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Levels of Monosodium Glutamate and Aspartame in selected Wines, Spirits and Beers in Nairobi County, Kenya

Paul Juma Ojumbo[1*] Wanjau R. N.[1] Ndiritu J.[2] Murungi J. I.[1]

[1]Chemistry Department, Kenyatta University, P.O Box 43844-0100, Nairobi, Kenya

[2]Department of Biological & Physical Sciences, Turkana University College, P.O Box 69-30500, Lodwar, Kenya

[1*]Corresponding Author: Paul Juma Ojumbo: Email: pojumbo@gmail.com

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ABSTRACT

Food additives are non-nutritive compounds included in foods during manufacturing or packaging. When added, they maintain or better the quality of the foods. Aspartame, propylene glycol and monosodium glutamate (MSG) are some food additives that may be present in alcoholic beverages. Monosodium glutamate can cause obesity, eye damage, headaches, depression and rapid heartbeat while aspartame can cause brain tumor, chronic fatigue and emotional disorders. Consequently, a constant check on amounts of additives in food is of essence. It was the aim of this research to assess the amounts of MSG and aspartame in beers, spirits and wines sold in Nairobi County. Sixty-six samples comprising of nine brands of wine, five brands of spirit and eight brands of beers were purchased from selected supermarkets; K, L, M and N in Nairobi city center. Aspartame and monosodium glutamate were derived out of beers, spirits and wine using water. High performance liquid chromatography (HPLC) was then used to analyse them. Analysis of variance (ANOVA) was used to analyse the data. The range of average amounts of MSG was 6.23-10.47 mg/L in beers, 13.11-70.02 mg/L in wines and 28.32 mg/L in spirits. Only one brand of spirit, S2, had detectable levels of MSG. The MSG levels detected were all within the permissible levels of 300 mg/L. The range of mean levels of aspartame was 2.41-20.88 mg/L in beers, 7.20-24.32 mg/L in wines and 67.23-213.56 mg/L in spirits. The levels of MSG and aspartame between the brands of beers, wines and spirits differed significantly. The finding of this research depicts that the amounts of MSG and aspartame in beers, wines and spirits are within the recommended levels. The findings will be used to educate the masses on the amounts of MSG and aspartame in alcoholic beverages and be presented to KEBS and other regulatory bodies.

Key words: Food additives, beverages, monosodium glutamate(MSG), aspartame, ANOVA and HPLC

INTRODUCTION

Natural or artificial substances that are included purposively to food or feed are known as food additives. When added, food additives make the food product more durable; alter its properties in terms of physical appearance, taste or structure (Codex, 2018). Laws governing all food additives demands that food additives be enumerated on packaging of foods in which they are used (EFSA, 2018). Similarly, food additives should be assessed constantly and re-evaluated because of changes in the use and new scientific information (EFSA, 2018). Food additives have largely been used since majority of people have opted to consuming processed foods. The quick fortified foods are easy to find, easy to prepare and they are durable. The food additives when used in levels beyond the acceptable limits each cause various types of diseases (Sabikun *et al.*, 2021). The widely used food additives in alcoholic beverages are monosodium glutamate (MSG) and aspartame (Soyseven, 2021). Other food additives that are present in wines, spirits, beers and other liquors are saccharin, sorbic acid, propylene glycol and sodium benzoate. (Carey *et al.*, 2015). Aspartame is a dipeptide with a chemical formula of $C_{14}H_{18}N_2O_5$. Aspartame is commercially known to as NutraSweet (Petri, 2019) and is represented in figure 1.

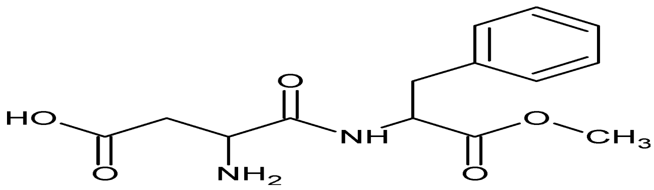


Figure 1: Aspartame

In 1996, FDA declared aspartame to be safe at an acceptable level of 50 mg/kg/day, except for phenylketonuric person (Petri, 2019). Aspartame should not be consumed by people with the genetic condition known as phenylketonuria (PKU) because it breakdown into phenylalanine product which later accumulates as toxic substance leading to mental retardation (McCullough *et al.*, 2022). Consumption of aspartame may damage brain, creates adverse neurological problems, such as insomnia, headache and seizure (Landrigan *et al.*, 2021).

Monosodium glutamate (MSG) (Figure 2) also referred to as sodium glutamate. It is a flavor enhancer with a chemical formula of $C_5H_8NNaO_4$. It occurs naturally in plants and animals. It is also produced by fermenting starch, sugar cane or molasses (Soyseven, 2021). Its structure is shown in figure 2.

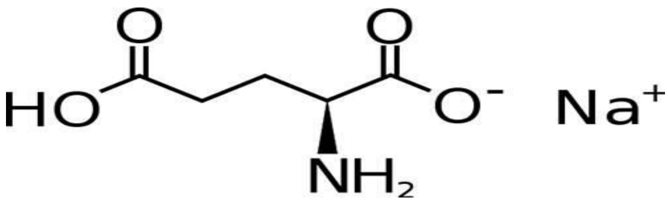


Figure 2: Structure of MSG

It is established through research that MSG in foods can damage brain cell, cause retinal problem and endocrine disorder (Butnarius *et al.*, 2019). There is no specified daily accepted intake limit for MSG however the recommended dose is 60 mg/kg (Mouritsen, 2019). In European countries, the MSG levels in processed foods should not be above 10 g/kg of substances or drinks (European Parliament and Council Directive, 2018). The intake of MSG beyond 10 g/kg is associated to retinal problems and the damage of neurons which kills the brain cells (Henry, 2022). The harmful effects of high alcohol consumption are connected to several injuries (Chen and Yoon, 2017). It can also lead to diseases such as tuberculosis, heart disease, diabetes, stroke, pneumonia and HIV/AIDS (Rehm et al., 2018). 5.2% of world burden of diseases is associated with alcohol consumption (Gakidou et al., 2021).

Deaths related to alcohol and social costs implications are of great public concerns in all countries (Kamenderi *et al.*, 2020). Intake of alcohol in high concentration is linked to fatal health hazards and untimely deaths. It also inhibits platelet aggregation, lowering of fibrinogen hence interfering with haemostasis (Kiiru, 2017). Majority of the people use alcoholic beverages without knowing that these beverages are made up of food additives since there is very little information on levels of food additives in alcoholic beverages sold in Nairobi. These food additives have negative effect to their well-being if used in amounts beyond acceptable limits (Li *et al.*, 2020). The improper use of food additives is becoming more frequent in Africa (CCAFRICA, 2018), according to Codex Alimentarius expert meeting on food additives in Nairobi. There is need therefore to regularly monitor the amounts of food additives in alcoholic beverages to establish their actual concentrations this ensures safety of this drinks and protect consumers from being exposed to dangerous levels of these food additives. In this study, amounts of MSG and aspartame in selected beers, wines and spirits in four supermarkets in Nairobi were determined. Aspartame (a sweetener) and MSG (a flavor enhancer) were chosen because they are widely used in beverages.

The findings of this study will serve as a bench mark data upon which other public health interventions to reduce food additives particularly MSG and aspartame in alcoholic beverages will be compared. It will also be crucial in future policy formulation by regulatory bodies like KEBS. Similarly, the findings will be vital in development, implementation and monitoring of the adherence level to labeling legislations in regard to food additive content and will be useful to clinical nutritionists and dietitians in recommending alcoholic beverage with reduced aspartame levels to people with the genetic condition phenylketonuria (PKU) and for general nutrition education. The manufactures will also use the finding of this study to assess the stability of monosodium glutamate and aspartame in alcoholic beverages that are in the market which can help them reduce the levels or find safer alternatives.

MATERIAL AND METHODS

Research design

It was experimental. It entailed collection of samples, preparation of the samples and the use of a blank, control experiment, to check the amounts of monosodium glutamate and aspartame in beers, wines and spirits purchased from common supermarkets of Nairobi County

Chemicals, reagents and solvents

During this research, chemicals and reagents of high quality were used. These reagents are: 2,4 –dinitrofluorobenzene, potassium hexacynoferrate, monosodium glutamate, ammonium acetate, Methanol, acetonitrile, hydrochloric acid, diethyl ether, phosphoric acid, aspartame, zinc sulphate, acetic acid, potassium dihydrogen phosphate, sodium bicarbonate, double distilled and deionized water. The apparatus that were used during the study included: filter paper and a filter funnel, 100 mL volumetric flask, 10 mL measuring cylinder, droppers, beakers, heaters and conical flasks.

Instrumentation

The pH meter was used for measuring pH value. All the analysis was performed by the HPLC fused with UV-visible detector, reverse phase column, oven and an auto sampler. All masses were measured by analytical balance. Water bath and a vortex mixer were also used.

Sampling and sample pre-treatment

Beers, wines and spirits were bought from four main supermarkets K, L, M and N in Nairobi city center, CBD. The brands found in most of the four supermarkets were bought and confirmed that they had not expired by looking at their expiry date. Only brands with KEBS marks were bought. Purposive, random and cluster methods of sampling was undertaken (UNODC, 2017). Identification of samples was done for a period of three weeks. 16 brands of wines, 18 brands of beers and 13 brands of spirits were considered. A total of 21 samples of wines, 30 samples beers and 15 samples spirits were purchased. The samples comprised of 5 brands of spirits, 9 brands of wines and 8 brands of beers. Every brand was identified thrice or four times. In awaiting preparation and analysis, samples were taken to the laboratory where they were labeled to avoid confusion.

Sample and standard preparation for aspartame analysis

The sample was homogenized by shaking then weighed. A 20.0 g of the homogenized sample was measured and placed in a flask. 60 mL of analytical grade distilled water was added and mixed properly by shaking. For 20 minutes the solution was in a trough full of water at 40 °C. The mixture was cooled then 2 mL of carrez solution1 (made by placing 3.6 g of potassium hexacynoferrate in a beaker containing 200 mL of analytical grade water) added. The product was shaken for it to mix properly then 2 mL of carrez solution 11 (made by placing 7.2 g of zinc sulphate in a beaker containing 200 mL of analytical grade water) added. The product was left to settle for 10 minutes after shaking it properly. Then the analytical grade distilled water was added up to the 100 mL level before using a filter paper to filter it. For it to be injected into HPLC machine, the solution obtained was filtered again this time by an analytical grade filter paper. 0.1 g of aspartame was placed into 100 mL analytical grade distilled water to make a 1 mg/mL aspartame stock standard solution. The aspartame stock standard solution was diluted using analytical grade distilled water to form diluents.

Standards and sample preparation of monosodium glutamate

The sample was thoroughly mixed by shaking. 0.5 g of the homogenized sample was placed into 100 mL of analytical grade distilled water. 5 % w/v sodium bicarbonate was added to change the pH of the solution to 7.8. The solution was then filtered. A 0.5 mL of filtered sample solution was placed in Eppendorf tube and dinitrofluorobenzene (DNFB) used for pre-column derivatization. 0.6 g of MSG was placed in 100 mL of analytical grade water to prepare 5 mg/mL of standard monosodium glutamate. 5% w/v sodium bicarbonate was added to change the pH value of the solution to 7.8. The standard solution of volume 0.5 mL was then placed into Eppendorf tube and pre column 22.

Sample analysis

Analysis of aspartame

20 µL of stock aspartame was introduced into HPLC in order to get a standard calibration curve of aspartame. The solvent was a phosphate buffer and acetonitrile in a ratio of 80: 20 v/v. A 1.8 g of potassium dihydrogen phosphate was placed into 800 mL of distilled water to make the phosphate buffer. 5 % w/w phosphoric acid was then added to the buffer to change the pH value to 3.5. Helium gas was used for degassing.

Conditions for working of the HPLC machine; Temperature at 25 °C, reverse phase C18 column ODS 10 µm, low pressure gradient and UV- Visible detector at 217 nm. 20 µL of every sample solution made was analysed by injecting it into the HPLC machine.

Analysis of monosodium glutamate

To obtain calibration curve of MSG, 20 µL MSG standard concentrations was injected into the HPLC machine. The solvent was a mixture of methanol and water. Helium gas was used for degassing. Conditions for working of the HPLC machine: Low pressure gradient, detector will be UV- Visible operating at 254 nm, reverse phase and flow rate of 1.2 mL/min at 25 °C. 20 µL of every derivatized sample solution made was analysed by injecting it into the HPLC machine.

Method validation

Linearity

Quantitative analyses were performed using external calibration method. Calibration curve was obtained with standard solutions with five levels of concentration, with three injections per each level. The regression equation for monosodium glutamate was y=40656x +397784 while that of aspartame was y = 969.18x. The peak area is represented by y while x represents amount of the standard in the sample. The correlation coefficient was higher than 0.99 ($r^2 \geq 0.99$) for both MSG and aspartame. The obtained values of r^2 were 0.9934 for aspartame and 0.9927 for MSG which are within the allowed value of $r^2 \geq 0.99$ (WHO, 2021) therefore the finding herein are accurate and reliable. Aspartame calibration curve and MSG calibration curve presented in Figure 1 and 2 respectively.

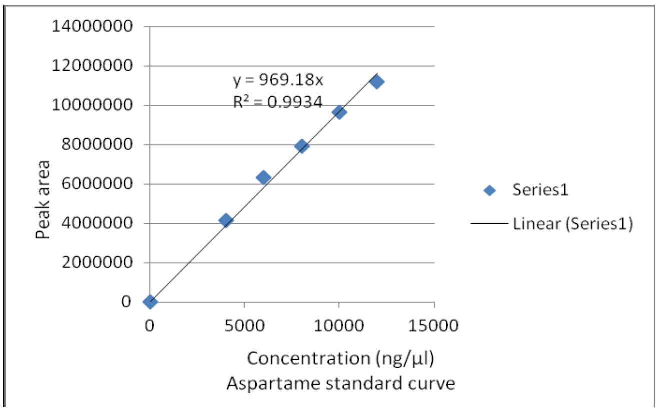


Figure 1: Calibration curve of aspartame

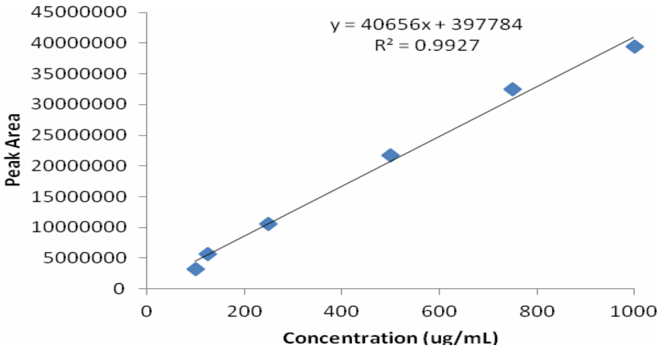


Figure 2: Calibration curve of monosodium glutamate

Accuracy and precision

Different concentrations of standard aspartame and MSG were analysed in triplicates for each concentration. The following concentrations were used to test for both precision and accuracy; 50 µg/mL, 100 µg/mL and 150 µg/mL for aspartame and concentrations of 20 µg/mL, 40 µg/mL, 60 µg/mL of MSG. The findings are presented in Table 1.

Table 1: Accuracy data for Aspartame and Monosodium glutamate

Concentration(µg/mL) of Aspartame standard	**Mean Amount recovered (µg) (n = 3)**	**Recovery ± RSD %**
50	50.23	100.46 ± 0.92
100	98.81	98.81 ± 1.19
150	149.32	99.55 ± 0.45
Concentration (µg/mL) of Monosodium Glutamate.	**Mean Amount recovered (µg) (n = 3)**	**Recovery ± RSD %**
20	20.01	100.50 ± 0.05
40	39.92	99.8 ± 0.2
60	60.34	100.57 ± 0.56

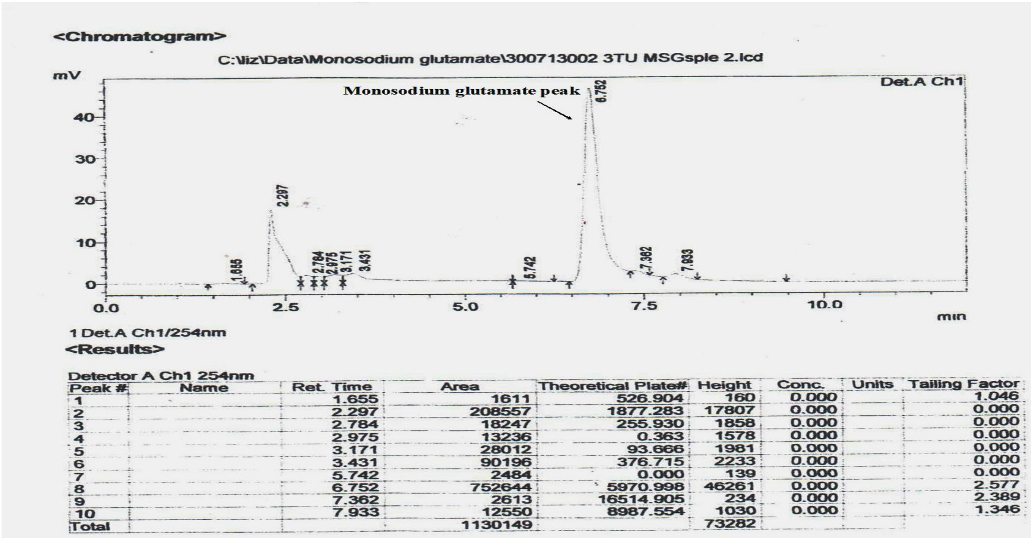
Repeatability

One concentration of aspartame and MSG within the linearity was used to confirm the repeatability. This concentration was injected into the column four times. Findings are shown in Table 2.

Table 2 Repeatability data for aspartame and monosodium glutamate

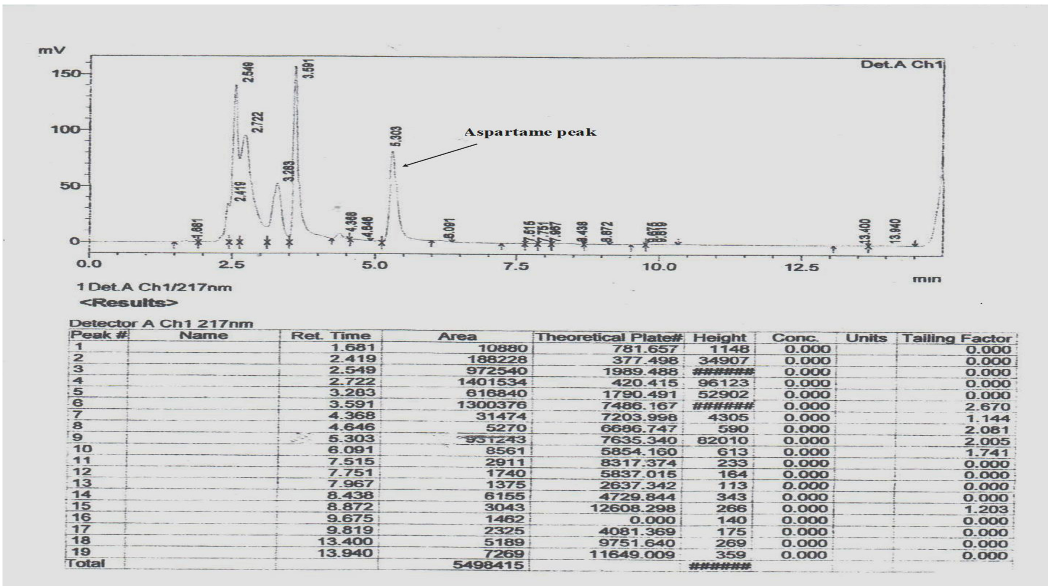
Number of injection times. Aspartame of concentration 125 µg/mL	Peak area
1	121008
2	120967
3	121238
4	12122
Number of injection times. Monosodium glutamate of 80 µg/Ml	**Peak area**
1	3650481
2	3651654
3	3649243
4	3651848

The relative standard deviation (RSD) for all the standards ranged between 0.0 - 5.2 %. This is within the allowed value of RSD ≤ 10 % and recoveries between 90.0 - 110.0 %. Therefore, the machine is accurate, reproducible, precise and repeatable. Chromatogram of standard monosodium glutamate (figure 3) and chromatogram of standard aspartame (figure 4)



Peak #	Name	Ret. Time	Area	Theoretical Plate#	Height	Conc.	Units	Tailing Factor
1		1.655	1611	526.904	160	0.000		1.046
2		2.297	208557	1877.283	17807	0.000		0.000
3		2.784	18247	255.930	1858	0.000		0.000
4		2.975	13236	0.363	1578	0.000		0.000
5		3.171	28012	93.666	1981	0.000		0.000
6		3.431	90196	376.715	2233	0.000		0.000
7		5.742	2484	0.000	139	0.000		0.000
8		6.752	752644	5970.998	46261	0.000		2.577
9		7.362	2613	16514.905	234	0.000		2.389
10		7.933	12550	8987.554	1030	0.000		1.346
Total			1130149		73282			

Figure 3: Chromatogram of standard monosodium glutamate



Peak #	Name	Ret. Time	Area	Theoretical Plate#	Height	Conc.	Units	Tailing Factor
1		1.681	10880	781.657	1148	0.000		0.000
2		2.419	188228	377.498	34907	0.000		0.000
3		2.549	972540	1989.488	######	0.000		0.000
4		2.722	1401534	420.415	96123	0.000		0.000
5		3.283	616840	1790.491	52902	0.000		0.000
6		3.591	1300376	7486.167	######	0.000		2.670
7		4.368	31474	7203.998	4305	0.000		1.144
8		4.646	5270	6686.747	590	0.000		2.081
9		5.303	931243	7635.340	82010	0.000		2.005
10		6.091	8561	5854.160	613	0.000		1.741
11		7.515	2911	8317.374	233	0.000		0.000
12		7.751	1740	5837.015	164	0.000		0.000
13		7.967	1375	2637.342	113	0.000		0.000
14		8.438	6155	4729.844	343	0.000		0.000
15		8.872	3043	12608.298	266	0.000		1.203
16		9.675	1462	0.000	140	0.000		0.000
17		9.819	2325	4081.369	175	0.000		0.000
18		13.400	5189	9751.640	269	0.000		0.000
19		13.940	7269	11649.009	359	0.000		0.000
Total			5498415		######			

Figure 4: Chromatogram of standard aspartame

Limits of detection

The limits of detection for monosodium glutamate and aspartame are as shown in Table 4.

Table 3: Data for LOD of aspartame and monosodium glutamate

Injected standard	LOD ± SE (mg/L) n = 3	S/N
1 µL of 200 mg/L MSG	0.3 ± 0.1	3:1
6 µL of 5 mg/L aspartame	0.004 ± 0.1	6:1

SE stands for standard error, LOD for limit of detection and S/N for signal to noise ratio

The obtained values of LOD ranged from 0.004 mg/L to 0.3 mg/L. The allowed detection of trace amounts of MSG and aspartame was within the lowest amount (Li *et al.*, 2020).

Quantification of the food additives

Comparing the retention time of the food additives and standards, peaks of the additive in the sample were identified. The amount of the food additives was checked on the calibration curves followed by use of the equation 1;

$$A_s = \frac{X\,Vo}{Vi\,Ms} \text{.................. Equation 1}$$

Where;
Vo represents volume of the sample in microliters.
Vi represents volume put in HPLC in microliters.
X represents the additive in milligrams that matches to Vi read on the curve.
Ms represents initial mass in grams.
As represents amount of the additive in drinks in mg/g of sample.

Data analysis

Data collected in the experiment was analyzed by analysis of variance (ANOVA) and the SPSS software (Levesque, 2017). Standard deviations and Mean comparisons were performed by the DMRT at 5 % probability. The outcomes of the analysis were illustrated in tables and line graphs.

RESULTS AND DISCUSSION

Amount of MSG and aspartame in beers, wines and spirits were analyzed in triplicates in the 21 samples of wines, 30 samples of beers and 15 samples of spirits from supermarkets K, L, M and N in Nairobi County, CBD. The brands from each supermarket were analyzed separately using HPLC system.

Level of Aspartame in beers, wines and spirits

Aspartame levels (mg/L) in various brands of beer

The levels of Aspartame in various brands of beer investigated in this study are presented in Table 4.

Table 4: The aspartame levels (mg/L) in various brands of beer from the four supermarkets

Beer brand	Supermarket K (mg/L)	Supermarket L (mg/L)	Supermarket M (mg/L)	Supermarket N (mg/L)	Overall Aspartame mean (mg/L)
B2	ND	7.58	0.24	4.20	4.006[a] n=12
B3	0.34	4.67	N/A	ND	2.505[a] n=9
B5	24.89	16.08	30.75	11.8	20.88 n=12
B7	ND	N/A	2.41	ND	2.41[a] n=9
B8	3.01	ND	8.43	N/A	12.68 n=9

The brands B1, B4 and B6 were not found in atleast three supermarkets therefore their results were not presented. ND is for not detected. N/A is for not available. (α = 0.05, One way ANOVA, SNK-test).

Table 4 shows that the levels of aspartame in beers in each supermarket depended on the brand. In supermarket K, the range of amount was 0.34 - 24.89 mg/L with brand B3 registering the least amount and B5 the highest. In supermarket L, the range of amount was 4.67 – 16.08 mg/L with brand B3 recording the least amount and brand B5 the highest. In supermarket M, the range of amount was 0.24 – 30.75 mg/L with brand B2 showing the least amount and B5 the greatest and in supermarket N, the range of amount was 4.20 - 11.8 mg/L with brand B2 having the least level and brand B5 the highest. The range of overall average amount of aspartame in all the brands was 2.41 – 20.88 mg/L with brand B7 having the least amount and B5 the highest. There was no significant difference in amount of aspartame amongst the means of the five brands except in brand B5 in supermarket M. The difference in this brand is a result of manufacturer adding higher amount of aspartame to this brand than others or this brand could be a substandard beer. This finding agreed with the work of Van Vliet *et al.* which recorded analysed amounts of aspartame of seven soft drinks from markets in Germany. Aspartame was found in five samples with a mean of 119 mg/L (range 53–330 mg/L) (Van Vliet *et al.*, 2020) and the research of Maes *et al.* which registered aspartame in only two brands of diet coke at 138 mg/L and 149 mg/L (Maes *et al.*, 2012). The mean amounts detected of aspartame in beers were all within the allowed amounts.

Aspartame levels (mg/L) in various brands of wine

The levels of aspartame in various brands of wine investigated in this study are presented in Table 5.

Table 5: Aspartame levels (mg/L) in various brands of wine from the four supermarkets

Wine brand	Supermarket K (mg/L)	Supermarket L (mg/L)	Supermarket M (mg/L)	Supermarket N (mg/L)	Overall Aspartame mean (mg/L)
W1	N/A	24.84	18.76	12.63	18.74 [a] n=9
W2	8.38	15.03	11.38	6.32	10.28 [b] n= 12
W3	19.8	N/A	21.30	17.87	19.66 [a] n=9
W4	5.08	10.23	14.28	3.2	8.20 [b] n=12
W5	14.4	9.6	N/A	6.7	10.23 [b] n=9
W7	36.3	26.4	21.5	13.2	24.32 n=12
W9	3.9	ND	7.10	10.6	7.20 [b] n=12

The brands W6 and W8 were not found in atleast three supermarkets therefore their results were not presented. ND is for not detected. N/A is for not available. ($\alpha = 0.05$, One way ANOVA, SNK-test).

Table 5 shows that the levels of aspartame in wines from each supermarket depended on the brand. From supermarket K, the range of the amount was 3.9 – 36.3 mg/L with brand W9 registering the least level and W7 the highest. In supermarket L, the range of amount was 9.6 – 26.4 mg/L with brand W5 registering the least amount and brand W7 the highest. In supermarket M, the range of amount was 7.10 – 21.5 mg/L with brand W9 recording the least amount and W7 the highest and in supermarket N, the range of amount was 6.32 - 17.87 mg/L with brand W5 having the least amount and brand W3 the highest. The overall range of average amount of aspartame detected in all the brands was 7.20 – 24.32 mg/L with brand W9 recording the least amount and W7 the highest. There was no significant difference in amount of aspartame amongst the means of the seven brands except in brand W7 in supermarket K. The difference in this brand is a result of manufacturer adding higher amount of Aspartame to this brand than others or due to poor storage. The results obtained agreed with the study of Georgiana *et al.* which recorded analysed amounts of aspartame in wines from Romanian market. Aspartame was registered only in two samples of wines at 4.70 mg/L and 22.858 mg/L (Georgiana *et al.*, 2020). The mean amounts detected of aspartame in wines were all within the allowed amounts.

The Aspartame levels (mg/L) in various brands of spirits

The levels of Aspartame in various brands of spirits investigated in this study are presented in Table 6.

Table 6: The Aspartame levels (mg/L) in various brands of spirit from the four supermarkets

Spirit brand	Supermarket K (mg/L)	Supermarket L (mg/L)	Supermarket M (mg/L)	Supermarket N (mg/L)	Overall Aspartame mean (mg/L)
S1	N/A	-	-	-	- n=9
S2	N/A	-	186.20	193.74	189.97 n=9
S3	-	N/A	-	-	- n=9
S5	-	N/A	213.56	67.23	160.40 n=9

The results of brands S4 were not presented because the brands were not available in at least three supermarkets. - For not detected. N/A is for not available.

From table 6 aspartame was found in brands S2 and S5 from supermarkets M and N only. Supermarket M, the levels of Aspartame ranged from 67.23 to 213.56 mg/L with brand S2 registering the least amount and S5 the highest, in supermarket N the amounts ranged between 67.23 and 193.74 mg/L with brand S5 recording the least amount and brand S2 had maximum amount. This difference in levels of aspartame is due to inconsistence by manufacturers when putting aspartame into the spirits. The amounts were all below the maximum allowed limit of 360 mg/L (Codex Standard, 2014). The finding of this study agreed with analysis performed in Ireland where the amounts varied from 10.0 to 553.0 mg/L (FSAI, 2016) and another analysis in soft drinks where the levels ranged between 78.2 and 339.8 mg/L (Ahmad *et al.*, 2015).

The level of monosodium glutamate in beers, wines and spirits

The levels of Monosodium glutamate (mg/L) in various brands of beer

The levels of monosodium glutamate in various brands of beer investigated in this study are presented in Table 7.

Table 7: The monosodium glutamate levels (mg/L) in various brands of beer from the four supermarkets

Beer brand	Supermarket K (mg/L)	Supermarket L (mg/L)	Supermarket M (mg/L)	Supermarket N (mg/L)	Overall MSG mean (mg/L)
B2	-	14.37	-	6.56	10.47 n=12
B3	12.68	-	N/A	-	-
B5	-	-	2.98	10.29	6.64[a] n=12
B7	4.67	N/A	5.81	8.23	6.23[a] n=9
B8	-	-	-	N/A	-

The brands B1, B4 and B6 were not found in atleast three supermarkets therefore their results were not presented. - is for not detected. N/A is for not available. (α = 0.05, One way ANOVA, SNK-test).

From table 7, the amount of MSG from each supermarket depended on the brand. In supermarket K, the range of amount was 4.67 – 12.68 mg/L with brand B3 recording the least amount and B7 the maximum. In supermarket L only brand B2 registered MSG detectable amount of 14.37mg/L. In supermarket M, the range of amount was 2.98 – 5.81mg/L with brand B5 recording the least amount and B7 the maximum and in supermarket M the range of amount was 6.56 – 10.29 mg/L with brand B2 having the least amount and brand B5 the highest. The range of overall MSG means of all the brands was 6.23 – 10.47 mg/L with brand B7 recording the lowest level and B2 the highest. MSG was only found in three brands B2, B3 and B7. There was no significant difference in amount of MSG amongst the three brands where MSG was detected. The finding of this study agreed with a research on free and natural glutamate in various foods which ranged from 2.3 to 12.7 mg/L (Henry, 2022) and 1.8 to3.2 g/kg (Loi *et al.*, 2022). The amounts were below the highest acceptable limit of 300 mg/L (Miranda *et al.*, 2021).

The levels of Monosodium glutamate (mg/L) in various brands of wine

The levels of monosodium glutamate in various brands of wines investigated in this study are presented in Table 8.

Table 8: The monosodium glutamate levels (mg/L) in various brands of wine from the four supermarkets

Wine brand	Supermarket K (mg/L)	Supermarket L (mg/L)	Supermarket M (mg/L)	Supermarket N (mg/L)	Overall MSG mean (mg/L)
WI	N/A	28.63	33.52	-	31.08 n=9
W2	18.7	-	-	N/A	-
W3	41.85	N/A	-	62.55	52.2 n=9
W4	87.64	45.24	13.67	5.6	38.04 n=12
W5	-	7.81	N/A	18.41	13.11[a] n=9
W7	121.78	78.21	58.78	21.31	70.02 n=12
W9	-	-	19.23	18.78	19.01[a] n=12

The results of brands W6 and W8 were not presented because the brands were not available in at least three supermarkets. SD is for standard deviation. - For not detected. N/A is for not available. (α = 0.05, One way ANOVA, SNK-test).

From table 8, the MSG levels from each supermarket depended on brand. From supermarket K the range of amount was 18.7 – 121.78 mg/L with brand W2 recording the lowest amount and W7 the maximum. In supermarket L, the range of amount was 7.81 – 78.21 mg/L with brand W5 having the least amount and W7 the highest. In supermarket M, the range of amount was 13.67 – 58.78 mg/L with brand W4 recording the lowest level and W7 the highest and in supermarket N, the range of amount was 5.6 – 62.55 mg/L with brand W4 having the least level and brand W3 the highest. The range of overall MSG means of all the brands was 13.11 – 70.02 mg/L with brand W5 recording the least amount and W7 the highest. There was no significant difference in amount of MSG amongst the six brands except in brand W7 in supermarket K. This difference could be due to poor packing, storage and handling of the drinks by the supermarket. The finding of this study agreed with a study of free and natural glutamate levels in variety of Greek wine which ranged between 36.3 and 265mg/L (Soufleros *et al.*, 2023). The amounts were below the highest acceptable limit of 300 mg/L (Miranda *et al.,* 2021).

The levels of monosodium glutamate (mg/L) in various brands of spirit

The levels of monosodium glutamate in various brands of spirits investigated in this study are presented in Table 9.

Table 9: The monosodium glutamate levels (mg/L) in various brands of spirits from the four supermarkets

Spirit brand	Supermarket K (mg/L)	Supermarket L (mg/L)	Supermarket M (mg/L)	Supermarket N (mg/L)	Overall MSG mean (mg/L)
S1	N/A	-	-	-	-
S2	N/A	25.31	38.04	21.61	28.32
S3	-	N/A	-	-	-
S5	-	N/A	-	-	-

The results of brands S4 were not presented because the brands were not available in at least three supermarkets. - For not detected. N/A is for not available.

From table 9, only one brand, S2, was found to contain MSG from supermarkets L, M and N only. Brand S2 had highest levels in Supermarket M and lowest level in supermarket N. The results obtained agreed with the work of Miranda *et al.* which recorded MSG analyses of wines. MSG was detected with a mean of 58.76 mg/L (Miranda *et al.*, 2021).

CONCLUSION

The research found amounts of monosodium glutamate and aspartame in beers, wines and spirits. The study established that: all the brands of beers, wines and spirits had monosodium glutamate levels within the maximum allowed limit of 300 mg/L. All the brands of beers, wines and spirits had aspartame levels within the highest acceptable limit of 360mg/L. More than a third of the samples (36 %) had huge variations of MSG and Aspartame levels. Therefore, the regulatory bodies should come up with guidelines on specific amounts of MSG and Aspartame that should be added to beers, wines and spirit. An effective monitoring system should be in place to enforce the set guidelines. The public is advised to consume low food additive alternatives.

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