



Physico-chemical Properties and Sensory Attributes of Butter Produced from Peanut, Crayfish and Ginger

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Abstract: Butters were produced from blends of peanut (100%), peanut and crayfish (80:20), peanut and ginger (90:10) and peanut, crayfish and ginger (70:20:10). The 100% peanut butter served as the control. The effects of the substitution on the proximate composition, amino acid profile and mineral content of the butter were investigated. Results showed that the proximate parameters increased insignificantly ($p > 0.05$) with addition of ginger, but crude protein and carbohydrate increased significantly ($p < 0.05$) with addition of crayfish. When incorporated with 10% ginger and 20% crayfish, there was significant increase ($p < 0.05$) in crude protein, crude fat and carbohydrate. The essential and non-essential amino acids contained in the butter decreased significantly ($p < 0.05$) upon incorporation of ginger but increased significantly ($p < 0.05$) when crayfish was incorporated. Sensory attributes such as aroma and appearance increased significantly ($p < 0.05$). Conclusively addition of crayfish into the butter significantly improved its nutrient composition while ginger enhanced sensory attributes of the butter.

Keywords: Butter, Crayfish, Ginger, Peanut, Physico-chemical

1. Introduction

Groundnut or peanut (*Arachis hypogea*) is a plant which belongs to the family of plants called Fabaceae [16]. Botanically, groundnut is a legume although it is widely identified as a nut and has similar nutrient profile with tree nuts [21]. This annual plant is generally distributed in the tropical, sub-tropical and warm temperate areas and represents the second most important legume in the world based on total production after soybean [32]. Peanuts make an important contribution to the diet in many countries. Peanut seeds are a good source of protein, lipid and fatty acids for human nutrition [21]. Peanut-containing foods have high consumer acceptance because of their unique roasted peanut flavour. Peanuts are continually applied for the preparation of new and improved food products. A large proportion of peanut production in the world is destined to domestic foods such as peanut butter, snack products, confections and roasted peanut products. Peanut constitutes a major annual oilseed crop and a good source of protein

containing high lysine content which makes it a good complement for cereal. The proximate composition of mature groundnut seeds in per 100 g edible portion is reported to be; moisture (6.5 g), protein (25.8 g), lipids (49.2 g), carbohydrate (16.1 g), dietary fibre (8.5 g), calcium (92 mg), magnesium (168 mg), phosphorus (376 mg) and iron (4.6 mg) [32]. However, peanut contains some anti-nutritional factors such as phytic acid, condensed tannins, trypsin and amylase inhibitor, that may limit its usage and nutritional value.

Peanuts and its derivatives are often classified as street food which satisfies essential need of the urban population by being affordable and available. Peanut seeds are eaten raw, boiled or roasted, made into butter or paste and are used for thickening soups [14]. Peanut butter is made by grinding dry roasted groundnuts into a paste [26]. Peanuts are also used as major ingredients in the formulation of weaning food with other cereals such as sorghum, corn, and millets because of their high protein and omega 6 fatty acid contents [25]. In Nigeria, the use of marketed peanut butter in the confection of sauce is very popular among the urban population [10].

Although, the primary purpose of spices is to impart flavor and piquancy to food, the medicinal, antimicrobial and antioxidant properties of spices are also exploited. Ginger (*Zingiber officinale*) is a perennial herb, with rhizome rich in the secondary metabolites such as phenolic compounds (gingerol, paradol and shogaol), volatile compounds (zingiberene and bisabolene) and monoterpenoids (curcumene and citral) [7]. Previous studies have demonstrated that plant extracts and isolated compounds from *Z. officinale* possess strong antioxidant, antibacterial, antifungal, anticancer and anti-inflammatory effects [23]. Crayfish are small fresh water crustaceans that can be found in many parts of the world. These distinctive invertebrates are rich protein sources and serve as good protein supplements in our diets [19]. They are proximately composed of 13.86% ash, 58.14% protein, 1.28% crude fibre, 89.92% dry matter and 2.87% gross energy [4]. This study is therefore set to investigate the effects of ginger and crayfish addition on the physico-chemical quality and sensory attributes of peanut butter.

2. Materials and Methods

2.1. Source of Raw Materials

Peanut, ginger, crayfish, salt and spices (calabash nutmeg) were purchased from Modern market, Makurdi – Benue State. All chemicals and reagents used were of analytical grade and purchased from credible scientific chemical suppliers.

2.2. Sample Preparation

The peanut seed (Red Boro specie), ginger and crayfish were subjected to pre-treatment and blended as shown in Table 1.

2.2.1. Preparation of Roasted Peanut Seed

Peanut seed was subjected to pre-treatment, the seeds were cleaned and sorted for bad seeds, after which it was roasted at 116 degrees for 20 minutes, another cleaning and selection was done to remove the skin.

2.2.2. Preparation of Ginger Powder

Ginger roots were collected, cleaned, sorted and sliced to 2cm and dried in the oven at 60 degrees after which it was milled and sieved using 0.6mm sieve to get the ginger powder.

2.2.3. Preparation of Crayfish Powder

Crayfish was collected and it was winnowed and preheated in the oven for few seconds, milled and sieved using 0.6mm sieve to get the crayfish powder.

2.3. Formulation for Butter Preparation

The roasted peanut seed was milled with the ginger and crayfish powder in the ratios shown in Table 1 for homogenization using attrition mill, it was allowed to cool and packed in hermetically sealed containers.

Table 1. Blend Formulation.

Sample	A	B	C	D
Peanut	100	90	80	70
Ginger	-	10	-	10
Crayfish	-	-	20	20

2.4. Proximate Analysis of Peanut Butter

Proximate analysis for each peanut butter product was by [8] Official methods. The percentage of moisture, crude protein, fat, ash and carbohydrate were estimated as follows;

2.4.1. Moisture Content

Two grams of each sample were weighed in duplicate into Petri dishes of known weights and covered immediately. The dishes were transferred into an electric oven (model: TT-9053, Techmel & Techmel USA) at 103±2°C for 3-5 hours. The samples were removed at regular intervals from the oven and placed in a desiccator to cool for 15 mins prior to weighing. Samples drying and weighing were repeated until constant weights were recorded. The loss in weight from the original weight was reported as the moisture content.

2.4.2. Crude Protein

Essentially, 0.2 gram of each sample was weighed, wrapped in whatman filter paper (No. 1) and placed in a Kjeldahl digestion flask. 10ml of concentrated H₂SO₄ and 0.5g of catalysts mixture (Na₂SO₄ + CaSO₄ + SeO, 10:5:1 w/w) were added to the materials in the flask. Four pieces of anti-bumping granules were added and the mixture digested by heating on a Kjeldahl digesting apparatus for 3 hours until the liquid turned light green. The digested sample was cooled and diluted with distilled water to 100ml in a standard volumetric flask. Aliquots (10ml of the diluted solution) and 10ml 45% NaOH solution were placed into Markhama distillation apparatus and distilled into 10ml of 2% boric acid containing 4 drops of bromo cresol green/methyl red indicator until about 70ml of distillate were collected. The distillate was titrated with standardized 0.01M HCl to grey coloured end point. The percentage nitrogen was then calculated.

2.4.3. Crude Fat

The Soxhlet Solvent extraction method was employed. Essentially, 2g of each sample was weighed into the extraction thimble. The thimble was then plugged with cotton wool and placed in the Soxhlet apparatus fitted with a flat bottom flask which was filled to about three quarter of its volume with petroleum ether of boiling point of 45°C. The extraction was carried out for a period of 4 – 8 hours. The petroleum ether was removed by evaporation on a water bath while the extractives in the flask were dried in electric oven at 800°C for 30mins followed by cooling and weighing.

2.4.4. Crude Fibre

The fibre contents were determined from 2g portion of each product. In this method, oils and other non-polar substances in each sample were exhaustively extracted with petroleum ether (b.p. 45°C). The residues were digested in

1litre flask with 200ml concentrated sulphuric acid and filtered through the California Buchner system. The insoluble matter was washed with boiling water until it was free from the acid. The residue was then washed back into the flask with 200ml of 0.3N NaOH followed by boiling for 30mins. The flasks were allowed to stand for 1min after which the content was filtered immediately through a filtering cloth. The insoluble material was then transferred into 100ml beaker using boiling water and was washed with 1% HCl and again with boiling water to free it from acid. The insoluble material was then finally washed with diethyl ether. The resulting material was transferred to a dish (previously ignited, cooled and weighed) and dried at 100°C for 2 hours followed by cooling in a desiccator and weighed. The dried, cooled and weighed residue was then transferred in muffle furnace and incinerated at 600°C for 4 hours followed by weighing. The percentage crude fibre content was calculated.

2.4.5. Ash Content

The ash content of each sample was determined by the [8] official method. A silica dish was heated to 600°C, cooled in desiccators and weighed. Then 5g of the sample was weighed into the silica dish and transferred to the furnace. The temperature of the furnace was allowed to reach 525°C before placing the dish in it. The temperature was maintained until whitish grey colour was obtained indicating that all the organic matter content of the sample had been burnt off. Each dish was then removed from the furnace and placed in a desiccator to cool prior to weighing. Ash content was then calculated.

2.4.6. Carbohydrates Determination

Carbohydrate was calculated by difference as reported by [24]

$$\% \text{ carbohydrate} = 100\% - (\% \text{ protein} + \% \text{ ash} + \% \text{ moisture} + \% \text{ fibre} + \% \text{ fat}) \quad (1)$$

2.5. Mineral Analysis

The minerals content of the products were determined by the [8] method using 2g of the oven dried sample of each peanut butter ashed at 600°C in a muffle furnace. The resultant ash was transferred into 250ml glass beaker and 120ml conc. HNO₃ and 10ml H₂O₂ added. The mixture was heated at 90°C for 1 hour, cooled and filtered using glass wool. The filtrate was transferred into a 250ml volumetric flask and made up to the mark with deionised water. After gentle shaking to mix, 2ml were pipetted into 250ml flask and diluted to the mark with deionised water. Stock solution of 1000mg/kg of Mg, Ca, K and Fe were prepared using deionised water. From stock solution working standard solution of 100mg/kg the elements were prepared by dilution with deionised water. Dilution comprising 0.4, 1.0, 1.5 and 2.0 mg/kg of each element were made with deionised water and together with the test sample were analysed using an atomic absorption spectrophotometer. Concentrations of the elements in the test samples were then calculated.

2.6. Amino Acid Profile

The amino acid profile in the sample was determined using methods described by [8]. The peanut butter sample was dried to a constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the technicon sequential multi-sample Amino Acid Analyzer (TSM). The sample was defatted using chloroform/methanol mixture of ratio 2:1. About 4g of sample was put in extraction thimble and extracted for 15 hours in soxhlet extraction apparatus. 200mg of ground sample was weighed, wrapped in whatman filter paper (No. 1) and put in the kjeldhal digestion flask. Concentrated sulphuric acid (10ml) was added. Catalyst mixture (0.5g) containing sodiumsulphate, copper sulphate and selenium oxide in the ratio of 10:5:1 was added into the flask to facilitate digestion. Four pieces of anti-bumping granules were added.

The flask was then put in kjeldhal digestion apparatus for 3 hours until the liquid turn light green. The digested sample was cooled and diluted with distilled water to 100ml in standard volumetric flask. Aliquot (10mls) of the diluted solution with 10ml of 2% boric acid containing 4 drops of bromocresol green/methyl red indicator until about 70ml of distillate was collected. The distillate was then titrated with 0.01 N hydrochloric acid, to grey colour.

2.7. Sensory Attributes of Peanut Butter Incorporated with Crayfish and Ginger

The peanut butter samples were kept in the sensory laboratory for sensory evaluation, A 9-point Hedonic scale (where 1 = dislike extremely, 9 = like extremely) was used to rate the sensory attributes of appearance, taste, aroma, texture and overall acceptability of the Products. Each Panellist was presented with four different samples. A sachet of drinkable water and carrot were also given for mouth rinsing and taste removal respectively in-between evaluation of samples [24].

2.8. Statistical Analysis

Statistical package for social sciences (SPSS) version 16 statistical software package was used for the statistical analysis of all the data. Similarities and differences amongst data were subjected to analysis of variance (ANOVA). Duncan multiple range test (DMRT) was used for mean separation and significance was accepted at 5% probability level.

3. Results and Discussion

3.1. Proximate Composition of Peanut Butter Incorporated with Crayfish and Ginger

The result of the proximate composition of peanut butter incorporated with crayfish and ginger is presented in Table 2. The moisture content of the peanut butter increased insignificantly when ginger (sample B), crayfish (sample C), and a combination of both ginger and crayfish (sample D) were incorporated into the peanut butter. The moisture

content of the 100% peanut butter was $6.23\pm 0.06\%$, this was slightly below the value ($6.27\pm 0.03\%$) reported by [22]. The result showed that, the incorporation of 10% ginger into the peanut butter resulted in marginal increase ($p>0.05$) in moisture content of the butter from $6.23\pm 0.06\%$ to $6.27\pm 0.11\%$. Other authors [22] reported that although ginger is very watery when harvested, it loses a large quantity of water during drying and readily becomes powdered when ground and as such cannot account for increase in the moisture content of a food when it is added to food. The reason for the increase in moisture could be because of the

hygroscopic nature of peanut which makes it pick up moisture readily even at extremely low water activities. The incorporation of 20% crayfish into the peanut butter also increased the moisture content of the peanut butter insignificantly from $6.23\pm 0.06\%$ to $6.31\pm 0.1\%$. In a similar manner, the incorporation of both ginger and crayfish into peanut butter increased the moisture content to an insignificant level as [22] had earlier reported. Their research attributed such insignificant difference in moisture content following the incorporation of ginger and crayfish to the dry nature of the ginger and crayfish.

Table 2. Proximate Composition of Peanut Butter Incorporated with Crayfish and Ginger.

Parameters (%)	Samples				LSD
	A	B	C	D	
Moisture	6.23 ± 0.06^a	6.27 ± 0.11^a	6.30 ± 0.10^a	6.31 ± 0.1^a	0.22
Crude protein	25.50 ± 0.44^a	25.70 ± 0.52^a	31.10 ± 0.61^b	31.98 ± 0.63^b	1.05
Crude fat	42.20 ± 0.10^a	42.53 ± 0.41^a	43.53 ± 0.59^a	43.70 ± 0.40^b	0.80
Crude fibre	2.08 ± 0.11^a	2.10 ± 0.05^a	2.15 ± 0.05^a	2.20 ± 0.10^a	0.15
Ash	2.60 ± 0.13^a	2.70 ± 0.27^a	2.80 ± 0.44^a	2.90 ± 0.36^a	0.60
Carbohydrate	21.39 ± 0.30^a	20.70 ± 0.61^a	14.12 ± 0.07^b	12.87 ± 0.56^c	0.82

Values are means of duplicate determination \pm Standard Deviation

Mean with different superscript row wise are significantly different ($p<0.05$)

Key: A= Control (Peanut) 100% B= 90% Peanut, 10% Ginger, C= 80% Peanut, 20% Crayfish.

D= 70% Peanut, 10% Ginger, 20% Crayfish, LSD= Least Significant Difference

The crude protein content of the butter increased to an insignificant level when 10% ginger was incorporated but the increase became significant when 20% crayfish was incorporated into the butter. In the same manner, incorporation of both ginger and crayfish (sample D) increased the protein content of the butter significantly. The crude protein analysis showed that, peanut butter is a good source of protein. The protein content of 100% peanut butter obtained in this study was $25.50\pm 0.44\%$. This was lower than the value ($27.53\pm 0.06\%$) reported by [2]. The variation in values could be due to variety used and growing conditions. Substituting peanut with 10% ginger did not create a significant difference ($p<0.05$) in the protein content of the peanut butter. This result agrees with the findings of [29] who reported in his work on the nutritional composition of ginger powder that ginger contains a very negligible amount of proteins. Substituting peanut with 20% crayfish however resulted in significant increase ($p<0.05$) in the protein content of the peanut butter as its protein content increased from $25.50\pm 0.44\%$ to $31.10\pm 0.61\%$. Several researchers and scholars like [30] had earlier established that crayfish contains 58.14% protein and is highly nutritious. The incorporation of ginger and crayfish into the peanut butter significantly increased the protein content from $25.50\pm 0.44\%$ to $31.98\pm 0.63\%$. Ginger is low in proteins and crayfish is the only protein contributor to the peanut butter in sample D.

The crude fat content of the peanut butter also recorded an increase that was not significant in sample A, B and C. The increase was however, significant in sample D. Peanut butter had a high crude fat content of $42.20\pm 0.10\%$ which is in conformity with the report of [20] who had reported that peanut butter contained crude fat in the range of 40 – 49%. The incorporation of ginger into the butter (sample B)

slightly increased the crude fat content of the butter from $42.20\pm 0.10\%$ to an insignificant level of $42.53\pm 0.41\%$. This result does not agree with the findings of [29] who undertook the proximate analysis of ginger and came out with a conclusion that ginger had little or no fat content. Substitution of peanut with 20% crayfish also led to insignificant ($p>0.05$) increase in crude fat content, however, the fat content in crayfish substituted butter (43.53%) was slightly higher than the value (42.53%) in ginger substituted butter. Similar report of insignificant increase in the fat content of *ogi* upon the incorporation of crayfish was given by [6]. The incorporation of both ginger and crayfish into the peanut butter increased the crude fat content of the peanut butter to a slightly significant level of $43.70\pm 0.40\%$. This significant increase is as a result of the fat content of crayfish.

The crude fibre and ash content of the peanut butter showed an insignificant increase in all the samples. The crude fibre content of the butter was low ($2.08\pm 0.11\%$). This is due to the low cellulose content of peanuts [2]. The result showed that, the addition of ginger into the peanut butter insignificantly increased its fibre content from $2.08\pm 0.11\%$ to $2.10\pm 0.05\%$. This increase was best explained by [29] when he reported that ginger like other rhizomes had high cellulose and a high crude fibre content of 10.36%. The addition of crayfish to the peanut butter insignificantly increased its crude fibre content from $2.08\pm 0.11\%$ in 100% peanut butter to $2.15\pm 0.05\%$ in 20% crayfish substituted butter. [30] had earlier explained that crayfish has low fibre content when they carried out its proximate analysis. The incorporation of ginger and crayfish into the peanut butter insignificantly ($p<0.05$) increased the crude fibre content of the butter from $2.08\pm 0.11\%$ in 100% peanut butter to $2.20\pm 0.01\%$ in butter substituted with the combination of ginger and crayfish.

However, this increase brought a significant difference between sample B where only ginger was incorporated and sample D where both ginger and crayfish were incorporated. This result shows that, the high cellulose ginger and crayfish was responsible for the increase in the fibre content of the butter.

Peanut butter contained low ash ($2.60 \pm 0.13\%$). This result compares favourably with the report by [20] that most butter is low in ash content. The result also shows the low mineral content of nuts as reported by [21]. The incorporation of ginger into the peanut butter insignificantly ($p < 0.05$) increased its ash content from 2.60 ± 0.13 to $2.70 \pm 0.05\%$. The failure of ginger to significantly increase the ash content of the peanut butter can be attributed to the severe grinding of the dried ginger during processing prior to incorporation into the peanut butter which must have rendered the available minerals prone to destruction during the ashing process. [35] Explained that food products tend to contain less ash when grinded than when ashed in their pure solid state. Also, the addition of crayfish to the peanut butter increased the ash content of the butter to $2.80 \pm 0.44\%$ but the effect was not significant. This result agrees with [30] who also reported that although crayfish contains an appreciable amount of minerals, its incorporation in a food product does not significantly affects the ash content of the food. In sample D where ginger and crayfish were both incorporated into the peanut butter, the ash content insignificantly increase from $2.60 \pm 0.13\%$ to $2.90 \pm 0.36\%$.

The carbohydrate content of pure peanut butter (sample A) and that of sample B could not show any significant difference. A significant decrease in the carbohydrate content was however observed in sample C and in sample D. Like other varieties of butter, peanut butter had a considerably high total carbohydrate content of $21.39 \pm 0.30\%$ which is within the

range of 20-32% of total carbohydrate reported by [10] for groundnut varieties. The incorporation of ginger and crayfish into the peanut butter had varying reduction effects on the carbohydrate content of the peanut butter. When ginger was incorporated, the carbohydrate content of the butter insignificantly decreased from $21.39 \pm 0.30\%$ to $20.70 \pm 0.61\%$. By the incorporation of crayfish, the protein content of the butter was increased and its carbohydrate content significantly decreased to $14.12 \pm 0.07\%$. [10] noted that, in the combination of two or more food products where the protein content is increased, the carbohydrate content of such foods tend to decrease due to the displacement of carbohydrate molecules by the protein molecules. The findings of [10] also explains what was observed in sample D where both ginger and crayfish were incorporated into the peanut butter and a significant difference was created by a decrease in its carbohydrate content from $21.39 \pm 0.30\%$ to 12.87 ± 0.56 .

3.2. Essential Amino Acid of Peanut Butter Incorporated with Crayfish and Ginger

Table 3 shows the result of the essential amino acid analysis. The isoleucine, leucine, lysine and valine content of the butter decreased significantly ($p \leq 0.05$) when 10% ginger was incorporated and increased significantly ($p \leq 0.05$) when 20% crayfish was incorporated. The incorporation of both ginger and crayfish also increased the isoleucine, leucine, lysine and valine content of the butter significantly. The butter's methionine and phenylalanine contents reduced significantly when 10% ginger was incorporated but remained insignificantly different when crayfish and a mixture of crayfish and ginger was incorporated. The threonine content of the peanut butter showed no significant difference in all the samples.

Table 3. Essential Amino Acids Profile of Peanut Butter Incorporated with Crayfish and Ginger.

Amino Acids (mg/g protein)	Samples				LSD
	A	B	C	D	
Isoleucine	31.90 ± 1.10^c	30.00 ± 1.00^d	35.90 ± 1.10^a	33.90 ± 1.00^b	1.90
Leucine	67.80 ± 1.00^{bc}	66.30 ± 1.00^c	72.80 ± 1.00^a	69.20 ± 1.00^b	2.00
Lysine	36.50 ± 1.00^c	33.50 ± 1.50^d	42.00 ± 1.00^a	39.00 ± 1.00^b	2.10
Methionine	10.40 ± 1.20^a	8.60 ± 0.40^b	10.70 ± 1.00^a	10.20 ± 1.00^a	1.30
Phylalanine	44.00 ± 1.00^c	43.10 ± 1.00^c	51.00 ± 1.00^a	47.5 ± 1.10^b	2.10
Threonine	28.70 ± 7.00^a	27.20 ± 1.10^a	31.8 ± 1.00^a	30.40 ± 1.00	6.30
Histidine	24.00 ± 1.40^{bc}	23.00 ± 1.00^c	25.40 ± 2.00^a	26.00 ± 1.00^a	2.30
Valine	38.30 ± 6.20	36.00 ± 1.00^b	43.00 ± 1.00^a	40.10 ± 1.00^{ab}	6.10

Values are means of duplicate determination \pm Standard Deviation

Mean with different superscript row wise are significantly different ($p < 0.05$).

Key: A= Control (Peanut) 100%, B= 90% Peanut, 10% Ginger, C= 80% Peanut, 20% Crayfish.

D= 70% Peanut, 10% Ginger and 20% Crayfish, LSD= Least Significant Difference

Essential amino acids are not synthesized by the body, as such; they are supplied to the body by food. Seven (7) essential amino acids were considered in the present study, these are isoleucine, leucine, lysine, methionine, phenylalanine, threonine, histidine and valine. These essential amino acids were selected based on earlier reports by [27] that they are the commonest in peanut butter. Peanut butter contained all the analysed essential amino acids in

relatively good amounts of $31.9 \pm 0.11\%$ isoleucine, $67.8 \pm 0.10\%$ leucine, $36.5 \pm 0.10\%$ lysine, $44.0 \pm 0.10\%$ phenylalanine, $28.7 \pm 0.7\%$ threonine, and $24.0 \pm 1.40\%$ histidine and $38.3 \pm 0.62\%$ valine except for methionine which was contained in small amounts (10.40 ± 1.20). The high essential amino acid content of peanut butter is as a result of the high protein content of the butter. This result compares favourably with that of [15] who reported that, peanut butter

is rich in all essential amino acids except for methionine where the amount is considerably low. The authors also reported that, leucine is the predominant essential amino acid in peanut butter as has also been found in this study. Incorporation of ginger into the peanut butter resulted in a significant reduction ($p < 0.05$) of isoleucine content by from $31.9 \pm 0.11\%$ to $30.0 \pm 0.10\%$. [17] reported that incorporation of rhizomes into meals results to a reduction in their essential amino acid contents. In this work, isoleucine was reduced from $31.9 \pm 0.11\%$ to $30.0 \pm 0.10\%$, leucine from $67.8 \pm 0.10\%$ to $66.3 \pm 1.0\%$, lysine from $36.5 \pm 1.0\%$ to $33.5 \pm 1.5\%$, methionine from $10.4 \pm 1.2\%$ to $8.6 \pm 0.4\%$, phenylalanine from $44.0 \pm 1.0\%$ to 43.1 ± 1.0 , threonine from $28.7 \pm 0.7\%$ to $27.2 \pm 1.1\%$, histidine from $24.0 \pm 1.4\%$ to $23.0 \pm 1.0\%$ and valine from $38.3 \pm 6.2\%$ to $36.0 \pm 1.0\%$ creating a significant difference in each case.

Conversely substitution of peanut with 20% crayfish resulted in significant increase ($p < 0.05$) in all the essential amino acid content in the prepared butter. The increase in the content of essential amino acid could be attributed to the widely established fact that crayfish contains high amounts of protein. [24] established that crayfish and grasshoppers contain high amounts of essential amino acids and their incorporation into human or broiler diet increases the essential amino acid content of the diet significantly. An antagonistic activity was observed when the peanut butter was incorporated with both ginger and crayfish. The ginger having little or no essential amino acid imposed a reducing effect on the essential amino acid content of the butter while crayfish with high essential amino acid content opposed the activity of the ginger by offering an increase in the essential amino acid content of the butter. As a result of the antagonistic activity, the essential amino acid content of the peanut butter increased but not as much as when only crayfish was incorporated due to the reducing effect of the

ginger. Thus, in some essential amino acids like isoleucine, leucine, lysine, phenylalanine, histidine and valine contained in the butter, the increase created a significant difference while in other essential amino acids like methionine and threonine the increase could not make a significant difference. This antagonistic activity was also reported by [5] when he incorporated 10% ginger and 10% grasshopper powder in a broiler diet. The fact that peanut butter incorporated with ginger and crayfish meet the 27% essential amino acids requirement as stipulated by NAFDAC confirms that, peanut butter incorporated with ginger and crayfish is a good source of essential amino acid and can be depended on for the supply of essential amino acids to the body except for methionine which is contained in a relatively low quantity and must be supplemented for proper growth as it is very essential in small mammals.

3.3. Non-essential Amino Acid of Peanut Butter Incorporated with Crayfish and Ginger

The result of the non-essential amino acids of peanut butter incorporated with crayfish and ginger are presented in Table 4. Result shows that the alanine, glutamic acid, aspartic acid, glycine, histidine and proline content of the peanut butter decreased significantly ($p < 0.05$) when 10% ginger was incorporated but increased significantly as 20% crayfish and a mixture of ginger and crayfish were incorporated into the butter. On the other hand, the cystine, serine and tyrosine content of the peanut butter was not significantly ($p > 0.05$) affected when 10% ginger was incorporated but was significantly increased when 20% crayfish and a mixture of crayfish and ginger was incorporated into the butter. The arginine content of the butter was significantly reduced as 10% ginger, 20% crayfish and a mixture of ginger and crayfish was incorporated.

Table 4. Non-Essential Amino Acids Profile of Peanut Butter Incorporated with Crayfish and Ginger

Amino Acids (mg/g protein)	A	B	C	D	LSD
Alanine	39.00 ± 1.00^c	36.40 ± 1.00^d	45.00 ± 0.30^a	41.00 ± 1.00^b	1.40
Arginine	100.40 ± 0.20^a	96.10 ± 1.10^c	99.00 ± 1.00^b	97.00 ± 1.00^c	1.50
Aspartic acid	114.30 ± 0.20^b	110.10 ± 0.10^c	126.00 ± 0.40^a	116.10 ± 1.10^b	2.10
Cystine	12.40 ± 1.00^b	12.40 ± 5.30^b	13.80 ± 1.00^a	13.80 ± 0.40^a	1.00
Glutamic acid	183.00 ± 1.10^c	173.40 ± 2.10^d	195.00 ± 1.10^a	187.00 ± 1.10^b	2.20
Glycine	49.90 ± 1.10^c	46.00 ± 1.10^d	57.10 ± 1.10^a	55.00 ± 1.00^b	2.10
Proline	36.00 ± 0.40^b	33.00 ± 0.40^c	39.40 ± 1.00^a	37.00 ± 1.10^a	1.20
Serine	47.00 ± 1.00^b	46.40 ± 1.40^b	49.90 ± 1.00^a	48.80 ± 0.20^a	2.10
Tyrosine	29.80 ± 6.00^a	31.40 ± 1.00^a	34.70 ± 1.00^a	29.80 ± 1.00^a	5.40

Values are means of duplicate determination \pm Standard Deviation

Mean with different superscript row wise are significantly difference ($p < 0.05$).

Key: A= Control (Peanut) 100%, B= 90% Peanut, 10% Ginger, C= 80% Peanut, 20% Crayfish D= 70% Peanut, 10% Ginger, 20% Crayfish, LSD= Least Significant Difference

These non-essential amino acids are synthesized in the body and the amount obtained from food only acts as a supplement. The non-essential amino acid values recorded for peanut butter in Table 4 of this study ($39.00 \pm 1.0\%$ Alanine, $100.40 \pm 0.20\%$ Arginine, $114.30 \pm 0.2\%$ Aspartic acid, $12.40 \pm 1.0\%$ cystine, $183.00 \pm 1.1\%$ Glutamic acid, $49.90 \pm 1.1\%$ Glycine,, 36.00 ± 0.40 proline, $47.00 \pm 1.0\%$

serine, $29.80 \pm 6.0\%$ tyrosine) were higher than those reported elsewhere for tiger nut, melon seeds and pumpkin seeds [9]. This suggests that, peanut butter is not only high in essential amino acids but also in non-essential amino acids.

The incorporation of ginger into the peanut butter brought about a decrease in all its non-essential amino acid content and such decrease created significant differences in all the

non-essential amino acids except in cystine, serine and tyrosine where the differences were not significant. [17] had in their separate works agreed that the addition of rhizomes in meals result to a decrease not only in its essential amino acids content but also in its non-essential amino acid content. [1] explained that, ginger contains some non-polar compounds of high electro negativity which readily reacts with the polar molecules of non-essential amino acids binding them together and causing a decrease in their bioavailability. [13] also shared a similar view but added that, the reaction of the non-polar ginger compounds and the polar molecules of amino acid are influenced by geographical locations relating to temperature. The authors explained that the reaction is faster at high temperature regions and lower at low temperature regions.

In sample C where crayfish was incorporated, several changes occurred in the non-essential amino acids contained in the butter. The concentration of amino acids like alanine, aspartic acid, cystine, glutamic acid, glycine, proline, serine and tyrosine were significantly increased indicating that crayfish is rich in such amino acids to have created a significant difference in their content. [34] had earlier done the non-essential amino acid content analysis of crayfish and reported that, crayfish is rich in the aforementioned non-essential amino acids. A significant difference was also observed in the arginine content of the butter when crayfish was incorporated, the arginine content reduced from $100.40 \pm 0.2\%$ to $99.00 \pm 1.0\%$. This decrease is an indication that crayfish contains a negligible or no amount of arginine. [34], [30] in their separate amino acids analysis of crayfish reported that, crayfish contained a very small amount of arginine (if any) such that it cannot be detected by any analytical method.

As reported in the analysis of essential amino acids, an antagonistic activity occurred when ginger and crayfish were incorporated into the peanut butter. As usual, the ginger with non-polar substances tend to react and bind with the polar molecules of the amino acids while crayfish, rich in non-essential amino acids [19] tried to affect the non-essential

amino acid content of the butter positively by donating its own non-essential amino acid content. The result was that, the butter had an increased amount of some non-essential amino acids like alanine, aspartic acid, cystine, glutamic acid, glycine, proline, serine and tyrosine at significant levels. Although these increase occurred at significant levels, it was not as high as was observed when only crayfish was incorporated due to the antagonistic activities of the ginger which weakened the non-essential amino acids increasing effect of the crayfish. A significant decrease in the arginine content of the butter was also observed since crayfish has no arginine content [30] to counter the binding activity of the ginger molecules. The incorporation of crayfish into peanut butter made the butter richer in non-essential amino acids. This result compares favourably with the conclusions of [33] that crayfish is rich in protein and its incorporation into foods increases its nutritional quality by increasing both its essential and non-essential amino acid content.

3.4. Mineral Composition

The result of the mineral content of peanut butter incorporated with crayfish and ginger is presented in Table 5. The result showed that zinc content of the peanut butter increased at significant levels as ginger, crayfish and a mixture of both were incorporated into the butter. On the other hand, the iron content of the butter increased at insignificant levels as ginger, crayfish and a mixture of ginger and crayfish were incorporated into the butter. A significant increase in the magnesium content of the peanut butter was seen in all samples while the potassium content of the butter decreased significantly upon the incorporation of 10% ginger but increased significantly when 20% crayfish and a mixture of ginger and crayfish were incorporated into the butter. The butter's phosphorous content decreased continuously at significant levels when ginger, crayfish, and a mixture of ginger and crayfish were incorporated into the peanut butter. This is shown in Table 5.

Table 5. Mineral Content of Peanut Butter (mg/100g) Incorporated with Crayfish and Ginger.

Samples	Mineral Elements				
	Zinc	Iron	Magnesium	Potassium	Phosphorous
A	2.02±0.01 ^d	2.33±0.04 ^a	71.61±0.62 ^b	661.4±0.10 ^d	28.35±0.99 ^a
B	2.26±0.12 ^c	2.90±0.52 ^a	79.71±0.50 ^a	655.0±0.00 ^c	25.14±0.24 ^b
C	2.42±0.10 ^b	2.94±0.50 ^a	79.79±0.24 ^a	671.1±0.60 ^b	23.29±0.10 ^c
D	2.84±0.10 ^a	2.68±0.30 ^a	79.22±0.21 ^a	698.6±0.80 ^a	23.63±0.70 ^c
LSD	0.21	0.72	0.80	0.91	1.20

Values are means of duplicate determination + Standard Deviation

Mean with different superscript column wise are significantly difference ($p < 0.05$).

Key: A= Control (Peanut) 100%, B= 90% Peanut, 10% Ginger, C= 80% Peanut, 20% Crayfish

D= 70% Peanut, 10% Ginger and 20% Crayfish, LSD= Least Significant Difference

Zinc, iron, magnesium, potassium, and phosphorous were selected and analysed for because they are the dominant minerals in peanut seeds used for producing the peanut butter. The result showed that, the mineral composition of the peanut butter was low as compared to reports of other researchers [11]. Reported that, the zinc, iron, magnesium

and phosphorous contents of most peanut butter were 2.50mg/100g, 2.83mg/100g, 84.07mg/100g, 702.01mg/100g and 36.12mg/100g respectively, which are much higher than the 2.02mg/100g, 2.33mg/100g, 71.61mg/100g, 6661.40mg/100g and 28.35mg/100g respectively obtained in this study. Several researchers have attributed variations in

the mineral content of the same variety of groundnut to different factors. [12] attributed such various in the amount of mineral binding anti-nutrients such as phytates, oxalates and saponins, explaining that, these anti-nutrients form insoluble complexes with the minerals and reduce their level of bioavailability and their concentration in the soil where the groundnut is cultivated go a long way in determining the mineral composition of the groundnut.

Peanut butter contained 2.02 ± 0.01 mg/100g zinc and the incorporation of ginger into the peanut butter significantly affected its zinc content by increasing to 2.26 ± 0.12 mg/100g indicating that ginger also contained an appreciable amount of zinc as reported by [29]. The incorporation of crayfish into the butter also significantly increased its zinc content to 2.42 ± 0.10 mg/100g. The peanut butter's significant increase in zinc content when ginger and crayfish were separately incorporated in samples B and C and also when both ginger and crayfish were incorporated in sample D. A significant increase from 2.02 ± 0.01 mg/100g to 2.84 ± 0.10 mg/100g occurred due to the high zinc content of both ginger and crayfish.

Iron is required in the body for the synthesis of hemoglobin and myoglobin which are oxygen carriers in the blood and muscles respectively. The daily iron requirement for men and non-menstruating and pregnant women is 18mg. The iron content of 100% peanut butter was low (2.33 ± 0.04 mg/100g) and falls short of the 3.00 mg/100g reported by [31] to be present in the butter from other nuts. The incorporation of ginger into the peanut butter increased its iron content from 2.33 ± 0.04 mg/100g to 2.90 ± 0.52 mg/100g but such increase could not make a significant difference in the iron content of the butter. [28] Similarly, reported that the addition of ginger to low iron content meal did not have a significant effect on the iron content of the feed. The incorporation of crayfish also increased the iron content of the peanut butter to 2.94 ± 0.50 mg/100g but failed to create a significant effect on its iron content. [28] also incorporated crayfish in their animal feed formulation and concluded that crayfish significantly improved the nutritional value of the feed in many ways but not in terms of its iron value. When both ginger and crayfish were incorporated in the peanut butter (sample D), the iron content of the butter still increased at an insignificant level.

The magnesium content of the peanut butter was 71.61 ± 0.62 mg/100g. The addition of ginger to the peanut butter significantly increased the magnesium content of the butter. This might be due to the high magnesium content of

ginger. The result agrees with the report by [9] that ginger is high in magnesium. The incorporation of crayfish into the butter significantly increased its magnesium content to 79.79 ± 0.24 mg/100g. This significant increase in the magnesium content of the butter was also observed when both ginger and crayfish were incorporated into the butter.

The potassium content of the pure peanut butter was 661.4 ± 0.1 mg/100g. This potassium content of the butter was significantly reduced ($p < 0.05$) to 655.0 ± 0.0 mg/100g when ginger was incorporated into the butter. However, the incorporation of crayfish into the peanut butter created a significant increase in its potassium content from 661.4 ± 0.1 mg/100g to 671.1 ± 0.6 mg/100g. This result means that, crayfish on its own contains an appreciable amount of potassium and contain little or no anti-nutrient that could attack the potassium content of the peanut butter [30]. In sample D where both ginger and crayfish were incorporated into the peanut butter, the potassium content of the butter was considerably increased to 698.6 ± 0.8 mg/100g thus creating a significant difference in the potassium content of the butter.

The content of phosphorus in 100% peanut butter was 28.35 ± 0.99 mg/100g. This concentration of phosphorus in the butter was significantly reduced to 25.14 ± 0.24 mg/100g when 10% ginger was incorporated into the butter. In a similar but more drastic manner, the phosphorus content of the butter was reduced to 23.29 ± 0.1 mg/100g when 20% crayfish was added creating a significant difference in the phosphorus content of the butter. This result alternates the findings of [4] that crayfish is adequately composed of phosphorus and its incorporation in a meal may not have a significant decreasing or increasing effect on the meals phosphorus content. The incorporation of both ginger and crayfish into the peanut butter created even more significant difference in the phosphorus content of the butter. The phosphorus content dropped from 28.35 ± 0.9 mg/100g to 23.63 ± 0.7 mg/100g. This result is in disagreement with those of [3], [18] who in their separate works incorporated ginger and crayfish into *ogi* and arrived at the same conclusion that it had no effect on the mineral quality of the *ogi*.

3.5. Sensory Properties of Peanut Butter Incorporated with Crayfish and Ginger

The sensory attributes of peanut butter incorporated with ginger and crayfish evaluated were appearance, taste, aroma and overall acceptability as presented in Table 6.

Table 6. Sensory Attributes of the Peanut Butters.

Sample	Appearance	Taste	Aroma	Overall acceptability
A	7.05 ^c	6.85 ^b	6.90 ^b	7.00 ^a
B	8.00 ^a	6.75 ^c	7.80 ^a	6.45 ^b
C	7.65 ^b	6.55 ^d	6.95 ^b	6.50 ^b
D	7.80 ^{ab}	6.95 ^a	7.60 ^a	7.15 ^a
LSD	0.24	0.03	0.31	0.20

Key: A= Control (Peanut) 100%, B= 90% Peanut, 10% Ginger, C= 80% Peanut, 20% Crayfish
D= 70% Peanut, 10% Ginger and 20% Crayfish, LSD = Least Significant Difference

Sample A had an appearance score of 7.05 which increased significantly to 8.00, 7.65 and 7.80 as ginger, crayfish and a mixture of both ginger and crayfish were respectively incorporated into the peanut butter. The taste of the butter increased insignificantly when ginger (sample B), crayfish (sample C) and mixture of ginger and crayfish (sample D) were incorporated into the peanut butter. The aroma of the butter was insignificantly improved as the ginger, crayfish and a mixture of both was incorporated into the peanut butter, sample B where ginger was incorporated had the highest score in terms of aroma but was not significantly different from sample D. Sample D was the most accepted as the incorporation of ginger (sample B) and crayfish (sample C) respectively reduced the overall acceptability of the butter.

From the result, 100% peanut butter (sample A) had its best appearance. However, the taste of the pure peanut butter sample was most preferred. When the butter was incorporated with 10% ginger; the product had an improved appearance level which was higher than that of sample A, even though the overall acceptability of sample A was high, the incorporation of ginger also provided the product with an improved taste.

The aroma of the peanut butter incorporated with ginger was greatly improved. In sample C, butter was incorporated with 20% crayfish and its good appearance decreased insignificantly. The taste of the butter also followed the same trend as its appearance. Sample D where 10% ginger and 20% crayfish were incorporated had an appearance score of 7.80, while the score for test was 6.95. The aroma score was also high at 7.60 due to the ginger's flavour. The peanut butter incorporated with ginger and crayfish (sample D) recorded the highest level of acceptability due to its better appearance, taste, and flavour in relation to the other products.

4. Conclusion

Results of the present study have shown that, the nutritional quality and sensory attributes of peanut butter were significantly improved when the butter was incorporated with crayfish. Peanut protein is increasingly becoming important as food and feed sources, especially in developing countries where protein from animal source is not within the reach of the majority of the populace, peanuts and peanut products can be efficiently used to reduce the protein energy malnutrition commonly found in these places.

The incorporation of ginger and crayfish into the separate butter blends created desirable effects in the nutritional quality and sensory attributes of the butter and the addition of both ginger and crayfish improved the nutritional and sensory quality to a significant level.

A mixture of both ginger and crayfish offered more desirable effects to the product than when only ginger or crayfish was incorporated into the butter. As such, the incorporation of a mixture of ginger and crayfish into the butter is preferable and should be the widely practiced blend.

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