70V with an ion source temperature at 250°C. Ultra-pure helium gas (99.9% purity) was used as carrier gas, while HP-5 (30mm X 0.25mm X 0.320μm) was used as the stationary phase.

The oven temperature at 100°C was held for 0.5 minute and ramped to 240°C at the rate of 20°C per minute holding for one minute, ramped to 280°C while holding for 20 minutes at the rate of 11°C per minutes. 1μL was auto injected into the machine. The constituents of the volatile oils were identified by comparing the mass spectra with a known standard in the instrument's library.

Results and Discussion

Results of Proximate Analysis

The result of moisture content, ash content, crude fat content, crude fibre, and proteinare presented in table 2.

Table 2: Results of proximate analysis

Sample	Ash %	Moisture %	Crude fibre %	Fat/lipids %	Protein %	Carbohydrate %
A		88.41±0.000	1.94±0.0100	0.46±0.0100	1.98±0.0100	5.31±0.0300
B	0.60±0.000	92.50±0.0058	0.67±0.0115	0.76±0.0173	6.30±0.0100	-
C	4.32±0.0058	84.90±0.000	4.34±0.0153	0.55±0.0058	5.71±0.0000	0.18±0.0173
D	0.82±0.0058	91.50±0.0058	0.88±0.0100	1.15±0.0058	4.89±0.0100	0.76±0.0115
E	0.31±0.0058	90.24±0.0058	0.37±0.0115	0.66±0.0100	1.79±0.0000	6.63±0.0306
F	1.85±0.0058	91.39±0.0058	1.88±0.0058	3.00±0.0000	1.30±0.0000	0.58±0.0100
G	6.72±0.0058	76.01±0.0058	6.99±0.0200	2.00±0.0000	5.90±0.0058	2.38±0.0208
H	5.29±0.0058	47.71±0.0000	5.39±0.0058	26.75±0.0058	2.90±0.0000	11.96±0.0153
I	1.31±0.0058	12.29±0.0058	1.68±0.0100	71.40±0.0058	1.91±0.0058	11.41±0.0173
J	2.44±0.000	28.58±0.0058	2.89±0.0153	11.90±0.0058	6.32±0.0173	47.87±0.0153
K	2.35±0.0058	3.36±0.0058	2.59±0.1530	16.70±0.0100	4.21±0.0100	70.79±0.0265
L	1.92±0.0115	7.68±0.0058	1.99±0.0058	12.90±0.0058	4.80±0.0000	70.71±0.0058
M	1.72±0.0058	14.14±0.0058	1.93±0.0173	21.31±0.0115	5.02±0.0200	55.88±0.0058
N	2.30±0.0058	23.39±0.0058	2.55±0.0252	7.95±0.0000	9.10±0.0000	54.71±0.0252
O	1.96±0.0058	7.60±0.0058	1.99±0.0058	14.30±0.0580	2.70±0.0100	71.45±0.0058
P	-	57.13±0.0115	-	0.15±0.0058	-	-
Q	-	47.08±0.0058	-	0.16±0.0058	-	-
R	-	56.16±0.0058	-	0.35±0.0100	-	-
S	-	49.94±0.0058	-	0.25±0.0580	-	-
T	-	60.52±0.0058	-	0.56±0.0115	-	-

The ash content of the samples were within the range of 0.00 to 6.72±0.0058%. Samples P, Q, R, S and T showed no ash content. These samples are all alcoholic drinks. Ash on food determine largely the extent of mineral matters likely to be found on food substance.

Moisture content of these samples fall within the range of 3.36±0.0058 and 92.5±0.0058%. Moisture in food determines the rate of food absorption and assimilation within the body. It is also a source of rehydration to the body.

The content of crude fibre falls within the range of 0.00 to 6.99±0.020%. However samples P, Q, R, S and T showed no crude fibre content. These samples are all alcoholic drinks. The content of crude fibre acts as intracellular signals stored in tissues and serves as reservoirs of energy. Fibre taken as part of diet cleanses the digestive tract by removing potential carcinogens from the body

and hence prevents the absorption of excess cholesterol. Fibre also adds bulk to food and reduces the intake of excess starchy food and hence guards against metabolic conditions such as hypertension and diabetics mellities (Sodamade *et al.,* 2013).

The percentage content of the fats in the samples fall within the range of 0.15±0.058 to 71.4±0.0058.Fat in food determine the amount of energy available. A diet providing 1-2% of its caloric energy as fat is said to be sufficient to human beings as excess fat consumption yields certain cardio vascular disorder such as atherosclerosis, cancer and aging.

From results obtained, the carbohydrate values of the samples ranged from 0.18±0.0173 to 71.45±0.0058. Samples P, Q, R, S and T showed no carbohydrates content. These samples are all alcoholic drinks. Samples H, I, J, K, L, M, N and O showed high level of carbohydrate content. Carbohydrate is the principal source of energy in food. The values of carbohydrates content in these samples can provide a lower calorie of energy (Sodamade *et al.,* 2013).

Results for Heavy Metal

Heavy metal contents (cadmium, lead, chromium, nickel and zinc) of the twenty samples were analysed and the results presented in Table 3. The data were presented as mean ± standard deviation of triplicate values. (<DL) represents values less than the detection limit of 0.001ppm while (*) represents values above the WHO acceptable range.

Table 3: Results of heavy metal analyses

Samples	Cadmium (ppm)	Lead (ppm)	Chromium (ppm)	Nickel (ppm)	Zinc (ppm)
A	<DL	<DL	0.016±0.005	0.01±0.005	1.18±0.010
B	<DL	<DL	0.04±0.000	<DL	0.71±0.006
C	<DL	<DL	0.03±0.005	0.01±0.000	0.3±0.005
D	<DL	0.01±0.005	0.05±0.000	0.01±0.005	0.81±0.005
E	<DL	<DL	0.04±0.000	<DL	0.03±0.000
F	<DL	<DL	0.03±0.005	<DL	1.89±0.005
G	<DL	<DL	0.03±0.000	<DL	0.79±0.005
H	<DL	<DL	0.01±0.005	0.01±0.000	0.35±0.005
I	<DL	<DL	0.004±0.000	0.00±0.000	0.84±0.005
J	<DL	0.06±0.000*	0.03±0.000	0.02±0.010	0.3±0.005
K	<DL	0.03±0.010*	0.04±0.000	0.03±0.000	2.99±0.010
L	<DL	<DL	0.01±0.000	<DL	0.79±0.005
M	<DL	<DL	0.02±0.006	0.01±0.010	0.35±0.005
N	<DL	<DL	0.04±0.005	0.02±0.005	0.84±0.005
O	<DL	0.04±0.000*	0.02±0.005	0.02±0.000	2.3±0.050
P	<DL	0.02±0.005*	0.01±0.010	<DL	0.91±0.010
Q	<DL	0.01±0.005	0.02±0.000	<DL	0.73±0.010
R	<DL	<DL	0.01±0.000	<DL	0.35±0.005
S	<DL	0.01±0.005	0.01±0.000	<DL	0.81±0.005
T	<DL	0.02±0.005*	0.02±0.000	0.01±0.005	0.3±0.005
WHO	0.003	0.01	0.05	0.07	5.0

The results as presented in Table 3 indicate that the concentration of lead in the samples ranged from <DL - 0.06 mg/kg, with sample "J" having the highest concentration of Pb of 0.06ppm. The concentration of lead in the samples were all within the permissible limit of Pb in alcoholic

beverages (0.5 ppm). However, the concentrations in samples J, K, O, P, T were above the Maximum Contaminant Level(MCL) of lead (0.01 ppm) (W.H.O., 2007). Lead is found in the earth's crust and has been reported to emit from anthropogenic activities such as combustion of fossil fuel, mining, paint, batteries production, etc from where they contaminate water bodies (Izah*et al.,* 2016).

Chromium was detected in all the samples, at concentrations ranging from 0.01 to 0.05ppm. The MCL for Chromium is 0.05 ppm. The chromium levels observed in our study are lower than the MCL. However the levels call for serious public health concern on the part of the Nigerian consumers and the regulatory agencies as frequency of consumption of these drinks and food can expose the consumer to higher levels that can pose serious health effect. This raises concern for persons who may potentially increase their chromium levels to a toxic level from frequently but low-level intake from any of these food and/or drink. Despite the popular opinion on increasing chromium intake as one of the essential elements, consumers of drinks and foods may be exposed to higher levels considering the relative contribution of chromium to the diet by beverage drinks and foods. Accumulation of chromium in the body can cause damage to the liver, kidney, nose, lungs; and possible asthma attack (Kleefstra*et al.,* 2004).

Results in Table 3 indicate that the mean concentration of Nickel (Ni) in the samples ranged between <DL – 0.03 ppm with sample K having the highest mean concentration of 0.03 ppm. The maximum permissible limit of Nickel in drinking water is 0.07 ppm (WHO, 2011). The concentration of Ni in the different samples were not above the WHO maximum permissible limit of Ni in drinking water. Caution should, however, be made in considering the frequency at which this foods and drinks are taken to avoid exceeding the tolerable limit.

The result for zinc is within the range of 0.03±0.00ppm to 2.99±0.01ppm Zinc is a trace mineral essential to all form of life. Zinc plays a vital role in gene expression, regulation of cellular growth and acts as a co enzyme for carbohydrates, protein and nucleic acids metabolism (Sodamade*et al.,* 2013; Hambridge, 2000).The tolerable limit for zinc is 4mg for babies between 0 to 6 months to about 40mg for adults above 19 years (Food and Nutrition Board, 2001). The concentrations in the samples analysed are far below the tolerable limit and as such pose no health challenge to consumers of these products.

The concentrations for Cadmium (Cd) in the samples were all below the World Health Organisation detection limits.

Results for Volatile Organic Compounds

Results of the volatile Organic Compounds are shown in Table 4. Fourteen common VOCs were analysed as shown in Table 4

Table 4: Result of Volatile organic compounds' analysis

Samples	Toluene (ppm)	Ethyl Benzene (ppm)	p-Xylene (ppm)	1-methylethyl-Benzene (ppm)	propyl-Benzene (ppm)	1,2,4-trimethyl-Benzene (ppm)	alpha.-Methylstyrene (ppm)	tert-butyl-Benzene (ppm)	hexachloro-Ethane (ppm)	Pentyl Tetratriacontyl (ppm)	1-Butoxy-2-methyl-2-butene (E)-(ppm)	5-ethenyl-2-methyl-Pyridine (ppm)	3,5-dimethyl-Benzenamine (ppm)	2-methyl-N-propyl-Benzamide (ppm)	3-methylbut-2-yl-neopenty-Glutaric acid (ppm)
A	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	0.02	N.D	0.28	0.02	N.D
B	0.01	0.02	0.02	N.D	0.01	N.D	0.01	0.01	0.08	0.09	26.93	0.41	1.02	5.36	N.D
C	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	0.02	0.01	0.01	N.D	N.D
D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	0.02	0.01	0.01	N.D	N.D
E	0.01	N.D	0.02	N.D	N.D	N.D	0.01	0.02	0.01	0.03	1.06	0.24	0.46	4.14	N.D
F	0.01	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	0.01	0.02	N.D	0.01	N.D	N.D
G	N.D	N.D	N.D	N.D	0.01	N.D	0.02	0.04	0.01	0.05	8.96	0.03	0.2	1.53	N.D
H	0.01	N.D	N.D	N.D	0.01	N.D	0.01	0.01	0	0.01	16.52	0.01	0.09	N.D	N.D
I	0.01	N.D	0.01	N.D	N.D	N.D	0.02	0.01	0.02	0.03	7.81	0.01	0.12	N.D	N.D
J	0.01	N.D	N.D	N.D	0.01	N.D	0.03	0.03	N.D	0.05	10.52	0.05	0.13	N.D	N.D
K	0.01	N.D	0.01	N.D	0.01	N.D	0.02	0.04	N.D	0.05	12.03	0.01	0.2	N.D	N.D
L	N.D	0.01	0.01	N.D	0.01	0.01	0.03	0.02	0.04	0.24	0.51	0.09	0.07	N.D	N.D
M	N.D	N.D	0.01	N.D	0.01	N.D	N.D	0.01	N.D	0.03	5.73	0.02	0.1	N.D	N.D
N	N.D	N.D	0.01	N.D	N.D	0.01	0.01	0.01	N.D	0.01	N.D	0.01	0.01	0.17	N.D
O	0.01	0.01	0.01	N.D	0.01	N.D	N.D	0.02	N.D	0.30	0.47	0.07	0.27	1.46	N.D
P	N.D	N.D	0.01	N.D	N.D	N.D	0.01	0.03	N.D	0.01	5.46	0.02	0.04	0.91	N.D
Q	0.01	N.D	N.D	N.D	N.D	0.01	0.04	0.02	0.03	0.07	N.D	N.D	1.19	0	N.D
R	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	0.01	0.08		0.04	0.02	0.01
S	0.01	N.D	N.D	N.D	0.02	N.D	0.02	0.02	0.07	0.08	N.D	N.D	N.D	0.93	N.D
T	N.D	0.01	0.01	N.D	N.D	N.D	0.01	0.01	0.01	0.06	N.D	0.03	0.48	1.36	N.D

Note: ND = not detected.

The concentration of the Volatile Organic Compounds (VOCs) were between 0.00ppm and 26.93ppm. Among the VOCs, 1-butoxy-2methyl-2-butene is present with the highest concentrations of 26.93 ppm, while 3, 5-dimethyl-benzenamine and pentyltetratriacontyl are the most dominant.

Toluene was detected and quantified in ten samples at 0.01ppm. These concentrations are far below their established Maximum Contaminant Level (MCL) of 1000 ppb. In all samples where toluene was detected, the possible route of exposure could be through the water used in production of these foods and drinks as observed concentration of toluene in water ranges from trace to 10 μg/L (EPA, 1990). Toluene has minimal effects on the liver and kidney, except in cases of toluene abuse. There has been no indication that toluene is carcinogenic in bioassays conducted to date and the weight of available evidence indicates that it is not genotoxic (EPA, 1990).However at higher concentrations, toluene is unequivocally associated with neurobehavioural functional decrements. Women exposed to toluene at an average concentration of 88ppm incurred higher spontaneous abortion rates and menstrual function disturbances. Men occupationally exposed to toluene at 5–25ppm have also been shown to exhibit hormonal changes (WHO, 2000). However, the concentration observed in these samples are far below the concentration that could pose health effect.

Ethylbenzene was detected and quantified in three samples in the range of 0.01ppm to 0.02ppm. It is used in the production of styrene, a monomer for the production of polystyrene plastics used in food packaging. It can migrate from polystyrene food packaging into food (WHO, 1996). Though relevant data for the human health effect of ethylbenzene are lacking, effects on liver and kidneys of laboratory animals were observed at 400 ppm of body weight and higher dose levels.Thus the observed concentration does not pose any threat to health.

Apart from ethylbenzene, other compounds like propyl benzene, 1-ethyl-methyl benzene, alpha methyl styrene, (1-methylethyl) benzene, 2-propenyl benzene, 1,2,4-trimethyl benzene and *p*-xylene were also identified and quantified.

In cases where they were detected and quantified, their concentrations were below the WHO guide line values.

These results confirmed the safety of the samples for human consumption with regards to the volatile organic compounds. However, chances are there that these volatile organic compounds might have synergistic effect as it has been stated that in combination with other commonly used products, the toxicity of the migratory chemicals can be potentiated by synergy (Payne et al., 2001). Thus, this and other similar chemicals have introduced a problem of protracted action of low concentrations upon human health.

Conclusion

This work involved the study of the physicochemical analysis of some packaged foods and drinks consumed in Enugu metropolis. The physicochemical analyses included VOCs, Heavy metals and proximate analysis. They were studied using GC-MS, AAS and standard methods respectively. VOCs and heavy metals are ubiquitous in the environment, thus their presence in packaged foods and drinks should be considered for human exposure. This is because the overall migration is usually the starting substances that are used to make the food, the materials and storage conditions. But relatively little detailed compositional information is known beyond this. The food ingredients may contain possible VOCs precursors and heavy metals. Nevertheless, they may be present as impurities in the substances used, as reaction intermediates formed during food production and polymerisation processes or as decomposition or reaction products of the packaging materials. The results of the studies revealed that the samples were safe for human consumption.

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