



Impact of Partial Replacement of Peanut Paste with Sesame Seed Paste on the Nutritional and Anti-nutritional Components of Butter Made from the Blends

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Authors' contributions

The study was carried out in collaboration among all authors OVO, UEI and ONO. Author UEI designed the study. The three authors carried out the experimentation and gathered the initial data. Authors OVO and ONO managed the literature searches and performed the statistical analysis. Author UEI wrote the protocol and the first draft. The three authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted to see the effect of replacement of peanut paste with different levels of sesame seed paste on the nutritional and anti-nutritional components of butter made from the blends. The peanut: Sesame seed pastes were used in the ratios of 100:00, 90:10, 80:20, 70:30, 60:40, 50:50 and 00:100 with 100% peanut and sesame seed pastes as control samples. The results showed that all the parameters determined varied with the proportion of sesame seed paste in the blends. The crude protein, ash, crude fibre and carbohydrate progressively decreased with increase in the level of sesame seed paste substitution. On the contrary, fat and caloric value increased progressively with increase in sesame seed paste in the blends. The total amino acids decreased from 88.24 g/100 g protein while the total essential amino acids increased from 35.30 g/100 g protein in 100% peanut butter to 87.36 g/100 g protein and 37.71 g/100 g protein respectively in 50% sesame seed paste substituted butter. Methionine and cystine increased while lysine decreased with increase in sesame paste substitution. Majority of essential amino acid

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chemical scores were above 100% except lysine (63.45 – 98 – 28% for samples that contained sesame seed paste) and sulphur containing amino acids (78.00% and 92.40% for 100% peanut butter and 10% sesame paste supplemented butter respectively). The contents of K, Na, saponin and tannin in the butter decreased while Ca, Mg, Fe, Zn, oxalate and phytate increased with increase in sesame seed paste substitution. The values for anti-nutrients were low and may not have serious effect on nutrients bioavailability. The result has shown that production of butter from blends of peanut and sesame seed paste would enhance the essential amino acids composition and other nutrients and could lead to increased utilization of sesame seed.

Keywords: Peanut paste; sesame seed paste; butter; nutrient composition; anti-nutritional factors.

1. INTRODUCTION

Peanut (*Arachis hypogaea*) is an important crop of leguminous family. It ranks as third major source of edible oil in the world [1]. The oil content in peanut ranges from 47 – 50% and has greater percentage of unsaturated fatty acids that makes it an edible oil of choice for human nutrition and good health [2]. Its protein content varies from 25 – 30% [3]. The protein contains relatively low amount of methionine and cystine but is high in lysine [4]. According to Asibuo et al. [5], peanut protein is increasingly becoming important as food and feed sources, especially in developing countries where protein from animal sources is not within the means of majority of populace. Peanut is also rich in minerals, vitamins and bioactive compounds that contribute towards its protective effects against cardiovascular ailment, cancer, diabetes, osteoporosis and other degenerative diseases [1].

Peanut butter is the most important product made from peanut in the world and it is utilized as nutritious spread for bread and crackers as well as ingredient in sandwiches, cookies, confectionaries and other products [6]. The retained high protein and unsaturated fatty acids content in peanut even after being processed into butter makes it an excellent and affordable protein and lipid source [7]. Due to its high nutritive value, peanut based ready-to-use-therapeutic food (RUTF) has been implemented in the diet programme to treat malnutrition among children in African countries [8,9]. However, due to its high oil content and richness in unsaturated fatty acids, peanut butter is susceptible to developing rancidity and off-flavour through lipid oxidation [10].

Sesame (*Sesamum indicum L.*) is a herbaceous annual plant cultivated for its edible seed, oil and flavoursome value [11]. It is cultivated in the tropical and sub-tropical areas including Nigeria [12]. The chemical composition of sesame seed

shows that the seed is an important source of oil (44 – 58%), protein (18 – 25%), carbohydrate (13.5%) and ash (5%) [13]. The oil is rich in polyunsaturated fatty acids (PUFAs) and natural antioxidants, sesamin, sesamolin and tocopherol [14,15]. According to Bedigian and Harlan [16], sesame seed is known as the “Queen of oil seed” due to its high degree of resistance to oxidation and rancidity. The seed is known to exhibit various health beneficial properties including hypocholesterolaemic, antihypertensive, hepatoprotective, antimutagenic effects and neuro-degenerative diseases [15,17,18]. The protein present in sesame seed butter is high in methionine and cystine but low in lysine [19]. This implies that sesame seed product could be used to complement peanut protein that is low in methionine and cystine but high in lysine. The utilization of sesame seed for human nutrition has been limited by the presence of high amount of undesirable oxalic acid and indigestible fibre in the hull which impart a dark colour and bitter taste to the meal [19]. This necessitates the dehulling of the seeds prior to being used for the production of butter or other products.

Despite the reported nutritional and health benefits associated with sesame seed, the crop is grossly underutilized in Nigeria. This may be due to the tiny nature of the seeds which makes processing difficult and lack of awareness of their nutritional and health protecting potentials. The present study was aimed at evaluating the impact of partial replacement of peanut paste with sesame seed paste on the proximate composition, amino acid profile, mineral and some anti-nutrients in the butter made from the blends.

2. MATERIALS AND METHODS

2.1 Materials Procurement

Red skin peanut, white sesame seed and honey were purchased from Monday market in Kaduna,

Kaduna State, Nigeria. Non-hydrogenated palm oil and salt were purchased from Akpan Andem Market in Uyo, Akwa Ibom State, Nigeria.

2.2 Samples Preparation

2.2.1 Preparation of peanut paste

The 5 kg peanut seeds were washed and spread for water on the surface of the nuts to dry off. They were roasted at 160°C for 45 minutes in a hot air oven (model pp 22 US, Genlab, England) until desirable golden colour and flavour were obtained and allowed to cool. The husk and hearts of the roasted nuts were manually removed alongside with damaged seeds, stones and other contaminants. The nuts were then ground in a food processor to a coarse paste and packaged in airtight plastic container for subsequent use.

2.2.2 Preparation of sesame seed paste

The seeds were first decorticated following the wet decortication method described by Moharram et al. [20]. This was done by soaking the 5 kg seeds in a mixed solution of 0.04% NaOH and 3% NaCO₃ for 50 minutes with a seed to lye ratio of 1:3 (w/v). The solution was drained and the seeds washed with clean water. While being washed, the seeds were rubbed between the palms to decorticate them. The water was drained and the seeds spread for water on the surface of the seeds to dry off. The decorticated seeds were roasted at 120°C for 30 minutes in a hot air oven (model pp 22 US, Genlab, England), cooled and sieved to remove the hull. The roasted seeds were ground in a food processor to a coarse paste and packaged in air tight plastic container for subsequent use.

2.2.3 Formulation of peanut - sesame seed paste blends

The formulation of blends utilized for butter preparation were made with peanut and sesame seed pastes in the ratios of 100:00, 90:10, 80:20, 70:30, 60:40, 50:50 and 00:100 (peanut paste: sesame seed paste). The 100% peanut paste and 100% sesame seed paste served as control samples.

2.2.4 Production of butter from the formulated blends

The formulation used for preparing butter from each of the blends comprised of 90% paste and 10% other ingredients. The other ingredients used were 1.5% salt for taste, 3.0% non-

hydrogenated palm oil as stabilizer and 5.5% honey for flavour enhancement. These three ingredients were added to each of the formulated paste in a food processor and ground to a homogenous viscous smooth butter. The butter was packaged in an air tight plastic container, labeled and used for various determinations.

2.3 Methods of Analysis

The crude protein, fat, ash and crude fibre contents in the samples were determined following the methods described in AOAC [21]. The carbohydrate was calculated by subtracting the sum of protein, fat, ash and crude fibre from 100 [22]. Energy value was calculated using Atwater factor formula [23]. Amino acid profile of the samples was determined by the method described by Benitez [24]. The samples for amino acid determination were dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator (Labratorums Technic AG, Model CH – 9230) and loaded into the applied biosystem PTH amino acid analyzer (Model 120A PTH, Serial No. 704520, USA). Essential amino acid scores were computed using the FAO/WHO/UNU reference amino acid pattern [25]. The mineral elements (K, Ca, Mg, Na, Fe and Zn) were determined using atomic absorption spectrophotometer (UNICAM, Model 939, UK) as described in AOAC [21]. Phytate was determined following the colorimetric method described by Haugh and Lantzsch [26]. The methods described in AOAC [21] were used for the determination of oxalate and tannin contents in the samples. The method described by Brunner [27] was used for saponin determination.

2.4 Statistical Analysis

Means of data collected and standard deviation of means were calculated. The collected data were subjected to Analysis of Variance (ANOVA) using SPSS version 18 statistical package (SPSS, Inc., USA) software. Duncan's Multiple Range Test was used to separate means. Significance was accepted at a probability of P = .05.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Proximate composition of the prepared butter

The effect of replacing peanut paste with 10 – 50% sesame seed paste on the proximate

composition of butter made from the blends is presented on Table 1.

The results showed that the crude protein, fat, ash, crude fibre and carbohydrate contents in 100% peanut butter were 23.91%, 44.63%, 4.05%, 3.68% and 23.73% respectively while their corresponding values for 100% sesame seed butter were 20.88%, 57.25%, 2.41%, 2.68% and 16.78% respectively. Substitution of peanut paste with different levels of sesame seed paste resulted in progressive reductions in crude protein, ash, crude fibre and carbohydrate contents in the butter made from the blends while the fat content increased with increasing level of sesame seed paste substitution. The caloric value for 100% peanut butter was 588.92 kcal/100 g while the value for 100% sesame seed butter was 665.89 kcal/100 g. The caloric value increased from 598.74 kcal/100 g in 10% sesame seed paste substituted butter to 626.04 kcal/100 g in 50% sesame seed paste substituted butter.

3.1.2 Amino acid profile of the prepared butter

The amino acid profile of butter made from blends of peanut and sesame seed pastes is shown on Table 2. The result showed that a total of eighteen (18) amino acids were identified and quantified in all the samples. The individual amino acids, total amino acids and total essential amino acids varied with the levels of sesame seed paste inclusion in the blends. The total amino acids and total essential amino acids contents in 100% peanut butter were 88.24 g/100 g protein and 35.30 g/100 g protein respectively. The 100% sesame seed butter recorded significantly ($P = .05$) lower total amino acids content (86.40 g/100 g protein) but significantly ($P = .05$) higher total essential amino acids content (40.16 g/100 g protein) than the 100% peanut butter.

The total amino acids content in the sesame seed paste substituted butter progressively decreased with increasing level of sesame seed paste substitution ranging from 87.95 g/100 g protein for 10% sesame paste substituted butter to 87.36 g/100 g protein for 50% sesame seed paste substituted butter. Conversely, the total essential amino acids increased with increasing level of sesame seed paste substitution ranging from 35.71 g/100 g protein for 10% sesame seed paste substituted butter to 37.71 g/100 g protein for 50% sesame seed paste substituted butter.

Glutamic acid was the highest contributor to the total amino acids content and was followed by aspartic acid while leucine was the highest contributor to the essential amino acids. Methionine and cystine increased while lysine decreased with increasing level of sesame seed paste substitution. The result of computed essential amino acid scores (Table 3) showed improvement in the essential amino acid scores as a result of partial replacement of peanut paste with sesame seed paste for butter preparation.

3.1.3 Mineral content of the prepared butter

The result presented on Table 4 shows the effect of partial replacement of peanut paste with sesame seed paste on the mineral content of butter made from the blends. The result showed that the contents of K, Ca, Mg, Na, Fe and Zn in 100% peanut butter were 527.46 mg/100 g, 59.43 mg/100 g, 192.74 mg/100 g, 430.18 mg/100 g, 2.97 mg/100 g and 3.29 mg/100 g respectively. The 100% sesame seed butter had significantly ($P = .05$) lower contents of K (305.09 mg/100 g) and Na (201.06 mg/100 g) but significantly ($P = .05$) higher contents of Ca (67.80 mg/100 g), Mg (289.11 mg/100 g), Fe (6.25 mg/100 g) and Zn (5.36 mg/100 g) than the values contained in the 100% peanut butter. The K and Na contents in the butter decreased with increasing level of sesame seed paste substitution ranging from 504.13 mg/100 g and 407.96 mg/100 g respectively in the 10% sesame seed paste substituted butter to 418.10 mg/100 g and 313.92 mg/100 g respectively in 50% substituted butter. On the other hand, the Ca, Mg, Fe and Zn contents in the butter increased with increasing level of sesame seed paste substitution ranging from 60.31 mg/100 g, 201.80 mg/100 g, 3.28 mg/100 g and 3.48 mg/100 g respectively in the 10% sesame seed paste substituted butter to 63.56 mg/100 g, 241.76 mg/100 g, 4.60 mg/100 g and 4.20 mg/100 g respectively in the 50% sesame seed paste substituted butter.

3.1.4 Levels of anti-nutrients in the prepared butter

The effect of substituting peanut paste with sesame seed paste on the phytate, oxalate, saponin and tannin contents in the butter made from the blends is presented on Table 5. The result showed that the contents of phytate, oxalate, saponin and tannin in 100% peanut butter were 2.05 g/100 g, 0.31 mg/g, 3.61 g% and 4.12 mg/g respectively while their corresponding

Table 1. Proximate composition of butter made from blends of peanut and sesame seed paste (dry matter basis)

Parameters	Blending ratios (peanut : sesame seed paste)						
	100:00	90:10	80:20	70:30	60:40	50:50	00:100
Crude Protein (%)	23.91 ^a ±0.10	23.37 ^a ±0.06	23.11 ^a ±0.08	22.81 ^b ±0.05	21.48 ^b ±0.09	21.22 ^b ±0.04	20.88 ^c ±0.06
Fat (%)	44.63 ^b ±0.08	45.78 ^b ±0.03	47.01 ^c ±0.04	47.92 ^c ±0.02	49.35 ^b ±0.05	50.36 ^b ±0.08	57.25 ^a ±0.10
Ash (%)	4.05 ^a ±0.02	3.93 ^a ±0.00	3.56 ^b ±0.03	3.55 ^b ±0.01	3.50 ^b ±0.04	3.17 ^b ±0.00	2.41 ^c ±0.02
Crude Fibre (%)	3.68 ^a ±0.13	3.61 ^a ±0.09	3.47 ^b ±0.11	3.30 ^b ±0.06	3.29 ^b ±0.08	3.27 ^b ±0.05	2.68 ^c ±0.12
Carbohydrate (%)	23.73 ^a ±0.05	23.31 ^a ±0.02	22.85 ^b ±0.06	22.42 ^b ±0.30	22.38 ^b ±0.04	21.98 ^c ±0.06	16.78 ^d ±0.04
Caloric Value (Kcal/100g)	588.92 ^g ±0.04	598.74 ^f ±0.08	606.93 ^e ±0.03	612.20 ^d ±0.06	619.59 ^c ±0.02	626.04 ^b ±0.05	665.89 ^a ±0.03

Each value is the mean of triplicate determinations. Means on the same row with different superscripts are significantly different at P = .05.

Table 2. Amino acid profile of butter made from blends of peanut paste and sesame seed paste (g/100 g protein)

Amino Acids	Blending ratios (peanut paste: sesame seed paste)						
	100:00	90:10	80:20	70:30	60:40	50:50	00:100
Leucine	6.83 ^b ±0.04	6.86 ^b ±0.02	6.90 ^a ±0.01	6.93 ^a ±0.02	6.95 ^a ±0.03	7.00 ^a ±0.05	7.19 ^a ±0.03
Lysine	5.94 ^a ±0.01	5.70 ^a ±0.05	5.48 ^a ±0.02	5.24 ^b ±0.08	5.05 ^b ±0.05	4.79 ^c ±0.03	3.68 ^d ±0.05
Isoleucine	3.80 ^a ±0.03	3.85 ^a ±0.02	3.91 ^b ±0.01	3.95 ^a ±0.03	3.99 ^a ±0.01	4.03 ^b ±0.06	4.32 ^b ±0.02
Phenylalanine	4.37 ^b ±0.02	4.42 ^b ±0.04	4.50 ^a ±0.03	4.58 ^b ±0.02	4.63 ^b ±0.04	4.70 ^b ±0.02	5.08 ^a ±0.04
Tryptophan	1.16 ^a ±0.01	1.17 ^a ±0.02	1.17 ^a ±0.06	1.20 ^a ±0.01	1.22 ^a ±0.03	1.23 ^a ±0.00	1.31 ^a ±0.02
Valine	4.27 ^a ±0.03	4.31 ^a ±0.01	4.37 ^a ±0.05	4.41 ^a ±0.02	4.48 ^a ±0.06	4.55 ^a ±0.01	4.79 ^a ±0.05
Methionine	0.93 ^e ±0.05	1.17 ^d ±0.00	1.38 ^c ±0.04	1.62 ^c ±0.01	1.89 ^b ±0.02	2.10 ^b ±0.00	3.25 ^a ±0.04
Cystine	1.02 ^d ±0.02	1.14 ^c ±0.02	1.28 ^c ±0.02	1.40 ^b ±0.00	1.56 ^b ±0.02	1.69 ^b ±0.03	2.41 ^a ±0.01
Tyrosine	3.46 ^c ±0.02	3.52 ^b ±0.04	3.59 ^b ±0.03	3.65 ^b ±0.05	3.74 ^b ±0.04	3.82 ^a ±0.02	4.13 ^a ±0.03
Threonine	3.52 ^c ±0.01	3.57 ^c ±0.01	3.60 ^b ±0.05	3.66 ^b ±0.03	3.72 ^b ±0.02	3.80 ^a ±0.05	4.00 ^a ±0.02
Proline	3.45 ^a ±0.03	3.47 ^a ±0.05	3.48 ^a ±0.03	3.52 ^a ±0.02	3.55 ^a ±0.01	3.60 ^a ±0.04	3.65 ^a ±0.02
Arginine	6.88 ^a ±0.04	6.82 ^a ±0.03	6.76 ^a ±0.01	6.74 ^a ±0.08	6.67 ^b ±0.05	6.61 ^b ±0.03	6.37 ^b ±0.05
Alanine	4.55 ^a ±0.03	4.43 ^a ±0.02	4.35 ^a ±0.06	4.22 ^a ±0.03	4.11 ^a ±0.02	4.00 ^a ±0.04	3.49 ^b ±0.02
Glutamic Acid	17.92 ^a ±0.02	17.58 ^a ±0.03	17.27 ^a ±0.04	16.91 ^b ±0.10	16.59 ^b ±0.06	16.31 ^b ±0.02	14.63 ^c ±0.04
Glycine	3.99 ^a ±0.05	3.95 ^a ±0.02	3.92 ^a ±0.01	3.87 ^a ±0.04	3.84 ^a ±0.04	3.79 ^a ±0.05	3.61 ^a ±0.03
Serine	4.54 ^a ±0.02	4.46 ^a ±0.01	4.40 ^a ±0.04	4.32 ^a ±0.01	4.27 ^a ±0.02	4.20 ^b ±0.04	3.89 ^b ±0.06
Aspartic Acid	9.37 ^a ±0.03	9.30 ^a ±0.04	9.22 ^a ±0.02	9.10 ^a ±0.08	9.06 ^a ±0.04	9.01 ^a ±0.02	8.56 ^b ±0.04

Amino Acids	Blending ratios (peanut paste: sesame seed paste)						
	100:00	90:10	80:20	70:30	60:40	50:50	00:100
Histidine	2.24 ^a ±0.01	2.23 ^a ±0.02	2.20 ^a ±0.01	2.19 ^a ±0.04	2.17 ^a ±0.06	2.13 ^a ±0.01	2.04 ^a ±0.00
TAA	88.24 ^a ±0.04	87.95 ^a ±0.03	87.78 ^a ±0.05	87.51 ^a ±0.04	87.49 ^a ±0.03	87.36 ^a ±0.06	86.40 ^b ±0.02
TEAA	35.30 ^d ±0.096	35.71 ^d ±0.02	36.18 ^c ±0.04	36.64 ^b ±0.01	37.23 ^b ±0.04	37.71 ^b ±0.02	40.16 ^a ±0.03
TEAA/TAA (%)	40.01 ^d	40.60 ^d	41.22 ^c	41.87 ^c	42.55 ^b	43.17 ^b	46.48 ^a

Each value is the mean of triplicate determinations. Means on the same row with different superscripts are significantly different at P = .05. TAA = total amino acids; TEAA = total essential amino acids

Table 3. Average essential amino acid chemical scores of butter made from peanut – sesame seed paste blends (%)

Essential amino acids	Blending ratios (peanut paste: sesame seed paste)							* FAO/WHO (1985) reference value (g/100 g protein)
	100:00	90:10	80:20	70:30	60:40	50:50	00:100	
Leucine	103.33±0.01	103.78±0.00	104.39±0.02	104.84±0.01	105.14±0.02	105.90±0.00	108.78±0.03	6.61
Lysine	102.41±0.04	98.28±0.02	94.48±0.00	90.35±0.02	87.07±0.01	82.59±0.03	63.45±0.01	5.80
Isoleucine	135.71±0.02	137.50±0.01	139.64±0.00	141.07±0.01	142.50±0.01	143.93±0.01	154.29±0.02	2.80
Phen. + Tyro.	124.76±0.00	126.03±0.00	128.41±0.03	130.64±0.00	132.86±0.02	135.24±0.00	146.19±0.04	6.30
Tryptophan	105.46±0.02	106.36±0.02	106.36±0.04	109.09±0.00	110.91±0.02	111.82±0.01	119.09±0.03	1.10
Valine	122.00±0.01	123.14±0.01	124.86±0.00	126.00±0.01	128.00±0.01	130.00±0.02	136.86±0.01	3.50
Met. + Cyst.	78.00±0.02	92.40±0.03	106.40±0.00	120.80±0.01	138.00±0.02	151.60±0.03	226.40±0.02	2.50
Tyrosine	103.53±0.01	105.00±0.02	105.88±0.01	107.65±0.00	109.41±0.00	111.77±0.02	117.65±0.01	3.40

* Reference amino acid pattern of pre-school children (2 – 5 years) (FAO/WHO/UNU, 1985).

Phen. = Phenylalanine; Tyro. = tyrosine; Met. = methionine; Cyst = cysteine

Table 4. Average mineral content in butter made from blends of peanut and sesame seed paste (mg/100 g)

Minerals	Blending ratios (peanut paste: sesame seed paste)						
	100:00	90:10	80:20	70:30	60:40	50:50	00:100
K	527.46 ^a ±0.20	504.13 ^b ±0.08	483.62 ^c ±0.10	462.49 ^d ±0.05	435.75 ^e ±0.14	418.10 ^f ±0.10	305.09 ^g ±0.12
Ca	59.43 ^d ±0.16	60.31 ^c ±0.05	61.20 ^c ±0.08	61.92 ^c ±0.13	62.81 ^b ±0.09	63.56 ^b ±0.05	67.80 ^a ±0.06
Mg	192.74 ^a ±0.09	201.80 ^b ±0.13	213.15 ^c ±0.11	221.93 ^d ±0.09	232.42 ^e ±0.20	241.76 ^f ±0.07	289.11 ^g ±0.09
Na	430.18 ^a ±0.11	407.96 ^b ±0.04	385.08 ^c ±0.09	359.27 ^d ±0.02	330.14 ^e ±0.08	313.92 ^f ±0.11	201.06 ^g ±0.06
Fe	2.97 ^f ±0.06	3.28 ^e ±0.01	3.65 ^d ±0.13	3.92 ^d ±0.06	4.26 ^c ±0.10	4.60 ^b ±0.04	6.25 ^a ±0.10
Zn	3.29 ^d ±0.08	3.48 ^d ±0.12	3.71 ^c ±0.11	3.89 ^c ±0.08	4.09 ^b ±0.15	4.20 ^b ±0.06	5.36 ^a ±0.08

Each value is the mean of triplicate determinations. Means on the same row with different superscripts are significantly different at P = .05

Table 5. Anti-nutrients content in butter made from blends of peanut and sesame seed paste

Minerals	Blending ratios (peanut paste: sesame seed paste)						
	100:00	90:10	80:20	70:30	60:40	50:50	00:100
Oxalate (mg/g)	0.31 ^c ±0.15	0.33 ^c ±0.21	0.34 ^c ±0.07	0.37 ^b ±0.14	0.38 ^b ±0.05	0.40 ^b ±0.15	0.47 ^a ±0.16
Phytate (g/100g)	2.05 ^d ±0.09	2.26 ^d ±0.11	2.43 ^c ±0.03	2.59 ^c ±0.06	2.86 ^b ±0.13	3.07 ^b ±0.09	3.98 ^a ±0.05
Saponin (%)	3.61 ^a ±0.11	3.50 ^a ±0.08	3.39 ^b ±0.15	3.20 ^b ±0.00	3.09 ^c ±0.04	2.98 ^c ±0.11	2.40 ^d ±0.21
Tannin (mg/g)	4.12 ^a ±0.16	3.91 ^b ±0.09	3.62 ^b ±0.10	3.44 ^c ±0.11	3.27 ^c ±0.21	3.04 ^d ±0.16	1.92 ^e ±0.08

Each value is the mean of triplicate determinations. Means on the same row with different superscripts are significantly different at P = .05

values for 100% sesame seed butter were 3.98 g/100 g, 0.47 mg/g, 2.40% and 1.92 mg/g respectively. The oxalate and phytate contents in the butter increased with increasing level of sesame seed paste substitution ranging from 0.33 mg/g and 2.26 g/100 g respectively in 10% sesame seed paste substituted butter to 0.40 mg/g and 3.07 g/100 g respectively in 50% sesame seed paste substituted butter. On the other hand, saponin and tannin contents decreased with increasing level of sesame seed paste substitution ranging from 3.50% and 3.91 mg/g respectively in 10% sesame seed paste substituted butter to 2.98% and 3.04 mg/g respectively in 50% sesame seed paste substituted butter.

3.2 Discussion

3.2.1 Effect of the treatment on the proximate composition of the prepared butter

As shown on Table 1, replacement of peanut paste with 10 – 50% sesame seed paste had varying effects on the crude protein, fat, ash, crude fibre and carbohydrate contents of butter made from the blends. The crude protein content of 100% peanut butter obtained in the present study (23.91%) was within the range (22.33 – 28.58%) reported by Boli et al. [28] but was higher than the range (20.50 – 23.00%) reported by Shibli et al. [6] for peanut butter. The protein content of 100% sesame seed butter (20.88%) was lower than the range (21.90 – 22.59%) reported by El-Adawy and Manour [19] and 24.7% reported by Sawaya et al. [29] for sesame seed butter. This could be due to varietal differences and differences in ingredients used in preparing the butter. The observed decrease in crude protein content in the butter with increasing level of sesame seed paste substitution could be attributed to lower protein content in 100% sesame seed paste than in 100% peanut paste. Despite the decrease in crude protein content with increasing level of sesame seed paste substitution, all the produced butters still contained high level of protein content. The human body needs protein to supply amino acids for the growth and maintenance of cells. The high protein content in the formulated butter suggests that the product could be used in conjunction with other foods such as bread, biscuits and crackers as protein supplement to enhance the protein intake of consumers especially those with protein – energy malnutrition.

As expected, fat was the most dominant constituent in both 100% peanut butter and in 100% sesame seed butter. The fat content in 100% peanut butter (44.63%) was within the ranges of 40.43 – 47.5% and 42.58 – 49.32% reported by Shibli et al. [6] and Boli et al. [28] respectively for peanut butter. The fat content of 100% sesame seed butter (57.25%) was slightly lower than 58.59 – 59.37% and 58.9% reported by El-Adawy and Manour [19] and Sawaya et al. [29] respectively but was higher than 56.50% reported by Rababah et al. [30] for sesame seed butter. The increase in fat content in the butter with increasing level of sesame seed paste substitution could be attributed to higher fat content in sesame seed paste than in peanut paste. Fat in food is usually the highest contributor of energy in the body. A small amount of dietary fat is an essential part of the diet as it provides the body with essential fatty acids and also acts as carriers of fat soluble vitamins [31]. In butters, fat imparts shortening effect and improves the tenderness, spreadability, mouth feel and flavour of the product [32]. The high percentage of unsaturated fatty acids in peanut oil [6,7] and in sesame seed oil [11,14,15] is considered advantageous for preventing heart diseases and controlling bad cholesterol level in human body [33,34]. In view of the fact that butter made from peanut paste and sesame seed paste consists of plant based unsaturated fats with negligible amount of trans fat [35], the product could be considered healthier alternative to dairy butter.

The ash content of a food material is an index of the mineral element in such food. The ash content obtained in the present study (Table 1) for 100% peanut butter (4.05%) was higher than 3.16 – 3.27% reported by Shibli et al. [6] but was lower than 4.64 – 5.82% reported by Boli et al. [28] for peanut butter. The ash content for 100% sesame seed butter (2.41%) was comparable to 2.62 – 2.88% reported by El-Adawy and Manour [19] but was lower than 3.0% and 3.6% reported by Sawaya et al. [29] and Rababah et al. [30] respectively for sesame seed butter. The decrease in ash content in the samples with increasing level of sesame paste substitution could be due to lower ash content in sesame seed paste than in peanut paste.

The crude fibre content for 100% peanut butter (3.68%) was within the range (2.12 – 4.47%) reported by Shibli et al. [6] but was lower than 5.0 – 5.63% reported by Boli et al. [28] for peanut butter. The crude fibre content of 2.68% recorded

for 100% sesame seed butter was within the range (2.40 – 2.92%) reported by El-Adawy and Manour [19] but was higher than 2.3% and 2.2% reported by Sawaya et al. [29] and Rababah et al. [30] respectively for sesame seed butter. The low crude fibre content in sesame seed butter could be attributed to the fact that the seeds were decorticated before processing to paste. The decreased in crude fibre content in the butter with increasing level of sesame seed paste substitution could be attributed to lower crude fibre content in sesame seed paste than in peanut paste. Intake of high fibre diet is associated with lower risk of coronary heart disease, colon cancer, type 2 diabetes and bowel disorders [36,37].

The carbohydrate contents of all the samples (Table 1) were low (16.78 – 23.73%). The carbohydrate content for 100% peanut butter (23.73%) was within the ranges of 22.73 – 32.98% and 17.23 – 23.92% reported by Shibli et al. [6] and Boli et al. [28] respectively for peanut butter. The value for 100% sesame seed butter (16.78%) was comparable to 16.31% reported by Mijena [38] for sesame fat spread but was higher than 13.15 – 13.54% and 11.2% reported by El-Adawy and Manour [19] and Rababah et al. [30] respectively for sesame seed butter. Progressive reduction of carbohydrate content in the butter with increasing level of sesame seed paste substitution could be attributed to lower carbohydrate content in sesame seed paste than in peanut paste.

The observed significant increase ($P = .05$) in caloric value of the butter with increasing level of sesame seed paste substitution could be attributed to increase in fat content in the samples with increase in the proportion of sesame seed paste inclusion. The food constituents that contribute to energy value are protein, fat and carbohydrate with fat as the major contributor (9 kcal/g) while protein and carbohydrate contribute about 4kcal/g each. This explains why the 100% sesame seed butter with the highest fat content (57.25%) had the highest caloric value and 100% peanut butter with the lowest fat content (44.43%) also exhibited the least caloric value.

3.2.2 Effect of the treatment on amino acid profile of the produced butter

The quality of protein food is nutritionally judged by its protein content and the number and amount of essential amino acid it contains.

Amino acids which are the basic building blocks of protein with a variety of functions are often categorized as essential or non-essential amino acids. All amino acids in foods have different role that help the body to grow and function optimally. However, essential amino acids are of major concern as they are not manufactured in the body and must be supplied in adequate amounts through the diet.

The observed variations in individual amino acids, total amino acids and total essential amino acids among butters produced from different levels of sesame seed paste substituted blends (Table 2) could be attributed to differences between amino acid profile of peanut paste and the sesame seed paste. Similar differences between the amino acid profile of peanut meal and sesame seed meal had been reported [39]. In agreement with the result of the present study, Maneemagalai and Prasad [39] also reported that the first two highest contributors to the total amino acids of peanut and sesame seed meal were glutamic acid and aspartic acid and leucine as the highest contributor to the essential amino acids. The total essential amino acids obtained for 100% sesame seed butter (40.16 g/100 g protein) in the present study was within the range (35.2 – 40.1 g/100 g protein) reported for sesame seed butter [19]. It is interesting to note that sulphur containing amino acids (methionine and cystine) that were higher in 100% sesame seed butter than in 100% peanut butter increased while lysine that was higher in peanut butter than in sesame seed butter decreased with increasing level of sesame seed paste substitution. This clearly shows that sesame paste protein was complementary to peanut protein. The result suggests that consumers of butter made from blends of peanut paste and sesame seed paste would derive protein of superior nutritional quality than the counterpart made from 100% peanut paste since these essential amino acids cannot be synthesized in the body.

Essential amino acid scores (Table 3) revealed that almost all the essential amino acids in the formulated butter had scores above 100% except for lysine with the value of 63.45% (for 100% sesame seed butter) and a range of 82.59 – 98.28% for sesame paste substituted butters and sulphur containing amino acids with 78.00% for 100% peanut butter and 92.40% for 10% sesame seed paste substituted butter. The high scores recorded in the present study for 100% sesame seed butter are in agreement with the reports by other authors [40,41] that almost all essential

amino acids of sesame seed protein were significantly higher than the FAO/WHO requirements for both infants and adults except for lysine, which was available in limited quantity. Sawaya et al. [29] similarly reported that sulphur containing amino acids in sesame seed butter were present in amounts exceeding the requirement of the FAO/WHO reference pattern. Comparison of the essential amino acid composition of the present study with the reference value of FAO/WHO/UNU [25] showed that majority of the essential amino acids of sesame seed paste supplemented butter would meet the recommended range of amino acids required for children 2 – 5 years and adults.

3.2.3 Effect of the treatment on mineral content of the produced butter

Minerals are inorganic substances that are needed in small amounts for the proper functioning of the body and are generally supplied by a variety of foods in the diet. They help the body to grow, develop and stay healthy. The result presented on Table 4 showed that both 100% peanut and sesame seed butter are rich sources of mineral elements. This agrees with the reports by Shibli et al. [6] for peanut butter and by El-Adawy and Manour [19], Sawaya et al. [29], Rababah et al. [30] and Akbulut [42] for sesame seed butter. The contents of K (527.46 mg/100 g) and Na (430.18 mg/100 g) for 100% peanut butter obtained in the present study were lower than the ranges of 661.34 – 820.86 mg/100 g and 603.16 – 790.87 mg/100 g respectively while the Ca (59.43 mg/100 g) and Mg (192.74 mg/100 g) were within the ranges of 58.06 – 64.45 mg/100 g and 146.73 – 203.30 mg/100 g respectively reported by Shibli et al. [6] for peanut butter. The differences in values could be due to variety of peanut used, growing conditions and ingredients used in producing the butter. For the 100% sesame seed butter, the values for K (305.09 mg/100 g) and Ca (67.80 mg/100 g) obtained in the present study were higher than 276.5 mg/100 g and 20.4 mg/100 g respectively while Na (201.06 mg/100 g) was lower than 288.6 mg/100 g reported by Rababah et al. [30] for sesame seed butter. Also, the values for Mg (289.11 mg/100 g), Fe (6.25 mg/100 g) and Zn (5.36 mg/100 g) were lower than 363.00mg/100g, 7.19 mg/100 g and 7.82 mg/100 g respectively while Ca was higher than 61.00 mg/100 g reported by Sawaya et al. [29] for sesame seed butter. The recorded increases in Ca, Mg, Fe and Zn and decreases in K and Na in the butter with

increasing level of sesame seed paste substitution could be attributed to higher contents of Ca, Mg, Fe and Zn and lower contents of K and Na in sesame seed paste than in peanut paste. The body requires relatively large amount of potassium because it functions as an important electrolyte in the nervous system and has been shown to have a powerful dose – dependent inhibitory effect on sodium sensitivity [43]. Calcium is an important mineral that contributes to the health of bone and teeth, blood clotting and muscle contraction [44]. Magnesium plays important role in maintaining normal muscle and nerve functions, contributes to bone health and is needed as a co-factor for numerous reactions in the body [44]. High amount of potassium, calcium and magnesium have been reported to reduce blood pressure in humans [45]. Iron aids in the formation of blood, oxygen transportation in haemoglobin through the human body and prevention of anaemia. Zinc is involved in cellular growth and differentiation. Zinc deficiency causes impaired growth, immune dysfunction, increased morbidity and mortality and abnormal neurobehavioral development [44].

3.2.4 Effect of the treatment on the anti-nutritional factors in the produced butter

Peanut butter and sesame seed butter are rich sources of protein and minerals (K, Ca, Mg, Na, Fe and Zn) (Tables 1 and 4). However, the bioavailability of these nutrients would be hindered by the present of anti-nutritional factors that exhibit undesirable physiological effects on them thereby reducing their nutritive value [46]. The recorded low levels of phytate, oxalate, saponin and tannin contents in the produced butter (Table 5) could be attributed to the processing treatments (soaking, decortication/hull removal and roasting) given to the raw peanut and sesame seeds during the production process. Embaby [46] for instance reported that roasting significantly reduce the level of phytate and tannin in peanut and sesame seed. Jimoh et al. [47] similarly reported that roasting led to significant reduction of oxalate, phytate, saponin and tannin in sesame seed meal. Significant reduction in phytate and oxalate contents in black and white sesame seeds as a result of dehulling was also reported [48].

The contents of phytate (3.98 g/100 g) and Tannin (1.92 mg/g) obtained in the present study for 100% sesame seed butter were comparable to 3.7 g/100 g and 1.8 mg/g respectively reported

for sesame seed butter [46]. The value for phytate was however lower than 4.64% reported by Mijena [38] for sesame fat spread. For the 100% peanut butter, the values for phytate (2.05 g/100 g) and tannin (4.12 mg/g) were lower than 2.9 g/100 g and 7.5 mg/g respectively reported by Embaby [46] for roasted peanut. The observed increase in phytate content and decrease in tannin content in the butter with increasing level of sesame seed paste substitution could be attributed to higher phytate and lower tannin contents in sesame seed paste than in peanut paste. Phytate has been reported to form insoluble complexes with nutritionally important minerals (Ca, Mg, Fe and Zn) and with protein thereby rendering them unavailable for absorption [49,50]. Tannin interferes with digestive processes either by binding to enzymes such as α -amylase, trypsin and chymotrypsin or by binding to food components like protein and some essential minerals [51,52]. The oxalate content for peanut butter (0.31 mg/g) was slightly higher than 0.29 mg/g while the saponin content (3.61%) was within the range of 2.9 – 5.7% reported by Mada et al. [53] for roasted groundnut. The oxalate content of sesame seed butter (0.47 mg/g) was lower than 0.75mg/g while the saponin content (2.40%) was higher than 1.90% reported by Jimoh et al. [47] for sesame seed meal. The increased in oxalate and decreased in saponin contents in the prepared butter with increasing level of sesame paste substitution could be attributed to higher oxalate content and lower saponin content in sesame seed paste than in peanut paste. Oxalate usually binds with calcium, iron and zinc and reduces the physiological availability of these minerals [54]. Saponin has been found to affect protein digestibility by various digestive enzymes such as trypsin and chymotrypsin [55] thereby reducing its bioavailability. Saponins have also been found to have beneficial effects in humans. Recent findings revealed that saponin – rich foods are important diets to control plasma cholesterol, prevent peptic ulcer, osteoporosis and to reduce the risk of heart disease [55]. This shows that some anti-nutrients usually play a dual role of acting as anti-nutrients and also providing health protecting effects in humans.

4. CONCLUSION

It is evident from the study that the nutritional value of peanut butter could be improved by using blends of peanut and sesame seed paste for its production. The result has clearly shown

that peanut paste complements sesame seed paste in butter production especially with respect to limiting essential amino acid of lysine in sesame seed and sulphur containing amino acids in peanut seed. Butter produced from the blended pastes had relatively high contents of protein with improved amino acid profile as well as mineral elements and the low anti-nutritional factors found in the samples may not have serious effect on nutrient bioavailability. The reduction of sodium content with increase in sesame seed paste substitution is of health benefit to the potential consumers of the product. Production of butter from blends of peanut and sesame seed pastes would provide variety of plant based butter to the consumers and may increase the utilization of sesame seed in Nigeria. Further work is ongoing to determine the blend that would give the most acceptable butter as well as storage stability of the product.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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