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Research Article

Physicochemical and sensory properties of roasted groundnuts sold in Rivers State University and its environment

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Roasted skinned and unskinned groundnuts, pH, Peroxide value, Free fatty acid, moisture content, sensory properties.

Abstract

This study assessed the physicochemical and sensory properties of roasted skinned and unskinned groundnuts sold in River State University campus and its environment. Samples were obtained from three locations: University's back gate, main gate and shopping complex with sample codes BSG, MSG and SSG respectively, for the skinned samples and BUG, MUG and SUG for the unskinned samples. Standard analytical methods were used for the analysis. The physicochemical properties of the skinned and unskinned samples ranged respectively, from 6.49 - 6.64 and 6.48 – 6.58 for pH; 0.04 – 0.07 and 0.06 – 0. 09 %lactic acid for titratable acidity (TTA); 1.17 – 2.55 and 1.12 – 2.08% for moisture; 0.28 – 0.47 and 0.53 – 0.99% for free fatty acid (FFA) and; 11.90 – 19.50 and 10.20 – 14.00 mEq for peroxide value (PV). The assessors' degree of likeness for the appearance, aroma, taste (sweetness), freshness, crunchiness and overall acceptability of the roasted skinned groundnut samples ranged from 6.20 – 7.10, 5.65 – 6.10, 5.35 – 6.20, 5.45 – 5.70, 5.75 – 6.45 and 6.00 – 6.15 respectively, while the values for the unskinned samples ranged from 5.15 – 5.80, 5.65 – 5.85, 5.65 – 6.10, 4.85 – 5.85, 5.90 – 6.50, and 5.55 – 5.88 respectively, pH, TTA, moisture, FFA and PV of the samples are within satisfactory limits and the third quartile sensory results reveal degree of likeness from like slightly to like very much, implying that the roasted groundnut whether peeled or unpeeled were of good quality for consumption.

1. Introduction

Groundnut (*Arachis hypogaea L.)*, commonly known as peanut, is a tropical legume grown for its edible seeds and consumed in different parts of the world. In West Africa, Nigeria is the largest groundnut producing country accounting for 51% of production in the region. Groundnuts are utilized in various forms. It can be consumed directly after boiling or roasting with or without the shell (epicarp) [1-2], crushed for oil extraction for home and industrial uses, cooking, soap production, and body cream [3], and the cake afterwards consumed as snack. It is also used in production of peanut butter, mixed with other spices for snack foods, used as flour for incorporation into different food formulations etc. [1-2, 4]. Groundnut roasted or boiled with or without the shell and the seed coat skinned or unskinned is sold in public places such as markets, offices, schools, motor parks, restaurants, supermarkets and also hawked along express way in both rural and urban areas especially in southern Nigeria. Nutritionally, roasted groundnut contain high levels of protein (31.45-33.17%) and fat (47.3-49.15%) with low levels of moisture (2.02 -2.17%), ash (4.04 – 4.13%, carbohydrate (6.63-7.87%) and crude fibre (5.47-6.56%) [5]. Low moisture content is desirable in roasted groundnuts. It prevents the formation of secondary, volatile compounds, such as

aldehydes and ketones, which cause groundnut off-flavor while high water content will encourage microbial growth, chemical reactions (oxidation) and sensory changes leading to decline in product quality and acceptability. The off-flavour in roasted groundnut is also attributed to the role of water activity during storage of fresh produce. Groundnut is a good source of lipid (47%) [6] and the lipid content is high in polyunsaturated fatty acids: Oleic acid (C18:1) in the range of 44.78-82.17%, Linoleic acid (C18:2) ranging from 2.85-33.92% with small amount of saturated fatty acid such as Palmitic acid (C16:0) in the range of 5.31-11.49 [7]. Susceptibility of groundnut to oxidation is attributable to the lipid content which can lead to decrease in nutritional and product quality. Hydrolysis of the lipid molecules in groundnut releases the free fatty acids. Free fatty acid is an indication of lipase efficacy that can catalyze oxidative decay of oils by enzymatic and or chemical hydrolysis to form off volatile components [8]. This can cause rancidity and affect the sensory quality of the product in terms of color, texture, and other physiological properties [9]. Peroxide value is another quality index for oil seed like groundnut. Peroxide values express the reactive oxygen content in terms of milliequivalents (meg) of free iodine per kilogramme of fat [10]. They are indicators of the ability to resist lipolytic and oxidative deterioration when stored [6]. Products with low peroxide value (< 10 mEg/kg) are considered fresh and of good quality, while high peroxide value would mean a weak resistance to reactive forms of oxygen and a signal of deterioration [11-12] and between 20-40 mEg/kg rancid, taste becomes noticeable. Lipid oxidation reactions will lead to the formation of aliphatic aldehydes, ketones and alcohols [13]. Aldehydes are key compounds that affect the flavour of roasted groundnuts. The pleasant sensory attributes of roasted groundnuts appreciated by consumers when eaten alone or with other foods are flavour, aroma, colour, appearance, taste, texture in terms of crunchiness. There are some studies on groundnut and groundnut based snacks in different parts of the country: proximate composition of raw and roasted varieties of groundnut [5], mycotoxin and fungi metabolites in groundnut snack foods in Lagos [14], effect of potash on quality of fried groundnut cake called *kulikuli* [15], effect of roasting on the quality of groundnuts [16] and effect of edible coating materials on roasted groundnut [13]. Knowledge of the quality characteristics of roasted skinned and unskinned groundnuts from Rivers State and the university campus is lacking. This study was therefore, aimed at assessing the physicochemical and sensory attributes of roasted skinned and unskinned groundnuts sold in Rivers State University and its environs.

2. Materials and methods

2.1 Materials

Freshly packaged roasted skinned and unskinned groundnut samples were purchased from three locations: Main gate, Back gate and Shopping complex of the Rivers State University, Port Harcourt Rivers State, Nigeria. The chemicals used were of analytical grade from the laboratories of the Department of Food Science and Technology, Rivers State University, Port Harcourt.

2.2. Method

2.2.1. Determination of the physicochemical properties of the roasted peeled and unpeeled groundnut samples.

The physicochemical properties of the samples: Moisture, pH, titratable acidity (TTA), peroxide value (PV) and free fatty acids (FFA) of the roasted peeled and unpeeled groundnuts were determined following the standard method of AOAC [17].

2.2.1.1 Moisture content determination

The moisture content of 5 g of the milled sample was determined gravimetrically after drying to a constant weight in a hot air oven (Gallen Kamp, UK) at 105^{0}C and cooling in a desiccator.

2.2.1.2. pH and total titratable acidity (% Lactic acid)

pH of the samples was determined using a pH meter (TS 625, USA) after calibration using standard buffer of pH 4.0 and 7.0. The milled sample (5 g) was homogenized with 20 ml of distilled water and then filtered into a beaker. The pH meter probe was inserted and the reading taken. Thereafter, 2 drops of phenolphthalein indicator were added and titrated against standard 0.1N sodium hydroxide solution until a pale pink color persisted for about 10-15 seconds for complete neutralization. The titratable acidity was calculated as: %TTA=(Titre X Normality of equivalent acid X 100)/sample weight.

2.2.1.3. Peroxide value determination

To each of the powdered samples (5 g) in a conical flask and a blank, was added 18 ml of chloroform, 12 ml of acetic acid and 0.5 ml of 2% Potassium Iodide solution. The solution was thoroughly mixed and stored in the dark for 30 min. Thereafter, 30 ml of distilled water and 1 ml of starch indicator were added and slowly titrated with 0.01N $Na_2S_2O_3$ until the purple color disappeared. The peroxide value was calculated as:

PV = (Titre X Normality of acid X 100)/Sample weight.

2.2.1.4 Free fatty acid determination

To 5 g of milled sample in a 200 ml conical flask with 2 ml of phenolphthalein indicator was added 25 ml of neutralized warm ethanol and titrated with 1 N NaOH until the solution retained a pinkish colour for at least 30 seconds the endpoint reading was recorded.

The FFA was calculated as:

%FFA = 0.256 x Titre.

2.2.2. Sensory evaluation

Sensory analysis was carried out according to the method described by Obinna-Echem and Torporo, [18]. Roasted skinned and unskinned groundnuts were evaluated for aroma, appearance, taste, crunchiness, rancidity and overall acceptability. Twenty untrained panelists from the University community were used. They were staff and students of the Department of Food Science and Technology, who are consumers of the groundnut type. The assessors evaluated the range of sensory attributes of the samples based on a 9-point Hedonic scale, with the degree of likeness of the product attribute expressed as: 1=Dislike extremely, 2=Dislike very much, 3= Dislike moderately, 4=Dislike slightly, 5=Neither like or dislike, 6 = Like slightly, 7 = Like Moderately, 8 = Like very much and 9 = Like extremely. The panelists were asked to rinse their mouths with water after tasting each groundnut sample.

2.3 Statistical analysis

Data obtained were subjected to statistical analysis using Minitab (Release 18.1) Statistical Software English (Minitab Ltd. Conventry, UK). Statistical differences and relationships among variables were evaluated by analysis of variance under general linear model and Turkey pairwise comparison at 95% confidence level. Differences in the sensory attributes were established using nonparametric Friedman test.

3. Results and discussion

3.1. Physicochemical properties of roasted skinned and unskinned groundnuts from different locations in Rivers State University campus and its environment

3.1.1. Moisture content

The moisture content of the roasted skinned and unskinned groundnuts is shown in Fig 1. Moisture content of the skinned roasted groundnuts ranged from 1.17–2.55% for samples BSG and SSG, respectively, while the roasted unskinned groundnuts moisture content varied from 1.12 – 2.08%. Sample from MUG had significantly ($P<0.05$) the highest moisture content and sample from BUG had the least. The moisture content of any food is an index of its water activity and is used as a measure of the stability and susceptibility to microbial contamination [19]. Moisture content of the skinned and unskinned roasted groundnuts is in agreement with the moisture content groundnut (1.81%) reported by Atasie *et al*., [6] and 2.02 – 2.17 reported by Kamuhu *et al*., [5]. 4 - 6.8%). Moisture content of 9.0% is recommended by the CODEX standard for peanuts [20]. Low moisture content is crucial for safe storage of nuts, this implies that the roasted groundnut samples with low moisture content can be stored for a long period of time and still retain their crunchiness which it is appreciated by consumers. It will also prevent the formation of secondary, volatile compounds, such as aldehydes and ketones, which cause off-flavour in groundnuts.

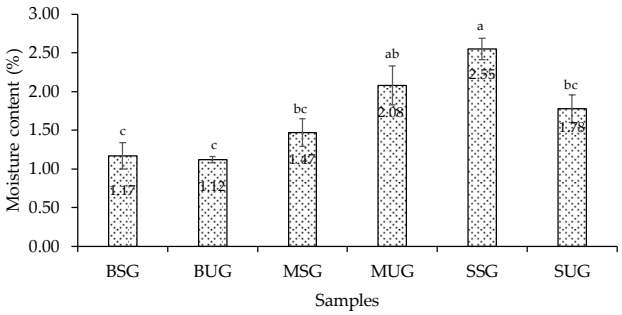

Figure 1. Moisture content of roasted skinned and unskinned groundnut from Rivers State University and its environment.

(Bars and error bars represent mean and standard deviation of duplicate samples. Bar with the same superscript are not significantly different at $p<0.05$. BSG = Back gate skinned roasted groundnut; BUG = Back gate unskinned roasted groundnut; MSG = Main gate skinned roasted groundnut; MUG =Main gate unskinned roasted groundnut; SSG = Shopping complex skinned roasted groundnut; SUG = Shopping complex unskinned roasted groundnut).

3.1.2. pH and Total titratable acidity

Fig. 2, presents the pH and Total titratable acidity (TTA) as % Lactic acid of the groundnut samples. pH of the roasted skinned groundnuts ranged from 6.49-6.64 for samples SSG and BSG, respectively. The pH of the roasted unskinned groundnuts ranged from 6.48–6.58, sample SUG had significantly (P<0.05) least pH and sample MUG had the highest. pH is a measure of the acidity or alkalinity of a solution on a logarithm scale on which 7 is neutral, lower values are more acid and higher values more alkaline [21].

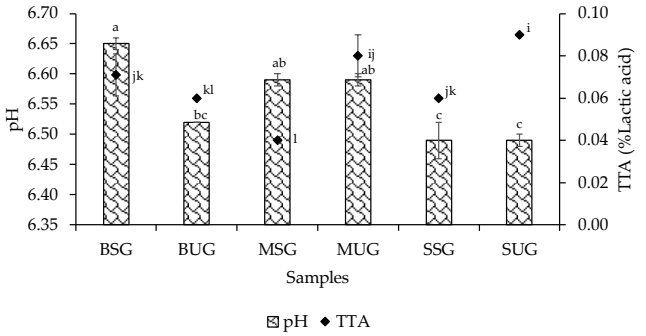

Figure 2. pH and total titratable acidity (% lactic acid) content of roasted skinned and unskinned groundnut from Rivers State University and its environment. (Bars and error bars represent mean and standard deviation of duplicate samples. Bar with the same superscript are not significantly different at p<0.05. BSG = Back gate skinned roasted groundnut; BUG= Back gate unskinned roasted groundnut; MSG = Main gate skinned roasted groundnut; MUG =Main gate unskinned roasted groundnut; SSG=Shopping complex skinned roasted groundnut; SUG=Shopping complex unskinned roasted groundnut).

The pH of the roasted groundnuts was near neutral (6.48- 6.64) and within the range of the standard pH (6–7) for peanuts [22]. TTA of the roasted skinned groundnuts ranged from 0.04–0.07 % lactic acid for samples MSG, SSG and BSG. TTA of the roasted unskinned groundnuts ranged from 0.06 – 0. 09 % lactic acid for sample BUG and SUG respectively. Total titratable acidity is a function of a given base (sodium hydroxide, NaOH) neutralizing an acid(s) (lactic, phosphoric, etc.) in a volume of liquid, thus estimating both free hydrogen ions and hydrogen ions that are bound to weak acids that can react with the strong base and be neutralized [23]. The TTA of the roasted groundnuts is low indicating little or no acid production in the samples which is desirable for an unfermented product. There was no significant (p<0.05) difference in the acidity of the roasted skinned or unskinned groundnut samples. The result was comparable with the values of 0.10-0.14 reported for groundnut milk by Adeiye *et al.,* [24]. pH and TTA impact on flavour. Tartness is attributable to acid pH due to the production of organic acids but TTA is a better prognosticator of acids impact on flavour than pH [24].

3.1.3. Free fatty acid

Free fatty acid (%) of the roasted skinned and unskinned groundnuts is presented in Table 1. The FFA of the roasted skinned groundnuts ranged from 0.28 – 0.47% for samples BSG and MSG, respectively, while that of the roasted unskinned groundnuts ranged from 0.53 – 0.99%. Sample from BUG had significantly (P<0.05) least value while sample from MUG had the highest value. Free fatty acid is an indication of lipase efficacy that can catalyze oxidative decay of oils by enzymatic and or chemical hydrolysis to form off volatile components [8] that can affect the sensory quality of the product. The free fatty acid content of the groundnut samples (0.28-0.99%) are within the acceptable CODEX standard of 1.0% for peanuts [20], implying that there was no hydrolytic retrogression or oxidative rancidity of the samples to levels that would impair the sensory attributes of the roasted groundnut, though the levels in the unpeeled samples were significantly (p<0.05) higher. FFA was employed to verify the quality and edibility of the oils of which groundnut is an excellent oil seed and the result indicated that the roasted groundnuts whether skinned or unskinned for sale were good for consumption.

Table 1. Free fatty acid and Peroxide value of roasted skinned and unskinned groundnuts from in Rivers State University campus and its environment

Sample	Free Fatty Acid (%)	Peroxide Value (mEq O_2/Kg)
BPG	0.28^{d}±0.03	10.20^{d}±0.28
BUG	0.53^{bc}±0.03	15.90^{d}±0.14
MPG	0.47^{c}±0.05	11.90^{cd}±0.14
MUG	0.99^{a}±0.03	15.00^{b}±1.41
SPG	0.39^{cd}±0.01	14.00^{bc}±0.00
SUG	0.67^{b}±0.05	19.50^{a}±0.70

Values are means ± standard deviation of duplicate determinations. Means within a column with different superscripts are significantly different at (p<0.05). (BSG=Back gate skinned roasted groundnut; BUG= Back gate unskinned roasted groundnut; MSG=Main gate skinned roasted groundnut; MUG=Main gate unskinned roasted groundnut; SSG=Shopping complex skinned roasted groundnut; SUG=Shopping complex unskinned roasted groundnut).

3.1.4. Peroxide value

Peroxide values of the roasted skinned and unskinned groundnuts are shown in Table 1. The roasted skinned groundnuts had peroxide values in the range of 10.20–14.00 mEq O_2/Kg, sample SSG had significantly ($P<0.05$) highest peroxide value and sample BSG had the least. Peroxide value of the roasted unskinned groundnuts varied from 11.90 – 19.50 mEq O_2/Kg respectively, for samples MSG and SUG. Fatty acid composition of peanut and peanut products makes them susceptible to rancid and off-flavours through lipid oxidation [26]. The peroxide values of the roasted skinned and unskinned groundnuts samples were within the range of peroxide value of different varieties of peanut crude oil (2.87–15.38 mEq O_2/Kg) [27], except for sample SUG with a peroxide value of 19.50 mEq O_2/Kg which may be due to the high proportion of unsaturated fatty acids (85.76%) in this sample compared to the others. The values are within the Codex Alimentarius acceptable peroxide values of 10–15 mEq O_2/Kg [28], except for sample SUG. At higher peroxide value, the groundnut would have a rancid flavour, due to lipolytic and oxidative reactions [6]. The high peroxide value (19.50 mEq O_2/Kg) of unskinned roasted groundnut from sample SUG could imply an onset of rancidity though the sample at the point of purchase was freshly packaged.

3.2. Sensory properties of roasted peeled and unpeeled groundnuts from different locations in Rivers State University campus and its environment

The mean of the assessors' degrees of likeness of the sensory attributes (appearance, aroma, taste - sweetness, freshness, crunchiness and overall acceptability) of the roasted skinned and unskinned groundnuts are shown in Fig. 3. Other relevant information from the analyzed sensory data such as the first and third quartile, interquartile ranges, mode and frequency of mode are shown in Table 2. Sensory evaluation is a scientific method that evokes, measures, analyzes and interprets responses to products as perceived through the senses of sight, smell, touch, taste, and sound [29]. The skills of the assessors in the interpretation of their perception of the attributes and translating same to the mean degree of likeness scale is very crucial for a reliable result. For the roasted skinned groundnut samples, the degree of likeness of the appearance, aroma, taste, freshness

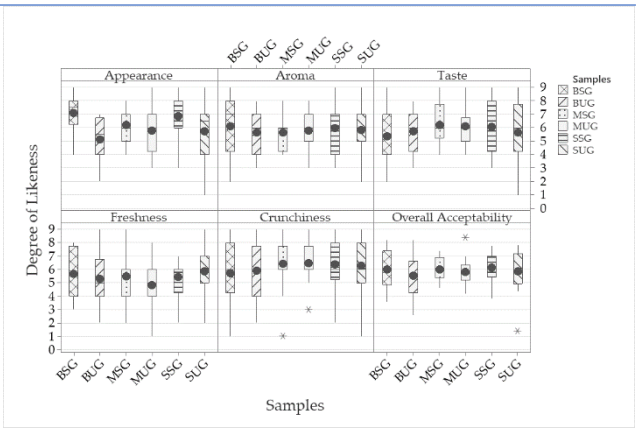

Figure 3. Box plot of Assessors' degrees of likeness of sensory attributes of roasted skinned and unskinned groundnut from Rivers State University and its environment.

Bars and error bars represent mean and standard deviation of duplicate samples. Bar with the same superscript are not significantly different at $p<0.05$. (BSG=Back gate skinned roasted groundnut; BUG = Back gate unskinned roasted groundnut; MSG = Main gate skinned roasted groundnut; MUG=Main gate unskinned roasted groundnut; SSG=Shopping complex skinned roasted groundnut; SUG=Shopping complex unskinned roasted groundnut).

against rancidity, crunchiness and overall acceptability ranged respectively, from 6.20–7.10, 5.65–6.10, 5.35–6.20, 5.45–5.70, 5.75–6.45 and 6.00–6.15, which is within the scale of neither like nor dislike to like moderately. The third quartile values for the appearance, aroma, taste (sweetness), freshness, crunchiness and overall acceptability as shown in Table 2 were respectively in the range of 7.00–8.00, 6.00–8.00, 7.00–8.00, 6.00-7.75, 7.75–8.00 and 6.90–7.40. It showed that 75% of the assessors' degree of likeness for the attributes was that of like moderately to like very much. For the roasted unskinned groundnut samples, the degree of likeness of the appearance, aroma, taste (sweetness), freshness, crunchiness and overall acceptability ranged respectively, from 5.15–5.80, 5.65–5.85, 5.65–6.10, 4.85–5.85, 5.90–6.50 and 5.55–5.88. These mean values are in the scale of neither like nor dislike. The third quartile values were 6.75–7.00, 7.00, 6.75–7.75, 6.00–6.75, 7.75–8.00 and 6.35– 7.20 respectively, for the appearance, aroma, taste (sweetness), freshness, crunchiness and overall acceptability. It showed that 75% of the assessors' degree of likeness for the attributes was that of like slightly to like moderately. The result revealed that the assessors' degree of likeness for the unskinned roasted groundnuts was significantly ($p<0.05$) lower than those of the skinned roasted groundnuts.

Table 2. Relevant analyzed sensory data of roasted skinned and unskinned groundnuts from the Rivers State University campus and its environment

Attributes	Samples	Mean	StDev	Minimum	Q1	Median	Q3	Maximum	Mode	N for Mode
Appearance	BPG	7.10	1.45	4	6.25	7.5	8	9	8	8
	BUG	5.15	1.57	2	4	5.5	6.75	7	4, 6, 7	5
	MPG	6.20	1.15	4	5	6	7	8	6	6
	MUG	5.80	1.54	3	4.25	6	7	9	6, 7	5
	SPG	6.85	1.27	3	6	7	8	9	7	7
	SUG	5.75	2.07	1	4	6.5	7	9	7	7
	Friedman Test Pvalue: Not Adjusted for ties =0.002; Adjusted for ties = 0.001									
Aroma	BPG	6.10	1.97	2	4.25	7	8	9	7, 8	5
	BUG	5.65	1.60	3	4	6	7	8	4	6
	MPG	5.65	1.27	4	4.25	6	6	8	6	8
	MUG	5.80	1.47	3	5	6	7	8	6	6
	SPG	6.00	1.81	3	4	6.5	7	9	7	6
	SUG	5.85	1.98	2	5	6	7	9	5	5
	Friedman Test Pvalue: Not Adjusted for ties =0.881; Adjusted for ties = 0.858									
Taste	BPG	5.35	2.32	2	4	5.5	7	9	4	5
	BUG	5.75	1.71	3	4.25	6	7	8	7	6
	MPG	6.2	1.58	4	5.25	6	7.75	9	6	9
	MUG	6.1	1.29	4	5	6	6.75	9	6	8
	SPG	6.05	1.82	3	4.25	6	8	9	6, 8	5
	SUG	5.65	2.39	1	4.25	6	7.75	9	6	8
	Friedman Test Pvalue: Not Adjusted for ties =0.918; Adjusted for ties = 0.907									
Freshness	BPG	5.70	1.66	3	4	5.5	7.75	8	4, 8	5
	BUG	5.30	1.69	2	4	5	6.75	9	5	5
	MPG	5.50	1.79	2	4	5.5	6	9	4, 6	6
	MUG	4.85	1.73	1	4	5	6	8	5	8
	SPG	5.45	1.4	2	4.25	6	6	7	6	9
	SUG	5.85	1.63	2	5	6	7	9	7	6
	Friedman Test Pvalue: Not Adjusted for ties =0.523; Adjusted for ties = 0.451									
Crunchiness	BPG	5.75	2.2	1	4.25	6	8	9	8	5
	BUG	5.90	2.27	2	4	6	7.75	9	6	6
	MPG	6.45	1.79	1	6	6.5	7.75	9	6	7
	MUG	6.50	1.47	3	6	6	7.75	9	6	7
	SPG	6.40	1.96	2	5.25	6	8	9	6	6
	SUG	6.30	1.98	1	5	6	8	9	6, 8	5
	Friedman Test Pvalue: Not Adjusted for ties =0.748; Adjusted for ties = 0.705									
Overall Acceptability	BPG	6.00	1.53	3.6	4.85	6	7.4	8.2	5	3
	BUG	5.55	1.46	2.6	4.25	5.7	6.6	8.2	6.6	3
	MPG	6.00	0.86	4.6	5.4	6	6.9	7.4	5.4, 7	3
	MUG	5.81	1.00	4.2	5.2	5.7	6.35	8.4	4.6, 5.2, 5.4, 5.6	2
	SPG	6.15	1.11	3.8	5.45	6.1	7	7.8	5.6	3
	SUG	5.88	1.54	1.4	4.95	5.7	7.2	7.8	5.6, 7.8	3
	Friedman Test Pvalue: Not Adjusted for ties =0.784; Adjusted for ties = 0.779									

This could be due to the already exposed appearance of the skinned ones against the unskinned and the unskinned ones required the assessors' efforts in skinning before assessment and consumption. The degree of likeness of the freshness of the samples confirms the physicochemical result that the samples had not gone rancid.

4. Conclusions

The pH of the samples is near neutral with low TTA which showed that there was no biochemical reaction for the production of organic acids in the sample. Moisture, FFA and PV of the roasted skinned and unskinned groundnut samples were within the CODEX standard for peanuts. The assessors' degree

of likeness for the sensory attributes: appearance, aroma, taste (sweetness), freshness, crunchiness and overall acceptability of the roasted skinned groundnut samples was within the scale of neither like nor dislike to like moderately (5.35 - 7.10) for the skinned samples and dislike slightly to like slightly (4.85 - 6.50) for the unskinned samples. The third quartile sensory results revealed that the degree of likeness by 75% of the assessors was that of like moderately to like very much. This implies that the roasted groundnut samples whether skinned or unskinned were of good quality and liked to varying degrees by the consumers. It will be important to ascertain the microbiological quality of the ready to eat roasted groundnuts as microbiologically unsafe foods may look, smell and taste good.

Authors' contributions

The concept of the paper, initial write up, data analysis, literature search and final write-up and supervision, P.C.O.E.; Sample collection and laboratory analysis, G.U.T.

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Availability of data and materials

All data will be made available on request according to the journal policy.

Conflicts of interest

Authors have declared that no competing interests exist.

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