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Functional and Sensory Properties of Biscuit Produced from Peanut Butter Substituted with Shortening.

[1]Alagbaoso, S.O., [1]Olawuni, I.A., [1]Ibeabuchi, J.C.,[1]Ofoedum, A.F. and [2]Onyeneke,E.N.

.[1]Department of Food Science and Technology, School of Engineering and Engineering Technology, Federal University of Technology Owerri,PMB1526 IMO State, Nigeria.
[2]DepartmentofNutrition and Dietetics, Faculty of Health Sciences,ImoStateUniversity,Owerri, Nigeria.
**Corresponding author: Ofoedum, A.F*

Abstract: *The production and evaluation of biscuits produced by the incorporation of peanut butter as substitute for shortening in biscuit was studied. Biscuit samples were prepared with margarine (fat) substituted with peanut butter (PB) in ratios; BSA (100:0), BSB (75:25), BSC (50:50), BSD (25:75) and BSE (0:100) where BSA was the control. The standard method of biscuit preparation was adopted. Functional and Sensory analysis were carried out on biscuit samples to determine the biscuit quality and the data obtained were analyzed statistically using ANOVA and Fisher's LSD to separate the mean. Functional properties such as bulk density, oil absorption capacity, water absorption capacity, wettability and solubility were improved. Sensory analysis showed that biscuit prepared with peanut butter had relatively harder texture and darker colour than control. The crispness of biscuit prepared with peanut butter reduced with increase in the substitution level. However, peanut butter gave palatable flavour and taste to the biscuit. BSC was the most preferred of all the samples.*

Keywords: *Biscuits, peanut butter, Shortenings, Functional Properties, Sensory properties.*

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I. Introduction

Biscuits are ready-to-eat, convenient and cheap snacks that are consumed by all age group in many countries (Adebowale *et al*., 2012). The word 'Biscuit' was derived from the Latin word 'Biscoctus', meaning twice cooked (Macrace *et al*., 1993). They are wheat based food product; the wheat variety commonly used for biscuit is the soft type. Biscuits are usually dried to low moisture content with a soft consistency. Thus, it is a baked product that has much lower moisture content as compared with other baked products thereby prolonging its shelf life. The main ingredients of biscuit include wheat flour, margarine (fats), sugar, water while other ingredients such as milk, aerating agent, emulsifier, flavour and colour can be included and hence, are called optional ingredients. (Ajibola *et al.* 2015). However, each of the ingredients used in the production of biscuit plays a specific role. Biscuits can be fortified or enriched to meet specific nutritional needs of consumers. This is because consumer health is of paramount interest in the food industry. Snack food industry is growing globally with rapid introduction of new products. These new products are formulated with the intention of meeting up with specific health or organoleptic needs of consumer (Omah and Okafor 2015).

The word 'Fat' refers to the lipid food group, and is used to mean both fats and oil. Fat is an essential part of diet, the taste of baked products depend greatly on the flavour of the fat. The fat used imparts flavor, texture and appearance of the baked product (Pyler, 1988). It is an important ingredient used to raise energy density in formulation of fortified blended foods for vulnerable population (Islamiy at *et al.,* 2016). On the other hand, excess intake of fat in diet may lead to higher risk of diseases/disorders like obesity, coronary heart disease and cancer (Akoh, 1988). As biscuits are typically higher in fat content, it becomes difficult to prepare biscuits by reducing fat contents in their formulation to lower the risk of such diseases. To reduce the amount of fat in bakery products, fat replacers from plant origin like peanut butter are used (Sanchez *et al.,* 1995).

Peanut (*Arachis hypogaea L.*) is the cheapest source of protein and also known as groundnut because it grows underground (Abegaz *et al.,* 2006). It is one of the leading agricultural crops of the world for the production of edible plant oil and protein (Adegoke *et al*., 2004). They are usually consumed after roasting or boiling, they have many value-added products that have been developed with a number of applications in bakery, confectionery and the general consumer market. Peanuts can be processed into different forms such as peanut butter, peanut flour, peanut oil, candy, chocolate, cake and others. Peanuts vary in colour from red to brown and are usually coarse in appearance.

It is estimated that as much as 30% of the population from many countries in the world are suffering from malnutrition (FAO, 2000). In many African countries, often deaths are reported as due to malnutrition and they would possibly be prevented by providing a protein rich diet (Sanghvi and Murray, 1997). Peanut and peanut added foods could provide such a nutritious diet. The World Health Organization recommended an average requirement of 0.66g of protein per kg of ideal body weight, and a 'safe level' of 0.86g/kg of body weight. (Food and Nutrition Board, 2002). Peanuts contain more plant protein than any other legume or nut. Peanuts, which are a rich source of protein and essential amino acids, can help in preventing malnutrition (Pelto and Armar-Klemesu, 2011). Moreover, peanuts contain lipids and carbohydrates which are energy rich compounds, capable of complementing the basic energy demands of the human body (Settaluri *et al.*, 2012). Peanut is one of the most widely used legumes due to its nutrition and taste, and it occupies a rank of major oilseed crop in the world. In the production of peanut butter, peanuts are roasted, blanched and sorted before grinding into a creamy consistency. Peanut butter contains a minimum of 90% peanuts, sweeteners and salt can be added to enhance flavor while small amounts of stabilizers are used to prevent oil separation (APC, 2011).

Incorporating peanut butter as substitute for shortening in biscuit will not only reduce the risk of diseases like obesity, coronary heart disease and cancer, but will also improve the nutritional qualities, sensory and organoleptic properties of the baked products.

The objective of this research is aimed at the incorporation of peanut butter as substitute for shortening in biscuits, determination of the functional properties and proximate composition of the biscuit produced. Nevertheless, biscuits are important snacks consumed in most parts of the world by both adults and children. Coronary heart disease, obesity and cancer have been implicated with excess intake of fat in diet (Akoh, 1998). Biscuits typically contain around 22-30% fat (Farheena *et al.,* 2015) which make them unhealthy especially for those suffering from coronary heart diseases. Hence, this study will help modify the composition of biscuits, cut down the amount of fat by reducing the saturated fats with the peanut butter while creating a new marketing nitch for the production of peanut butter.

II. Materials And Methods

Source of Materials

The baking materials were purchased from local market in Ihiagwa, Owerri in Imo State while the Chemicals and equipments used were obtained from Food Science and Technology department Laboratory and Biochemistry department laboratory both in Federal University of Technology Owerri, Imo State.

Peanut Butter Preparation

The peanut butter was prepared according to Woodroof (1983). The purchased peanuts were graded and sorted to remove damaged nuts and dirt. 1000g of the sorted peanuts were soaked with 52g of salt for 20minutes. Water was added to cover the peanuts, the soaked peanuts were dewatered and spread out on a tray to dry. Fine sand was heated in a pan over burning fire and the peanuts were added, left to roast for 10minutes with continuous stirring. After roasting, the skins of the peanuts changed from bright red to dull red and the peanuts from white to light brown. The roasted peanuts were spread on a tray to cool in order to stop the cooking process. The skins on the cooled peanuts were removed by rubbing the roasted peanuts between the palms and discoloured and spoilt nuts were removed. Cleaned peanuts were subjected to grinding in a roller mill and the peanut butter was packaged in an airtight glass container and stored at ambient temperature.

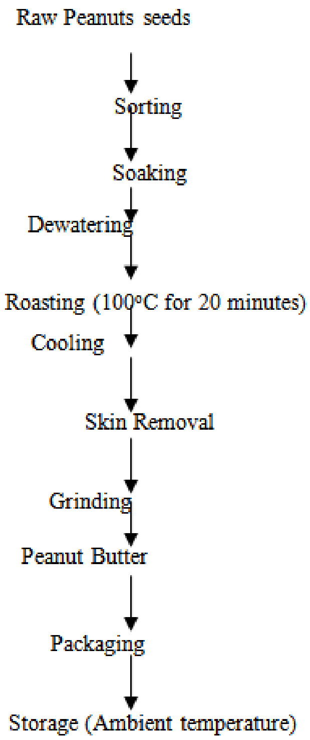

Figure 1: Flow diagram for the production of peanut butter

Fat Formulation Ratios

Biscuits were prepared using the Rubbing in method (Peter-Ikechukwu*et al.*, 2016) with margarine (fat) substituted with peanut butter (PB) in the following ratios 100:0, 75:25, 50:50, 25:75, 0:100.

Table 1: Fat Formulation Ratios

Samples	Margarine (Fat)	Peanut butter(PB)
BSA	100	0
BSB	75	25
BSC	50	50
BSD	25	75
BSE	0	100

The ratio of Margarine to butter is shown as follows: BSA=100: 0 (Control), BSB=75: 25, BSC=50: 50, BSD=25: 75, BSE=0: 100.

Production of biscuit

100% refined wheat flour and 0.5% baking powder were mixed and sifted. 35% granulated sugar and margarine/peanut butter (as per treatment) was mixed, the mixing was done manually.In a separate bowl, egg, vanilla and milk flavours with water were mixed and added to the flour based mixture and kneaded into a dough. The dough was rolled and flattened on a platform to a thickness of 3.5mm using a wooden rolling pin. The dough was cut out into shapes using a cutter and arranged on a greased baking tray for baking. The cut out dough were baked at 150^{o}C for 25 minutes in the oven (Peter-Ikechukwu, *et al.*, 2016). After baking, the biscuits were cooled and packed in low density polyethene bags and kept at ambient temperature for 24hours before analysis.

Raw materials (Wheat flour and Baking powder)

↓

Sifting and Mixing

↓

Addition of sugar, margarine/Peanut butter

↓

Addition of eggs, water and flavour

↓

Kneading (manually)

↓

Rolling

↓

Cutting into shapes

↓

Placing on greased pans

↓

Baking (at 150^{o}C for 20-25 minutes)

↓

Storage (cool dry place)

Fig 2:*Flow diagram for the production of biscuits*

Plate 1 Control BSA (100:0)

Plate 2 BSB (75:25)

Plate 3.3: BSC (50:50)

Plate 3.4: BSD (25:75)

Plate 3.5: BSE (0:100)

Functional properties

Determination of Bulk density

The bulk density of the flour samples was determined according to Onwuka (2008). A 10ml graduated cylinder was weighed, dried and gently filled with the flour sample. The bottom of the cylinder was then tapped gently on a laboratory bench several times. This continues until no further diminution of the test flour in the cylinder was observed. The volume was recorded and the cylinder plus sample was weighed and recorded. Triplicate determinations were made and average result taken.

$$\text{Bulk Density (g/cm}^3\text{)} = \frac{\text{Weight of Sample (g)}}{\text{Volume of Sample (ml)}}$$

Determination of Wettability

AOAC (2006) method was used. The samples were weighed and in each case, 1 g was introduced into a 25ml graduated measuring cylinder with a diameter of 1cm and a finger placed over the open of the cylinder. The cylinder was inverted and clamped at a height of 10cm from the surface of 600 ml beaker containing 500 ml of distilled water. The finger was removed and the rest of the sample was allowed to be dumped. The wettability is the time required for the sample to become completely wet.

Determination of Viscosity

The viscosity of the various samples was determined using the Oswald viscometer. The method described by Onwuka (2008) was adopted. Each sample was added to the viscometer, pulled into the upper section, and then allowed to drain by gravity back into the lower reservoir. The time it took for the liquid to pass between two etched marks, one above and one below the upper reservoir was measured. The relative viscosity was measured using the formula;

$n_{rev}=n/n_o\text{-}\rho t/\rho_0\tau_0$

Where; ρ is the Density

t is the time of outflow of the sample

ρ_o is density of the outflow of the reference liquid

t_o is the time of the outflow of the reference liquid (water).

$n_o$is the viscosity of the reference liquid.

n is the viscosity of the sample to be calculated.

Determination of Foam capacity and stability

Foaming capacity and stability of the samples was studied according to AOAC (2006) method. 2 g of the sample was weighed from each of the sample and blended with 100ml of distilled water using warming blender. The suspension was whipped at 1600 rpm (revolution per minute) for 5 minutes. The mixture was then poured into a 100ml measuring cylinder and its volume was recorded after 30 seconds.

Foam capacity was expressed as percentage increase in volume, thus;

$$\text{Foam Capacity} = \frac{\text{Volume after whipping} - \text{Volume before Whipping}}{\text{Volume before whipping}} \times 100$$

Triplicate measures were taken for each sample and mean value recorded. The foam stability of the samples was recorded at 15, 30, 60, 120 seconds after whipping to determine the foam stabilities.

$$\text{Foam Stability} = \frac{\text{Foam Volume after whipping time} \times 100}{\text{Initial Foam Volume}}$$

Determination of Gelation capacity

The method of AOAC (2006) was adopted in the determination of gelation temperature. In each case, 10g of the sample was dispersed in 100ml of distilled water in 250ml beaker. A thermometer was clamped on a retort stand with its bulb submerged in the suspension and magnetic stirrer. The heating and stirring continued until the suspension began to gel and the corresponding temperature was recorded. The temperature at boiling point was also recorded.

Determination of Emulsification capacity (EC)

The AOAC (2006) method was used. From each sample, 2g was blended with 25ml of distilled water at room temperature for 30 seconds in a warming blender at 1600 rpm. After complete dispersion, 25ml of vegetable oil was gradually added and the blending continued for another 30 seconds. Then the mixture was transferred into a centrifuge tube and centrifuged at 1600 rpm for 5 minutes. The volume of oil separated from the sample was read directly from the tube after centrifuging.
Calculation: The emulsion capacity was expressed as the amount of oil emulsified and held per gram of sample.

i.e. Emulsion Capacity (EC) = $\frac{X \times 100}{Y}$

Where X = Height of Emulsifier layer
Y = Height of the whole solution in the centrifuge tube.

pH measurement

The pH values of the samples were determined by dissolving 10g of each sample in 100ml of distilled water in 250ml beaker. It was then thoroughly mixed and stirred and the pH was taken. This was triplicated and the average calculated (Mathew *et al*., 2015).

Determination of Swelling Properties/Index

The swelling index of flour samples was determined as done by Ukpabi and Ndimele (1990). 3g of each sample was transferred into clean, dry 50 ml graduated cylinder. The flour samples were gently leveled into the cylinder and the volumes noted. 30ml of distilled water was added to each sample; the cylinder was swirled and allowed to stand for 60 minutes while the change was calculated as a multiple of the original volume.

Determination of Water Absorption Capacity (WAC)

The method as described by Abbey and Ibeh (1998) was adopted for determination of water absorption capacity. 1g of each flour sample was weighed separately. Water was mixed with the flour to make up to 10ml of dispersion. It was then centrifuged at 3500rpm for 15minutes. The supernatant was discarded and the tube with its contents reweighed as gram water absorbed per gram of sample. The gain in mass was the water absorption capacity of the flour sample.

Determination of Solubility

The cold extraction method as described by Udensi and Onuora (1992) was adopted. Flour dispersion (10% w/v, db) was prepared with each of the flour samples by dispersing 1 g (dry basis) of flour in 5ml distilled water and making it up to 10ml. It was left for 1hour while it was stirred every 10 minutes then allowed to stand for 15 minutes to settle. 2ml of the supernatant was weighed in a dry petri dish, evaporated to dryness and re-weighed. The difference in mass is the total soluble solids. Solubility is calculated as;
Solubility TSS (%)= $(V_sM_e-M_d)/2M_s$ x100

Where; V_s= Total supernatant/Filtrate
M_d= Mass of empty, dry petri dish
M_e= Mass of Petri dish + residual solid after evaporative drying
M_s= Mass of flour sample used in the preparation of the dispersion

Determination of Oil Absorption Capacity (AOC)

The AOAC (2006) method was used to determine the oil absorption capacity. 1g of the sample was weighed into a conical graduated flask and 10ml of oil was added to the weighed sample. A warring whirl was used to mix the sample for 30 seconds. The sample was allowed to stand at room temperature for 30 minutes and then transferred to a graduated tube and centrifuged at 5000 rpm for 30minutes. Afterwards the mixed sample was transferred from the graduated tube into a 10ml measuring cylinder and the volume of the freed oil was noted. The absorption capacity was expressed as grams of oil absorbed per gram of sample. The density of the oil was determined to be 0.926g/m^3.

III. Results and Discussion

Table 2. ***Functional properties of the biscuit samples***

Sample	Bulk Density (g/ml)	Wettability (sec)	pH	Swelling Capacity	OAC	WAC	Foam Capacity	Solubility	Viscosity
BSA	0.613 ± 0.00^a	12.33 ± 1.53^a	6.3 ± 0.1^a	5.9 ± 0.25^a	1.077 ± 0.02^b	1.43 ± 0.15^{bcd}	9.57 ± 0.07^a	8.00 ± 2.83^a	Nil
BSB	0.645 ± 0.00^b	11.33 ± 1.15^{ab}	6.4 ± 0.1^a	5.1 ± 0.00^b	1.30 ± 0.03^b	$1.6b\pm0.25^c$	8.42 ± 0.06^b	6.00 ± 1.41^a	Nil
BSC	0.662 ± 0.00^b	10.33 ± 1.15^{bc}	6.5 ± 0.1^a	4.96 ± 0.01^b	1.40 ± 0.02^b	2.07 ± 0.30^b	7.36 ± 0.01^c	6.00 ± 2.83^a	Nil
BSD	0.663 ± 0.00^c	9.00 ± 1.00^{cd}	6.5 ± 0.1^a	5.02 ± 0.09^b	1.51 ± 0.04^b	2.6 ± 0.1^b	8.14 ± 0.04^{bc}	5.00 ± 1.41^a	Nil
BSE	0.678 ± 0.00^d	7.67 ± 0.58^d	6.5 ± 0.1^a	4.85 ± 0.02^{cb}	1.73 ± 0.04^a	2.67 ± 0.12^a	6.69 ± 0.08^c	4.00 ± 1.41^a	Nil
LSD	0.0035	1.57		0.16	0.043	0.25	0.096		

Values are duplicate mean± standard deviation. Samples with different superscripts within the same column were significantly different ($p<0.05$).
The ratio of Margarine to butter is shown as follows: BSA=100: 0 (Control), BSB= 75: 25, BSC= 50: 50, BSD= 25: 75, BSE= 0: 100.

IV. Discussion

The result of the functional properties of the biscuit samples are shown in Table (2)

Bulk density (BD)

The values obtained for bulk density ranged from 0.613g/ml to 0.678g/ml with BSE having the highest bulk density and BSA having the least bulk density. The result obtained showed that increase in the peanut butter incorporation as substitute for shortening increased the bulk density of the biscuit samples. There was significant difference between the control (BSA) and the other samples ($p<0.05$) however there was no significant difference between BSB and BSC. Bulk density is important in determining the packaging requirement, material handling, and application in processing in food industry (Karuna *et al*., 1996)

Wettability

Wettability of the biscuit samples ranged from 7.67seconds to 12.33seconds with BSA having the highest value and BSE having the least value. There was significant difference ($p<0.05$) between BSA, BSC, BSD and BSE but there was no significant difference between BSA and BSB, BSB and BSC, BSC and BSD, BSD and BSE. Wettability is a function of ease of dispersing flour samples in water. The sample with the lowest wettability dissolves fastest in water (Ubhhor and Akobundu, 2009).

pH

There was no significant difference in the pH values of all the biscuit samples ($p<0.05$). The pH of the biscuit samples ranged from 6.3 to 6.5, BSA had 6.3, BSB had 6.4 while BSC, BSD and BSE had 6.5. pH therefore is the measure of hydrogen and hydroxyl ion concentration in a given solution or sample. (Mamat, *et al.*, 2010).

Swelling Capacity

There was significant difference between the control (BSA) and the other samples ($p<0.05$). Swelling properties of the biscuit samples ranged from 4.85 ml to 5.9 ml. BSE had the least value of 4.85 ml, BSC had 4.96 ml, BSD had 5.02 ml, BSB had 5.1 ml and BSA had the highest value of 5.9 ml.

Oil absorption Capacity

The oil absorption capacity of the biscuit samples increased with increase in peanut substitution. The values ranged from 1.077 to 1.73 with BSE having the highest value and BSA having the least value. High oil absorption capacity suggests better mouth feel and flavour retention. There was significant difference between BSE and the other samples ($p<0.05$). However, the vales obtain are in range with the work done by Nwosu (2013).

Water Absorption Capacity

The water absorption capacity of the samples ranged from 1.43 to 2.67 with BSE having the highest water absorption capacity value and BSA having the least water absorption capacity. Ma *et al.*, (2011) reported that high water absorption capacity involves handling characteristic and leads to an improved freshness of the baked product. The high value of BSE may be attributed to its protein subunits structure which dissociates on heating in agreement with the findings of Apotiola and Fashakin (2013) that foods high in protein subunits have more water binding capacity

Solubility

The solubility of the biscuit samples ranged from 4.00 to 8.00 with the control (BSA) having the highest value of solubility of 8.00 while BSE had the least value of 4.00. The value of solubility decreased with increase in the substitution level of peanut butter. There was no significant difference between all the biscuit samples ($p<0.05$).

Foaming capacity

There was significant difference between the control and the other samples. The values ranged from 6.69 to 9.57. The result however showed that the foaming capacities of the biscuit samples arelower in relation to the control.Sequel to that, samples BSB and BSD are not significantly different ($p<0.05$) while BSC, BSD and BSE do not differ significantly ($p<0.05$).

Sensory Properties:

The mean results of the sensory properties of biscuit the samples are shown below.

Table 3.0: ***Sensory Properties of the biscuit Samples***

Samples	Taste	Flavour	Crispness	Texture	Appearance	Overall Acceptability
BSA	5.9 ± 1.94^b	6.55 ± 1.10^b	6.75 ± 1.16^a	5.15 ± 1.69^b	6.55 ± 1.10^a	5.85 ± 1.31^b
BSB	6.9 ± 1.33^a	6.4 ± 1.10^b	6.05 ± 1.36^a	7.05 ± 0.94^a	5.8 ± 0.95^a	6.75 ± 0.97^a
BSC	7.25 ± 1.16^a	7.25 ± 1.12^a	5.86 ± 1.46^a	5.8 ± 1.58^a	6.65 ± 1.39^a	6.9 ± 0.97^a
BSD	7.15 ± 1.31^a	6.1 ± 1.80^b	5.95 ± 1.82^a	5.65 ± 1.66^a	6.60 ± 0.75^a	6.8 ± 1.24^a
BSE	5.9 ± 1.45^b	6.05 ± 1.15^b	5.8 ± 1.61^a	4.9 ± 1.52^b	6.30 ± 1.17^a	5.8 ± 1.51^b
LSD	1.2386	0.6103		1.8891		1.0269

Values are duplicate mean± standard deviation. Samples with different superscripts within the same column were significantly different. ($p<0.05$).

Samples BSA=100% Margarine: 0% Peanut Butter (Control), BSB= 75% Margarine: 25% Peanut Butter, BSC= 50% Margarine: 50% Peanut Butter, BSD= 25% Margarine: 75% Peanut Butter, BSE= 0% Margarine: 100% Peanut Butter

The result of the physical properties of the biscuit samples are shown in

Taste

Table 3.0 showed the results of the taste of the biscuit samples. The values ranged from 5.9 to 7.25. However, sample BSC had the highest score with a mean value of 7.25 while the control, BSA and BSE had the lowest mean value of 5.90. There were no significant differencesamong BSB, BSC and BSD ($p<0.05$) while samples

BSA and BSE were significantly different from BSB, BSC and BSD ($p<0.05$). Taste is however a function of all the aggregate ingredients used in the production of foods (Woodroof 1983).

Flavour

The flavour of the biscuit ranged from 6.05(BSE) to 7.25 (BSC). There was significant difference between BSC and all the other samples. However, BSA, BSB, BSD and BSE were not significantly different ($p<0.05$). The BSE had the lowest flavour rating, this could be due to the strong aroma of peanut butter which is not appreciated by everyone. Flavour therefore is one of the organoleptic properties of food which also determines the level of food acceptance (Woodroof 1983).

Crispness

The crispness of the biscuits ranged from 5.8 (BSE) to 6.75 (BSA) however, there was no significant difference between all the biscuit samples. The crispness rating of the biscuit reduced with increase in the peanut butter substitution. The decrease in the crispness could be due to the increase in weight and moisture content of the biscuit samples with increase in peanut butter substitution. Crispness is desired qualities in biscuits that make consumers purchase the product and these results were in agreement with that of Ayo, *etal*., (2007).

Texture

BSA had the highest texture rating of 7.05 while BSE had the lowest texture rating of 4.9. There was no significant difference between BSA, BSB and BSC, however, BSD and BSE were significantly different from BSB, BSC and BSD. The high value obtained by BSA could be due to the high fat content of the biscuit sample. Fat in biscuit production provides the product with desirable textural properties. This shows that fat plays a major role in the textural characteristics of baked product (Hasmadi and Sandra, 2014).

Appearance

The appearance rating ranged from 5.8 (BSB) to 6.65 (BSC), there was no significant difference between the biscuit samples. There was a visible colour change from milky yellow to brown as the biscuits were baked. The brown coloration of the biscuit was as a result of Maillard reaction and caramelization of sugar that takes place in the oven during baking (Ayo, *et al.,* 2007).

Overall Acceptability

The results revealed that all the biscuit samples were in acceptable range. The highest score was recorded for BSC (6.9) while BSE had the lowest score (5.8). There was no significant difference between BSB, BSC and BSD. However, BSA and BSE differed significantly ($p<0.05$) from BSB, BSC and BSD.

V. Conclusion and Recommendation

Conclusion

Incorporating peanut butter as substitute for shortening in the production of biscuit improved the functional properties of the biscuit such as bulk density, wettability, oil absorption capacity and water absorption capacity. The sensory analysis carried out on the biscuit showed that BSC had overall acceptability over the other biscuit samples. Hence, incorporating peanut butter as substitute for shortening up to 50% will give biscuit of acceptable quality. It is therefore recommended that, more work should be done to improve the textural quality of biscuits produced with peanut butter as shortening as well as on the packaging of the biscuits to help retain organoleptic properties and extend shelf life.

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