**Proximate Composition and Sensory Properties of Maize Pap Fortified with Peanut and Muskmelon Flours**

**ABSTRACT**

**Aims:** This study was carried out to investigate the proximate and sensory attributes of pap by incorporation of muskmelon and peanut flours.

**Study Design:** Using a Completely Randomized Design (CRD).

**Place and Duration of Study:** The research was carried out at the Department of Food Science and Technology, Faculty of Agriculture, Nnamdi Azikiwe University Awka. The research was done in June-August, 2024.

**Methodology:** Peanut (*Arachis* *hypogaea*) and muskmelon (*Cucumis* *melo)* were processed into flours and used to fortify maize pap gruel at different mixing ratios of 0:0:100(maize pap); 4:10:86 (peanut: muskmelon: maize pap); 6:10:84 (peanut: muskmelon: maize pap); 2:15:83 (peanut: muskmelon: maize pap); 10:10:80 (peanut: muskmelon: maize pap); 5:15:80 (peanut: muskmelon: maize pap); 8:20:72 (peanut: muskmelon: maize pap); 10:20:70 (peanut: muskmelon: maize pap); 15:20:65 (peanut: muskmelon: maize pap). The formulated blends were used to produce pap gruel. The proximate and sensory properties were carried out on the pap gruel.

**Results:** The protein, ash, fibre, and fat contents of the samples increased while moisture and carbohydrate reduced with increase in peanut and muskmelon inclusion. The moisture content of the pap gruel ranged from 10.33 to 12.83%, ash 4.60 to 7.90%, fibre 3.88 to 4.98%, fat 5.12 to 9.24%, protein 9.23 to 11.13% and carbohydrate 56.51 to 64.34%. The sensory property results show that mean score for general acceptability of the pap produced ranged from 7.20 to 7.80 with sample ratio 15:20:65% being the most preferred in terms of taste and appearance.

**Conclusion:** Incorporation of peanut and muskmelon flours in the production of pap gruel made significant changes in the protein, ash, fibre, and fat contents. This product can be added to the list of pap meals as weaning food for infants and young children.

***Keywords:*** *Peanut; muskmelon; maize pap; proximate composition; sensory properties.*

**INTRODUCTION**

Pap is a fermented cereal porridge from West Africa which can be produce from maize (*Zea mays*), guinea corn (*sorghum bicolor*) and millet (*Pennisetum typhodenum*). It is a staple food in most African countries with varying preparation methods and names. It is commonly used as weaning food for babies and also for young children and as a standard breakfast cereal in many homes. Pap usually has smooth texture and is boiled into porridge or cooked and turned into a stiff gel called “agidi” or “eko” prior to consumption (Steinkraus, 2019). The color of pap depends on the cereal used; slightly cream for white maize, cream for yellow maize, light brown for sorghum and greenish to grey for millet (Nakazato *e*t *al*., 2020). It is produced generally by soaking maize grains in warm water for 2-3 days followed by wet milling and sieving through a screen mesh. The sieved material is allowed to sediment and ferment and is marketed as wet cakes wrapped in leaves (Jay, 2014). Nnanyelugo and Onofiok (2014) reported the use of pap as a weaning food in Southern Nigeria to supplement breastfeeding, because only breast feeding may be inadequate to meet the nutritional demands of the growing infant. The same authors also reported that pap is usually introduced to the infant between the ages of 3-6 months. It has also been shown that pap Liquor has both antibacterial and antifungal properties (Adebayo *et* *al*., 2010). Akinrele (2010) reported that pap contains riboflavin, niacin, thiamine and several amino acids by virtue of the fermentation process. Also, Akinrele (2020) reported on the carboxylic acids in pap and found lactic acid in greatest concentration (0.55%) followed by acetic acid (0.09%) and smaller amounts of butyric acid (acetic acid is responsible for its sour taste). These authors also reported on amino acid content and found no difference between maize flour and pap for all amino acids including the essential ones. Adeniji (2018) revealed that pap processing did not decrease protein content of maize but total and available lysine was significantly decreased. On the other hand, tryptophan levels were more stable. These authors also found an increase in neutral detergent fiber and ash but no change in lignin.

Maize is a versatile cereal grain cultivated globally, serving as a primary food source in many regions. It is rich in carbohydrates and provides a significant energy source. However, maize alone lacks some essential nutrients such as lysine, tryptophan, and micronutrients like iron and zinc, necessitating complementary processing or fortification to enhance its nutritional value. In pap production, maize serves as the base ingredient due to its starch-rich composition, which contributes to the creamy texture of the final product (Klaenhammer and Fitgerald, 2014).

Peanut is an annual crop reaching 20-40 cm in height. It has a taproot with round nodules. Bright yellow flowers are produced singly from the leaf axils near the base of the stem. The flowers peg into the soil after pollination. The pods are yellowish-brown with 1-4 seeds. Depending on the variety, peanut requires a minimum rainfall of 3-5m during the growing season and dryness during harvest. Well-drained, loose, sandy soils, rich in calcium are most suitable leaf spot due to the fungus *Cercosporin* a*rachidocala* is most common. Peanuts have a variety of uses. The green haulms may be fed to animals as well as crude kernels. The nuts may also be cooked in a variety of ways. Oils can be extracted from them, which are used in cooling. Peanut flour combines well with wheat flour in breads and cakes. Peanut butter also derived from peanut is popular locally and internationally (Adeniji, 2018).

Muskmelon fruit is a sterile, reed-like plant which it relies for vegetative propagation. The plant is a cultigen, that is, it is only known from cultivation. Its wild origins are not known with certainty but are believed to be India or South-East Asia (Vaughan and Geissler, 2009). Muskmelon fruit has a very long history of use, both as a spice and as a medicinal plant, and is mentioned in ancient Sanskrit texts and in classical Buddhist, Arabic, Greek and Roman literature (Govindarajan *et* *al*., 2012). It was used widely in Europe by the tenth century (Vaughan and Geissler, 2009) and was first exported from Jamaica, where it became a significant agricultural crop, in 1547 (Mabberly *et* *al*., 2007). It is now cultivated in many tropical and subtropical regions including India, Africa, China, the West Indies and Australia, with the annual world production estimated at 100,000 tons in 2000 (Bartley and Jacobs, 2000). Muskmelon fruit is used as flavoring in a vast array of foods, including savory dishes such as curries, and sweets such as cakes and biscuits, and also in beverages such as muskmelon fruit ale, Muskmelon fruit beer and muskmelon fruit wine. Muskmelon fruit is used in several traditional systems of medicine, including Traditional Chinese Medicine, Ayurveda and Western herbal medicine (Williamson, 2002). Its traditional uses cover a great variety of complaints including dyspepsia, flatulence and colic, nausea and vomiting, colds and flu, migraine, as well as muscular and rheumatic disorders (WHO, 1999).

**2. MATERIALS AND METHODS**

**2.1 Material procurement**

Maize yellow varieties (TZB and Agric TBr), muskmelon fruit and peanut were purchased from Eke Awka markets in Anambra State. The materials were sorted, cleaned and kept in high density polyethylene to avoid moisture uptake and contamination before use.

**2.2 Preparation of pap from maize**

The method described by (Ahaotu *et* *al*., 2021) was adopted. High quality maize grains were selected by sorting. The grains were free from mold, dirt and pests. The maize was winnowed and thoroughly washed in clean water to remove impurities. The cleaned maize was soaked in a large container and submerged in water for 3 days at room temperature. Over time, mass of bubbles were noticed in the soaking water which indicated active fermentation. The soaked maize was drained and ground into a paste using wet grinder to form a thick slurry. The slurry was sieved with clean water using a muslin cloth. The starchy, smooth component of the slurry sieved was retained for pap. The sieved liquid was allowed to settle in a container for 18 hours. During this period, the starch settles at the bottom while excess water was at the surface. The surface water was gently decanted off and discarded. The wet starch was spread on a sterile tray and transferred into a drying oven (model 10-D1390) at 60oC for 6hours. The dried pap was further ground into a fine powder using a hammer mill machine (Hammer Mill Imported 4.5hp).

**2.3 Preparation of peanut flour**

The method described by (Igbabul *et* *al*., 2014) was used. The peanut was sorted to remove damaged moldy, or immature Kernels. It was then washed thoroughly to remove dirt, stones and impurities. The peanuts were manually shelled to separate the kernels from hard outer shells. The peanuts were then roasted in a hot air oven at 180oC for 15 minutes. After roasting, the red outer skin was removed; then the peanut was partially defatted, the remaining defatted peanut cake was used as the base material for flour production. The defatted peanuts were ground into a fine powder using a hammer mill. The flour was passed through sieves to ensure uniform particle size. The peanut flour was packaged in airtight container.

**2.4 Preparation of Muskmelon Flour**

The method described by (Adjou *et* *al*., 2017) was used. Fully ripened muskmelon fruit was selected and sorted for maximum quality, flavor and nutrient content. The muskmelon were washed thoroughly to remove dirt, pests, and impurities. The outer rind was removed manually leaving only the edible pulp and seeds. The pulp was cut into smaller pieces to form puree for uniform drying at 55oC until complete drying was achieved (<10%). After drying, the pulp along with the seed were ground into fine powder using a hammer mill. The flour was passed through sieves to ensure uniform particle sizes. Then, the flour was packed in air tight, moisture-proof packaging and stored in a cool, dry place to maintain its shelf-life.

**2.5 Research Design**

Completely randomized design was used for this formulation of composite blends.

**Table 1: Mixing ratios of blends of peanut muskmelon and maize pap.**

**Run Peanut Muskmelon Maize**

 **flour(%) flour (%) (%)**

1 0 0 100

2 4 10 86

3 6 10 84

4 2 15 83

5 10 10 80

6 5 15 80

7 8 20 72

8 10 20 70

9 15 20 65

**2.6 Proximate Composition**

The moisture, crude protein, fat, ash and fibre contents in the composite flour were evaluated in the composite flour were evaluated using the (AOAC, 2010) method.

**2.7 Sensory Evaluation**

A group of 25 panelists, consisting of both male and female individuals who were staff and students of the Department of Food Science and Technology at Nnamdi Azikiwe University, Awka, Anambra State, Nigeria participated in the study. These panelists received training in the specific descriptive terms of the sensory scales and were asked to assess the different pap samples for aroma, taste, colour, appearance, texture and overall acceptability using a 9-point Hedonic Scale. In this scale, a rating of 9 indicated extreme liking while a rating of 1 indicated an extreme disliking. The presentation of coded samples was conducted randomly, and participants were provided with potable water to rinse their mouths between the evaluations (Iwe, 2010).

**2.8 Statistical Analysis**

The mean of all parameters were evaluated for significance (p<0.05) by analysis of variance (ANOVA) and the mean separation and significant effect tasted by Duncan’s Multiple Range Test using SPSS version 25 (IBM, USA).

**3. RESULTS AND DISCUSSION**

**3.1 Proximate Composition of Pap Produced from Composite Flours**

Table 2 shows the proximate composition of pap samples. Showing the composition of the pap samples changed in response to the varying proportions of the three components used in the formulated mixtures. These variations can be attributed to differences in the chemical makeup of the individual flours employed in creating the pap blends. The inclusion of peanut and muskmelon in the pap samples led to a reduced moisture and carbohydrate contents but increased the ash, fat, fiber and protein.

**3.1.1 Moisture content**

The moisture contents showed a variation in values ranging from 10.33 to 12.38 % with sample mix ratios (15:29:65) and (0:0:100) having the lowest and highest values, respectively. Significant differences occurred among some samples whereas sample ratios 2:15:38, 5:15:80 and 10:10:80 were similar. Obtained values from this study are in consonance to the reported values 9.74 to 10.87 % and 10.44 to 14.23 % by (Okafor and Ukueze, 2024) and (Ayo *et* *al*., 2011) for protein-enriched akamu and millet-egg-soybean composite akamu flours, respectively. The low moisture content reported in this study is within the acceptable limits for dry flour shelf stability of ≤ 12 % (Kigigba *et* *al*., 2016). These low values could be as a result of the drying method adopted in this research which is capable of preventing early spoilage when stored appropriately.

**3.1.2 Ash content**

The percentage ash of the fortified samples significantly increased among each other, although sample ratios 8:20:72 and 15:20:65 were not significantly different. While sample ratio 8:20:72 had the highest ash content of 7.90%, sample ratio 0:0:100 had the lowest value of 4.60 %. This could be because the dried pap with mainly starch components, had lost most of its minerals during the processing stages, especially soaking and drying. The obtained value, in this study agreed slightly with the values 3.36 to 6.02 % by (Kigigba *et* *al*., 2016); and highest when compared to the reported values 0.47 to 0.86 % by (Ahaotu and Igboh-Harlord, 2023) in quality assessment of ‘akamu’ powder formulated using cofermented maize and African bread fruit powder. This increasing pattern with the addition of peanut agrees with previous research by (Mounjouenpou *et* *al*., 2018).

**3.1.3 Fibre**

The fibre content of pap at varying mixing ratios ranged from 4.13 to 4.98 % against the control 3.88 %. The fibre composition of the samples increased significantly as the quantity of peanut increased, except for sample ratio 10:10:80 (4.33 %), which was significantly similar to sample ratio 6:10:84. Sample ratio 15:20:65 and 0:0:100 (control) had the highest and lowest crude fibre content, respectively. The highest fibre content in the ratio could be because pap is made of maize starch while peanut is made from the whole nut, which contains other food components aside from starch. Also, variations in the species of peanuts can be a factor (Afolabi *et* *al*., 2018). The values obtained in this study are higher when compared to the reported values 0.12 to 0.22% by (Ahaotu and Igboh-Harlord, 2023) in composite akamu powder produced from maize and African bread fruit. Fibre aids in lowering blood cholesterol level and slows down the process of absorption of glucose; thereby helping in keeping blood glucose level in check (Anderson *et* *al*., 2009). It also ensures smooth bowel movements thus helps in easy flushing out of waste products from the body; increase satiety and hence impacts some degree of weight management (Anderson *et* *al*., 2009).

**3.1.4 Crude fat**

Fat contents of dried pap samples ranged from 7.08 % in 10:10:80 to 9.24 % in 15:20:65 against the control (0:0:100) 5.12%. There were significant differences (p<0.05) among the samples. Comparably, the values obtained in this study were similar to the reported values 6.31 to 10.67% by (Ayo *et* *al*., 2011) in millet-egg-soybean hull composite flour. The lipid contents of dried pap samples studied were higher than 2.94 to 4.33% reported by (Okeke and Eze, 2006) in pap consumed in Nsukka situated in the North of Enugu State, Nigeria. Roasted peanuts paste is one of the basic ingredients in pap preparation increasing the fat content of dried pap studied. This fact is evident in the obtained value ratio 15:20:65 which had the highest fat content (9.24%) while the control (0:0:100) which does not contain peanut had the least (5.12%). The fat content of the fortified samples would not have had significant differences from the control (5.12%) until the addition of peanut flour. This implies that if no significant improvement is required for the fat content, there would be no need to add peanut on different proportions in the fortified pap blends. Also, high fat content could lead to oxidative rancidity if not adequately preserved (Okparanta *et* *al*., 2018).

**3.1.5 Protein content**

The protein contents of dried pap samples varied from 9.32 to 11.13 % against the control (9.23%) and were significantly different (p<0.05). The highest and lowest values were recorded in ratio 15:20:65 and 0:0:100, respectively. The protein contents of these pap samples were in line with the reported values 8.91 to 13.69% by (Ponta et al., 2006) in pap produced from five different varieties of maize consumed in Maroua (Far-North, Cameroon). However, the protein contents of these pap samples in this study were higher than protein contents of 7.88 and 6.76 % reported by (Anigbo et al., 2010) respectively in maize and millet pap consumed in North Western of Nigeria. These values were also higher than the protein content of 2.22 % in yellow pap and 4.48 % in sorghum pap eaten in Nassarawa State of Nigeria (Makanjuola and Awogbanja, 2012). The high protein content of akamu samples studied was due to addition of roasted peanut. Ponta et al. (2006) reported that roasted peanuts paste was a good source of protein (35.76 g/100g).

**3.1.6 Carbohydrate**

The carbohydrate contents of pap ranged between 56.51% for sample ratio 15:20:65 to 64.34% for 0:0:100. The values of the carbohydrate content in the pap samples collected were significantly different. The carbohydrate contents of akamu in this study agreed to the reported values 57.11 to 64.93 % by (Ayo *et* *al*., 2011) in millet-egg-soybean hull composite flour. The carbohydrate content decreased significantly from sample ratios 15:20:65, 8:20:72, and 10:10:80 and 10:20:70 (56.51 to 61.48 %), indicating that as peanut content increased, carbohydrate decreased. The decrease in carbohydrate content trend in the pap with increasing protein agreed with the findings of Adeyemo and Onilude (2013) in reductions in maize gruel (akamu). This reduction in carbohydrate values was determined by difference. Thus, an increase in other components like crude protein, fat, ash and crude fibre would cause a decrease in carbohydrates.

**Table 2: Proximate composition of dried pap at varying mixing ratios of peanut, muskmelon and maize (%)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | PNT :MSM: MZP | MOISTURE | ASH | FIBRE | FAT | PROTEIN | CARBOHYDRATE |
|  | 0:0:100 | 12.83 a ± 0.30 | 4.60 f ± 0.10  | 3.88 e ± 0.20 | 5.12e ± 0.20 | 9.23e ± 0.30 | 64.34a ± 0.52 |
|  | 5:15:80 | 11.06 c+ 0.51 | 5.29 e+ 0.21 | 4.15 d+ 0.00 | 7.10 d+ 0.11 | 9.85 d+ 0.11 | 62.55 b+ 0.11 |
|  | 10:20:70 | 11.55b+ 0.20 |  5.30d ± 0.10  | 4.16d ± 0.20 | 8.19b ± 0.10  | 9.32d±0.10 | 61.48c ± 0.50  |
|  | 4:10:86 | 11.73 b± 0.57 | 5.47 c+ 0.21 | 4.13 d+ 0.02 | 7.12 d+ 0.01 | 10.08 c+ 0.21 | 61.47c+ 0.10 |
|  | 6:10:84 | 11.87 b+ 1.20 | 5.34 d+ 0.26 | 4.45 b+ 0.11 | 7.55c+ 0.20 | 9.88 d+ 0.20 | 60.91 c+ 0.14 |
|  | 10:10:80 | 11.08 c+ 0.11 | 6.31 bd+ 0.26 | 4.33 c+ 0.15 | 7.08 d+ 1.11 | 10.20 c+ 0.10 | 61.00 c+ 1.00 |
|  | 2:15:83 | 11.02 c+ 0.21 | 5.45c+ 0.21 | 4.13 d+ 0.02 | 7.12d+ 0.01 | 10.08 d+ 0.21 | 62.20b+ 0.10 |
|  | 8:20:72 | 10.55d ± 0.50  | 7.90a ± 0.05  |  4.83a± 0.11 |  8.87b ± 0.11 | 10.80b ±0.20 | 57.01d ± 0.66  |
|  | 15:20:65 | 10.33d+ 0.21 | 7.81a + 0.26 | 4.98 a+ 0.20 | 9.24 a+ 0.21 | 11.13 a+ 0.11 | 56.51e+ 0.10 |

\*Values are mean scores± Standard deviation of triplicate \*Data in the same column bearing different superscript differ significantly (p <=0.05)

Key: PNT- Peanut, MSM- Muskmelon, MZP- Maize pap

**Table 3 Sensory evaluation of dried pap at varying mixing ratios of peanut, muskmelon and maize.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PNT :MSM:MZP**  | **Aroma**  | **Taste** | **Colour** | **Appearance**  | **Texture**  | **General Accept.** |
|  | 0:0:100 | 6.50c± 1.96 | 6.70bc ± 0.30 | 8.30bc ± 0.90 | 8.00a ± 0.50 | 7.00b ± 2.17 | 7.00d ± 2.17 |
|  | 5:15:80 | 6.30c ± 0.88 | 6.80b ± 0.27 | 8.70b ± 0.10 | 7.00b ± 1.70 | 7.10a ± 1.24 | 7.20c ± 1.24 |
|  | 10:20:70 | 7.00a ± 0.28 | 7.30a ± 0.80 | 8.70a± 1.50 | 7.00b± 1.00 | 7.50a ± 0.13 | 7.80a ± 0.13 |
|  | 4:10:86 | 6.70b± 0.89 | 6.50c ± 1.24 | 8.00b ± 0.10 | 8.00a± 2.00 | 7.00b ± 0.20 | 7.30c± 0.20 |
|  | 6:10:84 | 6.50b ± 1.21 | 6.50c± 0.35 | 8.10b± 0.01 | 8.00a ± 1.10 | 7.10a ± 1.23 | 7.30c ± 1.23 |
|  | 10:10:80 | 6.30c ± 1.39 | 6.70bc ± 0.90 | 8.00b ± 0.10 | 8.00a± 0.10 | 7.00b± 1.20 | 7.50b± 1.20 |
|  | 2:15:83 | 6.50b ± 1.32 | 6.90b ± 1.00 | 8.00b ± 0.40 | 8.00a± 0.10 | 7.00b± 1.20 | 7.50b± 1.20 |
|  | 8:20:72 | 6.60b ± 1.30 | 7.40a ± 1.25 | 8.50a ± 0.30 | 8.00a± 0.10 | 7.20a± 1.20 | 7.60a± 1.20 |
|  | 15:20:65 | 6.90a ± 0.10 | 7.50a± 0.64 | 8.50a± 0.10 | 8.00a± 0.10 | 7.10a± 1.20 | 7.70a± 1.20 |

\*Values are mean scores± Standard deviation of 25 panelists

\*Data in the same column bearing different superscript differ significantly (p = 0.05)

Key: PNT- Peanut, MSM- Muskmelon, MZP- Maize pap

**3.2 Sensory Properties of the Pap Samples**

The effect of fortification of maize pap with different ratios of peanut and muskmelon flour on the sensory properties of dried pap is presented in Table 3. The average mean scores for aroma, taste, colour, appearance, texture and overall acceptability values obtained ranged from 6.30 to 7.00, 6.50 to 7.50 8.00 to 8.90, 7.00 to 8.00, 7.00 to 7.50 and 7.00 to 7.80, respectively. There was significant difference in the values obtained for all the sensory parameters considered. It was observed that sample 15:20:65 was the most preferred for taste and appearance, while sample 0:0:100 was the least preferred in terms of general acceptability, maybe because it contained, no peanut and muskmelon. It was reported by Muhimbula et al. (2011) that in addition to energy density, sensory qualities of a weaning food formulation were of highest significance regarding food preferences for infants and young children. The mean scores for aroma of the pap sample food produced ranged from 6.30 to 7.00. Sample 10:20:70 had the highest mean value (7.00), while samples 10:10:80 and 5:15:80 had the lowest mean values (6.30).

The mean values for taste ranged from 6.50 to 7.50. Sample 15:20:65 had the highest taste value (7.50) while samples 4:10:86 and 6:10:84 had the least mean score (6.50).

The result shows that mean scores for general acceptability of the pap food produced ranged from 7.20 to 7.80. Sample 10:20:70 had the highest general acceptability value (7.80) closely followed by 15:20:65, while sample 0:0:100 had the lowest general acceptability value (7.00). However, sample ratio 15:20:65 (15 % peanut: 20% muskmelon: 65% maize) was most preferred in all the samples in terms of taste and appearance.

**4. CONCLUSION**

The nutrient contents of the acceptable pap product has been greatly improved (protein, fat, ash and fibre content to 11.13%, 9.24%, 7.81% and 4.98%, respectively). The low moisture content in the preferred product confers long shelf-life relative to the recommended moisture content of flours (< 12%). The results of proximate parameters also suggested that these pap samples were found to contain reasonable amount of carbohydrates. On the basis of sensory evaluation, it was revealed that pap sample ratio 15:20:65% was the best.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

**ACKNOLEDGEMENT**

The author would like to express gratitude to the Faculty of Agriculture, particularly the Department of Food Science and Technology and all parties who have contributed directly and indirectly in completing this research. The author(s) hope that this journal can provide rewards to readers.

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