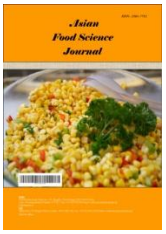

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Fatty Acid Profile and Oil Stability of Butter Made from Peanut Paste Supplemented with Sesame Seed Paste

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Authors' contributions

The study was conducted in collaboration between both authors. Author UEI designed the study, wrote the protocol and the first draft. Both authors carried out the experimentation and gathered the initial data. Author OVO managed the literature searches and data analysis. Both authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted to assess the effect of supplementation of peanut paste with 0, 10, 20, 30, 40 and 50% sesame seed paste on the fatty acid profile and oil stability of butter made from the blends. Packaged samples from each blend were stored at ambient temperature (27±2^{o}C) for 12 weeks and analysed for oil separation, peroxide value (PV) and acid value (AV) at four weeks interval. Unblended peanut and sesame seed butters served as control samples. The result showed that apart from behenic acid that was not detected in sesame butter oil, the other eight fatty acids detected in peanut butter oil were also found in sesame butter oil but in varying quantities. Oil extracted from 100% peanut and sesame seed butters contained slightly below 20% saturated fatty acids (SFAs) and slightly above 80% unsaturated fatty acids (UFAs). Palmitic, palmitoleic, oleic, linolenic, arachidic and behenic acids decreased while stearic, linoleic, and eicosenoic acids increased with increase in sesame paste supplementation. Butters made from blended pastes had higher percentages of SFAs and polyunsaturated fatty acids (PUFAs) but lower percentage of monounsaturated fatty acid (MUFAs) than 100% peanut butter oil. Oil separation, PV and AV significantly (P = .05) increased with storage time. Quantity of oil separated

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at week 12 ranged from 1.05% to 3.19%. The rate of peroxide formation decreased with increase in sesame paste supplementation. Consequently, at week 12, while 10% sesame paste supplemented butter recorded 263.12% increment in PV, the value for 50% sesame paste supplemented butter was 143.01%. The treatment had no effect on acid value during storage. At week 12, the AV increment for the butters from the blended pastes ranged from 179.59% to 181.82% while the values for 100% peanut butter and 100% sesame butter were 183.72% and 119.64% respectively. The study has shown that butter of high unsaturated fatty acids with delayed onset of oxidative deterioration could be produced from peanut paste supplemented with sesame seed paste.

Keywords: Peanut paste; sesame seed paste; butter; fatty acid profile; storage time; oil stability.

1. INTRODUCTION

Health concerns regarding the consumption of dairy butter due to its fat content and high saturated fatty acids has stimulated the search for alternative plant based butters such as nuts and seed butters [1]. Most nuts such as peanut and some seeds including sesame seed are generally consumed as snack foods in roasted form as they are of good flavour, handy and easy to eat. However, with the emergence of new technologies, many varieties of processed products are at present available in the grocery stores, out of which nut and seed butters have gained more popularity than other products. Processing of nuts and seeds into butter is one of the healthy ways of integrating the locally available nuts and seeds into our daily diets.

Peanut (*Arachis hypogaea*) which is also known as groundnut is a legume crop that belongs to the family fabaceae. It is cultivated in semi-arid and sub-tropical regions of the world including Nigeria. Although a legume, peanut is generally included amongst the oil bearing seeds due to its high oil content. It is ranked as the third major source of edible oil in the world as well as a rich source of energy and protein [2,3]. It contains 47 – 50% oil content which has greater percentage of unsaturated fatty acids (UFAs) that makes it an edible oil of choice for human nutrition and good health [4]. Peanut is also a rich source of minerals, vitamins and bioactive compounds that contribute towards its protective effects against cardiovascular ailments, cancer, diabetes and other degenerative diseases [2].

Peanut butter is the most important product made from peanut and it is utilized as nutritious spread for bread and crackers as well as ingredient in sandwiches, cookies and confectionaries among other products [5]. Peanut butter is considered healthier alternative to butter and margarine because it mostly consists of plant based unsaturated fats with negligible amount of trans-fat [6]. The appealing flavour, nutritional value and convenience of use contribute greatly to its popularity. Due to its high oil content and richness in unsaturated fatty acids as well as oil separation during storage, peanut butter is susceptible to oxidative rancidity and off-flavour development thereby affecting the shelf-stability of the product [7-10]. Oil separation during storage affects textural quality and spreadability of peanut butter [11].

Sesame seed (*Sesamum indicum L.*) is an oil bearing seed cultivated in the tropical and sub-tropical areas including Nigeria [12]. The seeds are considered as valuable food as they enhance the diet with pleasing aroma and offer nutritious and physiological benefits [13]. It is popularly known as “Queen of oilseeds” due to its high degree of resistance to oxidation and rancidity [14]. Sesame seed contains 50 – 60% of high quality oil that is rich in polyunsaturated fatty acids (PUFAs) and natural antioxidant lignans (*sesamin, sesamolin and sesamol*) and tocopherol [13,15]. The presence of these lignans along with tocopherol and phytosterols in the oil provide defence mechanism against reactive oxygen species and increases the keeping quality of oil by preventing oxidative rancidity [13,16,17,18]. Clinical studies have shown that sesame oil consumption has many benefits to health like minimizing the occurrence of cancer, contributes to the avoidance of degenerative processes and therefore decrease the death rate through cerebro and cardiovascular diseases [19].

Although sesame seeds are used essentially for the production of oil, but they are also used in the production of paste called tehina (butter) and in various food formulations [17,20]. According to Sawaya [21], sesame butter is high in protein

(24.7%) and mineral contents. The protein is high in sulphur containing amino acids (methionine and cystine) but is low in lysine content [21,22]. Sesame paste has remarkable oil stability and resistant to oxidative deterioration due to endogeneous antioxidants that are present in sesame seed [23]. This suggests that peanut paste that is usually susceptible to oxidative deterioration and rancid flavour development could be substituted with sesame paste as a means of enhancing the stability of the product. The aim of the present study therefore was to assess the effects of peanut paste supplementation with dehulled sesame seed paste on the fatty acid profile and oil stability of butter made from the blends.

2. MATERIALS AND METHODS

2.1 Materials Procurement

Red skin peanut, white variety of sesame seed and honey were purchased from Monday market in Kaduna, Kaduna State, Nigeria. 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 peanut seeds (5 kg) were washed and spread for water on the surface of the nuts to dry off. The nuts were roasted at 160^{o}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 at ambient temperature (27^{o}C). 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 air tight 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. [24]. This was done by soaking the seeds (5kg) in a mixed solution of 0.04% of NaOH and 3% $NaCo_3$ for 50 minutes with a seed to lye ratio of 1:3 (w/v). Sieve was used to drain off the solution and the seeds washed with potable 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^{o}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 Ingredients formulation for butter production

The ingredients and their levels used for the production of butter made from blends of peanut-sesame seed pastes are shown in Table 1.

2.2.5 Production and storage of peanut – sesame seed paste butter

The formulated ingredients which comprised of 90% paste and 10% other ingredients were used for producing the butter. The salt (1.5%) for taste, non-hydrogenated palm oil (3.0%) as stabilizer and honey (5.5%) for flavour enhancement were added to each of the formulated paste in a food processor and ground to a homogenous viscous smooth butter. Samples were taken from the freshly prepared butter for fatty acid determination. Part of each of the prepared butter was packaged (150 g per pack) in pre-sterilized plastic containers, covered air tight, labeled and stored at ambient temperature (27±2^{o}C) for 12 weeks. Triplicate samples were taken from each lot at four weeks interval for peroxide value (PV) and acid value (AV) determinations. The remaining part of each of the butter was packaged (20g per container) in small plastic sample containers, covered air tight, labeled and stored at ambient temperature for 12 weeks. Triplicate samples were taken from each lot at four weeks interval and assessed for quantity of oil separated from the samples. The storage environment was chosen to reflect the retail environment for peanut butters.

Table 1. Ingredients formulation for butter production

Ingredients (g)	Blending Ratios (Peanut Paste : Sesame Seed Paste)						
	100:00	**90:10**	**80:20**	**70:30**	**60:40**	**50:50**	**00:100**
Peanut Paste	800	720	640	560	480	400	-
Sesame Seed Paste	-	80	160	240	320	400	800
Salt	13.33	13.33	13.33	13.33	13.33	13.33	13.33
Palm Oil	26.67	26.67	26.67	26.67	26.67	26.67	26.67
Honey	48.90	48.90	48.90	48.90	48.90	48.90	48.90
Total	888.90	888.90	888.90	888.90	888.90	888.90	888.90

2.3 Methods of Analysis

2.3.1 Determination of fatty acid profile

Oil was first extracted from each of the samples using hexane. Fatty acids content in the extracted oil was converted to fatty acid methyl esters (FAMEs) before using gas chromatography to identify and quantify the individual fatty acids in the samples.

Preparation of FAMEs: The method described by Christopherson and Glass [25] was followed in the preparation of FAMEs with slight modifications. Each of the samples (0.10g) was weighed into a glass tube with screw cap and dissolved in 10.0 mL hexane. Then 100 μL of 2 N potassium hydroxide solution prepared in methanol was added and the tubes were shaken vigorously for 30 seconds. The mixed solution was subjected to centrifugation at 2500 x g for 5 min. The upper layer was transferred to a small vial and kept at 0^{o}C until analyzed.

Gas Chromatography Analysis: The prepared fatty acid methyl esters (FAMEs) were analyzed by injection of 1μL of the hexane layer through the injection port of the GLC (Model GC – 2010, Shimadzu Corporation, Koyoto, Japan) equipped with a flame ionization detector (FID) and a column (DB – 23, 30 m x 0.25 m and 0.25 μm thickness). The FAMEs were injected after adjusting the GLC conditions as follows: The injector temperature was 250^{o}C with split ratio of 1:70 and nitrogen was used as the carrier gas. The flow rate was 1.2 mL/min. The flame ionization detector temperature was 260^{o}C. Column oven temperature was 180^{o}C for 10min, increased to 200^{o}C (heating rate 5^{o}C/min) and kept at 200^{o}C for 5min before increasing to 210^{o}C (heating rate 3^{o}C/min) and kept at 210^{o}C for 20 mins. The peaks of FAME were analyzed by comparing their retention time with those of the authentic standards purchased from Sigma Aldrich (St. Louis, MO, USA) and which had been subjected to similar separation conditions. The amount of individual fatty acid was expressed as percentage of the total fatty acids.

2.3.2 Oil separation determination

The method described by Radocay et al. [26] was followed in the measurement of separated oil with slight modification. Each of the containers was opened, inverted and placed on a pre-weighed petri dish with two folded No. 4 Whatman filter papers to absorb the oil. The inverted container in the petri dish was left to stand for 8 hours for the separated oil to drain into the filter papers. The container with the sample was removed and the petri dish together with the filter paper containing the absorbed oil was weighed. The amount of oil separated was calculated and the result expressed as percentage of the original weight of the sample as shown in the following equation:

$$\text{Oil separation (\%)} = \frac{\text{Weight of Oil Separated}}{\text{Weight of Sample}} \times \frac{100}{1}$$

2.3.3 Determination of Peroxide Value (PV) and Acid Value (AV)

AOCS official methods [27] were used for the determination of peroxide value (Cd 8 – 53) and acid value (Cd 3d – 63).

2.4 Statistical Analysis

The results were expressed as the means ± standard deviation of triplicate determinations. Data were subjected to one-way analysis of variance (ANOVA) using SPSS version 18 statistical package (SPSS Inc, Chicago, USA) to determine significant difference at P= .05. Means were separated using Duncan's Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

3.1 Effect of Supplementation of Peanut Paste with Sesame Seed Paste on the Fatty Acid Profile of Butter Made from the Blends

The effect of supplementation of peanut paste with sesame seed paste on fatty acid profile of butter made from the blends is presented on Table 2. The result showed that oils extracted from the produced butter are sources of important fatty acids. A total of nine fatty acids were detected and quantified in 100% peanut butter oil while eight fatty acids were recorded for 100% sesame seed butter oil. Apart from behenic acid (C22:0) that was not detected in sesame seed butter oil, the other fatty acids present in 100% peanut butter oil were also present in sesame butter oil but their values varied from each other. Orsavova et al. [28] had earlier reported that each vegetable oil has specific fatty acid distribution depending on the plant source. It has also been shown that environmental factors play an important role in fatty acid composition [29]. Similar variations in fatty acid composition of oils from different seeds and nuts have been reported [30,31,32].

Fatty acids detected in 100% peanut butter oil in the present study are in harmony with reports by other authors [33,34] while those in sesame seed butter oil agree with the reports by Hussein et al. [33], Borchani et al. [35] and Hama [36]. Fatty acids extracted from both 100% peanut and 100% sesame butter oils composed of a mixture of saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs). The saturated fatty acids constituted slightly below 20% while unsaturated fatty acids constituted slightly above 80% of the total fatty acids in both peanut and sesame butter oils.

This result is in harmony with the reports by Özcan and Seven [34], and Riveros et al [37] for peanut butter oil and Borchani et al. [35] and Gharby et al. [38] for sesame seed oil. For both 100% peanut and 100% sesame seed oils, palmitic acid (C18:0) and stearic acid (C18:0) were the most predominant saturated fatty acids while oleic acid (C18:1) and linoleic acid (C18:2) were the most predominant unsaturated fatty acids. These results were similar to those obtained in different studies [5,32,34,35] for peanut oil and [35,39,40] for sesame seed paste oil. The nutritional quality of edible seed oil is determined ideally by the presence of a low level of saturated fatty acids and a high level of unsaturated fatty acids [41]. Unsaturated fatty acids like oleic, linoleic and linolenic acids are fundamental in human diets as they cannot be produced by human body metabolism [42].

The values of palmitic, palmitoleic, oleic, linolenic, arachidic and behenic acids in 100% peanut butter oil were 13.04%, 0.43%, 46.85%, 0.53%, 0.74% and 1.25% respectively and were higher than the corresponding values of 12.68%, 0.19%, 42.74%, 0.34%, 0.51% and 0.00% respectively recorded for 100% sesame seed butter oil. Supplementation of peanut paste with 10 – 50% sesame seed paste led to the reduction of the aforementioned fatty acids with increase in the proportion of sesame seed paste addition. This could be attributed to higher contents of these fatty acids in peanut paste than in sesame seed paste. The stearic, linoleic and eicosenoic acids in 100% peanut butter oil were 4.11%, 32.91% and 0.13% respectively and were significantly ($P = .05$) lower than the corresponding values of 6.26%, 36.99% and 0.25% respectively recorded for sesame seed butter oil. Consequently, supplementation of peanut paste with sesame seed paste resulted in increased in the aforementioned fatty acids with increase in the proportion of sesame seed paste substitution. This could be attributed to their higher values in sesame paste oil than in peanut paste oil. The percentage of saturated fatty acids (19.14%) and polyunsaturated fatty acids (33.44%) in peanut butter oil were lower than 19.45% and 37.33% respectively recorded for sesame seed butter oil. On the other hand, the percentage of monounsaturated fatty acids in peanut butter oil (47.41%) was significantly higher than the value (43.18%) recorded for sesame butter oil. For the butters made from the blended pastes, the result showed increases in the percentage polyunsaturated fatty acids and saturated fatty acids and decrease in monounsaturated fatty acids with increase in sesame seed paste substitution. All the samples contained oleic acid as the major unsaturated fatty acid with a range of 42.74 – 46.85%. This is of significant importance because oleic acid has been associated with several human health benefits; including decreased risk of cardiovascular disease (CVD), by reducing the level of serum low-density lipoprotein (LDL) cholesterol and maintaining the level of high-density lipoprotein (HDL) cholesterol, without causing significant weight gain [43].

Table 2. Effect of supplementing peanut paste with sesame seed paste on the fatty acid profile of butter made from the blends (%)

Fatty Acids	Blending Ratios (Peanut Paste : Sesame Seed Paste)						
	100:00	**90:10**	**80:20**	**70:30**	**60:40**	**50:50**	**00:100**
Palmitic acid (C16:0)	13.04^{a}±0.01	13.01^{a}±0.00	12.98^{a}±0.02	12.92^{a}±0.01	12.89^{a}±0.03	12.85^{b}±0.00	12.68^{b}±0.02
Palmitoleic acid (C16:1)	0.43^{a}±0.00	0.40^{a}±0.03	0.38^{a}±0.01	0.36^{a}±0.04	0.33^{b}±0.02	0.31^{b}±0.01	0.19^{c}±0.01
Stearic acid (C18:0)	4.11^{d}±0.02	4.32^{c}±0.00	4.52^{c}±0.02	4.77^{b}±0.00	4.96^{b}±0.01	5.20^{b}±0.02	6.26^{a}±0.00
Oleic acid (C18:1)	46.85^{a}±0.01	46.42^{a}±0.04	46.04^{a}±0.02	45.61^{b}±0.01	45.20^{b}±0.00	44.75^{c}±0.03	42.74^{d}±0.02
Linoleic acid (C18:2)	32.91^{d}±0.03	33.31^{d}±0.02	33.71^{c}±0.01	34.09^{c}±0.03	34.53^{b}±0.02	35.03^{b}±0.02	36.99^{a}±0.01
Linolenic acid (C18:3)	0.53^{a}±0.02	0.51^{a}±0.01	0.49^{a}±0.00	0.48^{a}±0.02	0.46^{b}±0.01	0.41^{b}±0.02	0.34^{c}±0.03
Arachidic acid (C20:0)	0.74^{a}±0.01	0.72^{a}±0.03	0.70^{a}±0.01	0.69^{a}±0.00	0.66^{b}±0.02	0.60^{b}±0.01	0.51^{c}±0.02
Eicosenoic acid (C20:1)	0.13^{b}±0.03	0.14^{b}±0.00	0.15^{b}±0.02	0.17^{b}±0.01	0.18^{b}±0.03	0.20^{a}±0.00	0.25^{a}±0.00
Behenic acid (C22:0)	1.25^{a}±0.04	1.12^{a}±0.02	0.99^{b}±0.03	0.86^{b}±0.02	0.74^{c}±0.01	0.61^{c}±0.02	ND
SFAs	19.14^{a}±0.00	19.17^{a}±0.00	19.20^{a}±0.02	19.24^{a}±0.01	19.25^{a}±0.02	19.26^{a}±0.03	19.45^{a}±0.01
MUFAs	47.41^{a}±0.01	46.69^{a}±0.01	46.57^{b}±0.01	46.14^{b}±0.02	45.71^{b}±0.00	45.26^{c}±0.01	43.18^{d}±0.02
PUFAs	33.44^{d}±0.00	33.82^{d}±0.02	34.20^{c}±0.01	34.57^{c}±0.00	34.99^{b}±0.01	35.44^{b}±0.02	37.33^{a}±0.01
UFAs/SFAs	4.22	4.21	4.21	4.20	4.19	4.19	4.14

Each value is the mean of triplicate determinations. Means on the same row with different superscripts are significantly different at P = .05. SFAs = Saturated fatty acid, MUFAs = Monounsaturated fatty acid, PUFAs = Polyunsaturated fatty acid, ND = Not detected

Wahrburg et al. [44] reported that oleic acid can reduce cholesterol, regulate blood fat, lower blood sugar and participate in other important physiological functions. Because of these nutritional roles, oleic acid is regarded as one of the healthy dietary fatty acid and as an indicator of product quality [45]. The ratio between total unsaturated fatty acids and saturated ones (UFA/SFA) was 4.22 for 100% peanut butter oil and 4.11 for sesame butter oil. The values for butter made from the blended pastes ranged from 4.19 for 50% sesame paste substituted butter to 4.21 for 10% sesame paste substituted butter. The ratio is usually used to predict the shelf-life of the sample. The lower the ratio, the longer will be the shelf-life of the butter [32]. The result obtained in this study suggests that 100% sesame seed butter and butter made from sesame paste supplemented blends would be more shelf-stable than the 100% peanut butter.

3.2 Effect of Storage Time on Oil Separation

Separation of oil from nut and seed butter or spread is viewed as a quality defect and is one of the most common problems encountered during the storage of the product. It accelerates lipid peroxidation which results in rancidity and off-flavour development due to the exposure of the free oil to air and light [11]. Oil separation also results in contamination of the container, reduction in marketability and formation of a tough and non-smooth texture of the product [46].

The effect of storage time on the oil separated from butter made from blends of peanut paste and sesame seed paste is presented on Fig. 1.

The result showed that percentage oil separated from the samples varied with the proportion of sesame seed paste substitution and the storage time. All the samples exhibited increase in oil separation with storage time. This result is in agreement with the reports from other studies [10,46,47]. The result revealed that oil separation increased rapidly within the storage period of eight weeks and occurred somewhat slightly afterwards. Similar observation was reported by Hou et al. [46]. At the end of the 12 weeks storage period, the 100% sesame seed butter recorded the highest percentage of oil separation (3.19%) while the 30% sesame seed paste substituted butter recorded the least value (1.05%). For the 100% peanut butter, the percentage oil separation at the end of the storage period was 2.41%. The values for oil separation recorded in the present study were lower than 14.8% reported by Grills and Resurrection [47] for peanut butter stored at 21^{o}C for 153 days and 11.74% reported by Hou et al. [46] for sesame seed paste stored at 20.5^{o}C for 180 days. The inclusion of non-hydrogenated palm oil as stabilizer in the formulation might have increased the viscosity of the oil phase resulting in low oil separation recorded in this study. Ereifej et al. [48] reported that addition of 1.0% and 2.5% of non-hydrogenated palm oil as an ingredient in halva (sesame seed butter) preparation resulted in no visible oil separation in the sample stored at room temperature (25^{o}C) for 32 days. Variations in the level of separated oil in seed and nut butters reported by different authors in the literature could be due to differences in the variety of seeds and nuts that are used, particle size of the product, storage temperature and time. Mohd Rozalli et al. [10] reported that peanut variety, grinding time, storage temperature and time were the major factors that had significant influence on oil separation of natural peanut butter during storage for 16 weeks. Oil separation in nut and seed butter is due to differences in specific gravity of solid particles and oil comprising the product. Hou et al. [46] reported that with increase of storage time, the small particles might aggregate to form large particles and sink, causing the oil to rise and thus increase the oil quantity separated.

3.3 Effect of Storage Time on Peroxide Value (PV)

Peroxides are primary products of lipid oxidation and the peroxide value is indicative of the extent to which oil, or other lipid is oxidized [49]. Determination of PV is widely used to document the oxidative status of oil and lipid based foods as the highly reactive peroxides promote formation of aldehydes and other small molecular weight compounds that negatively affect flavour [50]. Assessment of oil quality of peanut based butter with storage time is important because of its high oil content and richness in unsaturated fatty acids which make it susceptible to developing rancidity and off-flavour through lipid oxidation [7,9].

The effects of supplementation of peanut paste with sesame seed paste as well as the storage time on peroxide value of butter made from the blends are presented on Table 3.

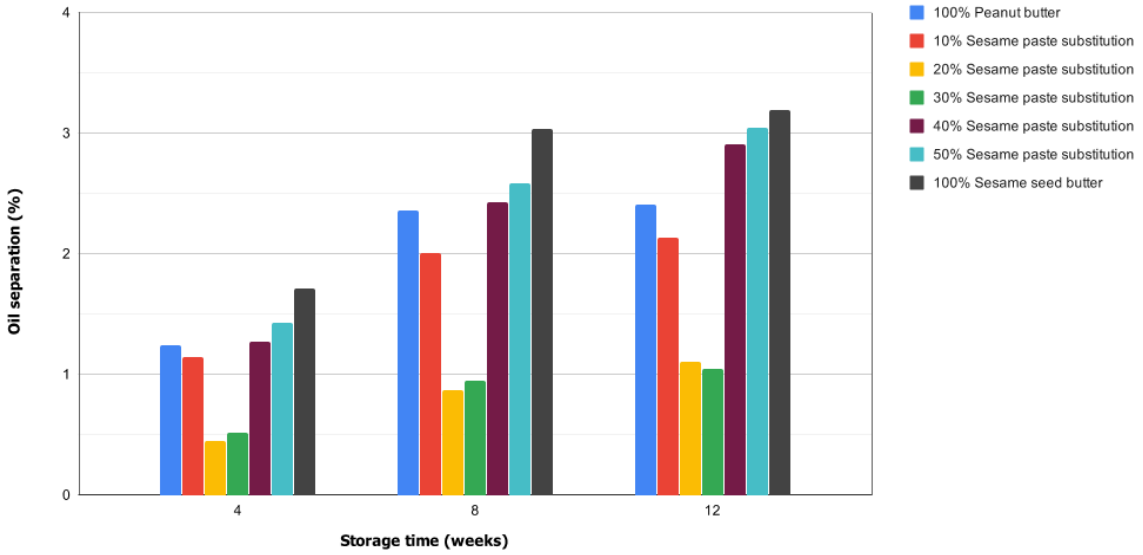

Fig. 1. Percentage oil separated from butter with storage time

The result showed that the PV of oil extracted from the formulated butters was affected by both the percentage of sesame seed paste in the blends used for preparing the butter and the storage time. The PV of 100% peanut butter oil at zero time of storage (fresh sample) was 1.28 meq O_2/kg oil while the corresponding value for 100% sesame seed butter oil was significantly (P = .05) lower (0.86 meq O_2/kg oil) than that of peanut oil. The lower PV of oil extracted from freshly prepared sesame seed butter than the value for peanut butter oil may be due to higher stability of sesame seed oil during processing and extraction operations than the peanut oil. According to Bedigian and Harlan [14], sesame seed is known as "the Queen of oil seeds" due to its high degree of resistance to oxidation and rancidity. The PV obtained in the present study for freshly prepared peanut butter was lower than 2.80 meq O_2/kg oil and 2.08 meq O_2/kg oil reported by Shibli et al. [5] and Özcan and Seven [34] respectively but was in agreement with 1.30 meq O_2/kg oil reported by Afolabi et al. [51] for freshly prepared peanut butter oil. The PV for 100% sesame seed butter oil was lower than 0.90 meq O_2/kg oil and 0.92 meq O_2/kg oil reported by Abou-Gharbia et al. [17] and Rababah et al. [40] respectively but was higher than 0.19meq O_2/kg oil reported by Borchani et al. [35] for freshly prepared sesame seed butter oil. The PV of oils extracted from sesame seed paste supplemented butter progressively decreased with increase in sesame seed paste supplementation ranging from 1.22 meq O_2/kg oil for extracted from 10% sesame seed paste supplemented butter to 0.93meq O_2/kg oil for oil extracted from 50% sesame seed paste supplemented butter. The recorded decrease in PV in the samples with increase in sesame paste supplementation could be attributed to lower PV in 100% sesame paste than in 100% peanut paste.

The PV of all the samples (controls and butter from the blends) significantly increased (P = .05) with the storage time. This result is in harmony with the reports by other authors [10,35,40,46]. Okturk et al. [52] and Abegaz et al. [53] reported that storage time was a significant factor that influence peroxide value in peanut butter stored at atmospheric temperature.

The result revealed that during storage, the PV of 100% peanut butter determined at weeks 4, 8 and 12 were significantly higher than those of 100% sesame seed butter (Table 3). The PV of peanut butter increased from 1.28 meq O_2/kg oil on zero week of storage (fresh sample) to 5.01 meq O_2/kg oil on the last day of storage (week 12) while that of sesame seed butter increased from 0.86 meq O_2/kg oil on the zero week of storage to 1.20 meq O_2/kg oil on the last day of storage. This result shows that sesame seed butter oil exhibited better resistance to oxidative deterioration than peanut butter oil during the storage period. The presence of fat soluble natural antioxidants such as sesamin, sesamolin and sesamol as well as tocopherol in sesame seed [23,39,46,54] might have contributed to the higher oxidative stability of sesame seed butter

Table 3. Effect of storage time on PV of butter made from blends of peanut and sesame seed pastes (meq O_2/kg oil)

Storage Time (wks)	Blending Ratios (Peanut Paste : Sesame Seed Paste)						
	100:00	**90:10**	**80:20**	**70:30**	**60:40**	**50:50**	**100:00**
0	1.28^{d}±0.11	1.22^{d}±0.04	1.14^{d}±0.08	1.08^{d}±0.06	1.01^{d}±0.03	0.93^{d}±0.10	0.86^{d}±0.05
4	2.40^{c}±0.03 (87.50)	2.27^{c}±0.02 (86.07)	1.99^{c}±0.05 (74.56)	1.79^{c}±0.11 (65.74)	1.55^{c}±0.08 (53.47)	1.34^{c}±0.04 (44.09)	1.00^{c}±0.11 (16.28)
8	3.67^{b}±0.08 (186.72)	3.34^{b}±0.06 (173.77)	2.87^{b}±0.03 (151.75)	2.52^{b}±0.05 (133.33)	2.11^{b}±0.10 (108.91)	1.79^{b}±0.06 (92.47)	1.09^{b}±0.06 (26.74)
12	5.01^{a}±0.05 (291.41)	4.43^{a}±0.10 (263.12)	3.75^{a}±0.06 (228.95)	3.16^{a}±0.02 (192.59)	2.67^{a}±0.08 (164.36)	2.26^{a}±0.04 (143.01)	1.20^{a}±0.08 (39.54)

Each value is the mean of triplicate determinations. Means on the same column with different superscripts are significantly different at P = .05. Values in parenthesis indicate percentage increase in peroxide values

Table 4. Effect of storage time on acid value of butter made from blends of peanut and sesame seed pastes (mg KOH/g oil)

Storage Time (wks)	Blending Ratios (Peanut Paste : Sesame Seed Paste)						
	100:00	**90:10**	**80:20**	**70:30**	**60:40**	**50:50**	**100:00**
0	0.43^{d}±0.11	0.44^{d}±0.09	0.46^{d}±0.04	0.47^{d}±0.05	0.49^{d}±0.10	0.50^{d}±0.08	0.56^{d}±0.06
4	0.69^{c}±0.08 (60.47)	0.70^{c}±0.04 (59.09)	0.73^{c}±0.06 (58.70)	0.74^{c}±0.09 (57.45)	0.78^{c}±0.03 (59.18)	0.79^{c}±0.10 (58.00)	0.79^{c}±0.08 (41.07)
8	1.00^{b}±0.03 (132.56)	1.02^{b}±0.10 (131.82)	1.06^{b}±0.08 (130.43)	1.08^{b}±0.05 (129.79)	1.14^{b}±0.06 (132.65)	1.15^{b}±0.09 (130.00)	1.02^{b}±0.05 (82.14)
12	1.22^{a}±0.06 (183.72)	1.24^{a}±0.04 (181.82)	1.29^{a}±0.11 (180.43)	1.32^{a}±0.04 (180.85)	1.37^{a}±0.02 (179. 59)	1.40^{a}±0.05 (180.00)	1.23^{a}±0.10 (119.64)

Each value is the mean of triplicate determinations. Means on the same column with different superscripts are significantly different at P = .05. Values in parenthesis indicate percentage increase in peroxide values with storage time

than peanut butter. According to some authors [16,17,18], the presence of these lignans along with tocopherol and phytosterols in the sesame seed oil provide defence mechanism against reactive oxygen species and increases the keeping quality of oil by preventing oxidative rancidity. Butter made from the blended pastes also exhibited increase in PV with storage time. The percentage increase in PV of sesame paste supplemented butter decreased with increase in the proportion of sesame seed paste in the blends. Consequently, at week 12, it was found that while oil from 10% sesame paste supplemented butter recorded 263.12% increase in PV, oil from 50% sesame paste supplemented butter recorded significantly lower value (143.01%). This could be due to increase in the antioxidant lignans with increase in sesame seed paste supplementation. Similar observation was reported by Sumainah et al. [55] for peanut – sesame – soy blends. The result of the present study has clearly shown that supplementation of peanut paste with sesame seed paste for butter preparation could extend the shelf-stability of the product by suppressing lipid oxidation. Despite the increase in PV with storage time, the final values on the last day of storage for all the samples were less than maximum acceptable value of 15meq O_2/kg oil for cold press and virgin oil set by the Codex Alimentarius Commission [56].

3.4 Effect of Storage Time on Acid Value (AV) of the Samples

Fatty acids in foods are normally found in the form of triglycerides but may break down into free fatty acids during processing and storage [57]. Acid value (AV) represents the amount of the free fatty acids present in food samples and shows the extent to which the glycerides in the oil have been decomposed by lipase, heat and light [58]. High acid value usually indicates high free fatty acid, which causes the oil to become rancid.

The acid values of the oils extracted from freshly prepared butter (zero storage time) and the changes that occurred with storage time are presented on Table 4.

The result showed that the acid value of freshly prepared 100% peanut butter oil (0.43 mg KOH/g oil) was lower than 0.56 mg KOH/g oil recorded for 100% freshly prepared sesame seed butter oil. The AV obtained in the present study for 100% peanut butter oil was within the range (0.10 – 0.75 mg KOH/g oil) reported by Gong et al. [45] but was lower than 1.45 – 1.53 mg KOH/g oil and 1.90 mg KOH/g oil reported by Özcan and Seven [34] and Afolabi et al. [51] respectively for freshly prepared peanut butter oil. The value was however higher than the range (0.24 – 0.27 mg KOH/g oil) reported by Shibli et al. [5] for freshly prepared peanut butter oil. For the 100% freshly prepared sesame seed butter oil, the acid value was higher than 0.37 mg KOH/g oil reported by Rababah et al. [40] but was lower than 1.10 mg KOH/g oil and 0.61 mg KOH/g oil reported by Borchani et al. [35] and Hou et al. [46] respectively for oil from freshly prepared sesame seed butter. The oils extracted from butter made from the peanut – sesame seed paste blends (fresh samples) recorded slight increase in AV with increase in the proportion of sesame seed paste in the blends. This could be attributed to higher AV in sesame paste than in peanut paste. The recorded low acid value of the freshly prepared samples is indicative of good product quality.

The acid value of all the samples increased significantly ($P = .05$) with storage time. Similar increases in acid value with storage time have been reported by other researchers [5,34,51] for stored peanut butter oil and [35,40,45,46] for stored sesame seed butter oil. At week 12, the 100% peanut butter recorded 183.72% increase in AV while the 100% sesame seed butter recorded 119.64%. The percentage increase in AV for the sesame seed paste supplemented butter ranged from 179.59% to 181.82% on the last day of storage. Contrary to the observation made with peroxide value, the result showed that supplementation of peanut paste with 10 – 50% sesame seed paste had no effect on the acid value of the samples during storage. According to Atinafu and Bedemo [57], increase in acid value with storage time may be caused by elevated temperature, moisture in oil, light and most importantly, lipases coming from the source or contaminating microorganisms. Since the samples for the present study were stored at ambient conditions, there was the possibility of exposure to elevated temperature and light conditions during the storage period, which could led to increase formation of free fatty acids in addition to the activity of lipolytic enzymes from microorganisms. Despite the increases in AV with storage time, the final values on the last day of storage for all the samples (1.22 – 1.40 mg KOH/g oil) were below the maximum acceptable limit of 4.0 mg KOH/g oil set by Codex Alimentarius Commission for cold press and virgin oils.

4. CONCLUSION

The result of this study has shown that apart from behenic acid that was not detected in sesame butter oil, the other eight fatty acids detected in peanut butter oil were also found in sesame butter oil but in varying quantities. Oils extracted from both 100% peanut and sesame seed butters contained slightly below 20% saturated fatty acids and slightly above 80% unsaturated fatty acids. Palmitic, palmitoleic, oleic, linolenic, arachidic and behenic acids progressively decreased while stearic, linoleic, and eicosenoic acids progressively increased with increase in sesame seed paste supplementation. Oils extracted from sesame paste supplemented butter had higher percentages of saturated and polyunsaturated fatty acids but lower percentage of monounsaturated fatty acids than 100% peanut butter oil.

Oil separation, peroxide value and acid value increased with storage time. Supplementation of peanut paste with sesame seed paste significantly reduced oxidative deterioration as the amount of peroxide formed with storage time occurred to a lesser degree with increase in the proportion of sesame paste in the blends. However, the treatment did not have effect on the acid value. It is evident from the results that butter of high unsaturated fatty acids with delayed onset of oxidative rancidity could be produced from peanut paste supplemented with sesame seed paste. The effect of the treatment on sensory attributes and microbiological stability of the butter during storage is in progress.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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