Evaluation of Quality Characteristics of High Nutrient Dense Complementary Food from Mixtures of Malted Quality Protein Maize (Zea mays L.) and Steamed Cowpea (Vigna unguiculata)

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Abstract

Quality Protein Maize is an improved variety of maize which contains higher amount of lysine and tryptophan. Cowpea is an indigenous legume widely consumed in Nigeria. Quality Protein Maize was malted by steeping, germinating, drying and milling while cowpea was dehulled, steamed, dried and milled. The resulting flours were blended to produce complementary food at ratios of 100:0; 70:30 (Quality Protein Maize and Cowpea). The quality characteristics of the blends were assessed by determining the chemical composition, sensory properties, functional and pasting characteristics. The results showed that 30% substitution of cowpea and malting increased the protein level significantly (p<0.05). Potassium, Magnesium and Phosphorus also increased with supplementation. The water absorption capacity, bulk density, peak and final viscosities were significantly (p<0.05) reduced in the malted samples. All the formulated diets were acceptable to the nursing mothers who served as the panelists. The low bulk, water absorption capacity and viscosity of the germinated samples encouraged addition of more solid to the thin gruel produced from it; such addition increased the energy and other nutrients of the gruel as required by infants for growth and development.

Keywords: Pasting characteristics; Sensory properties; Protein; Water absorption capacity; Viscosity

Introduction

The World Health Organization [1] issued a global recommendation to extend the duration of exclusive breastfeeding from the previous four to six months of age to a full six months. Breast milk has all the nutrients that babies need to stay healthy and grow. But after this period it may become inadequate to support the nutritional demands of the growing infants. Thus, there is the need to complement the breast milk with other food which can help alleviate any deficiency that can result from such inadequacy.

The World Health Organization (WHO) defines Complementary Food as any food, whether manufactured or locally prepared, suitable as a complement to breast-milk or to a breast-milk substitute, when either becomes insufficient to satisfy the nutritional requirements of the infant [2].

In Nigeria, like most other developing countries, the traditional complementary foods have been reported to be grossly inadequate when compared with estimated needs. The most popular complementary food fed to infants in Nigeria is a fermented cereal gruel called ‘pap’, ‘akamu’ or ‘oghi’ which is generally perceived by mothers as easy to be digested [3,4]. But this has been reported to be deficient in certain nutrients essential for the growth of infants and has been implicated in the occurrence of malnutrition in the developing countries.

The formulation and development of nutritious complementary foods from locally and readily available raw materials (e.g maize, sorghum, etc) has received a lot of attentions in Nigeria [5-7]. This has brought a lot of varieties to the traditional complementary foods used in Nigeria. However, the common maize used in traditional complementary foods production has two significant flaws like all cereals. Firstly, it is low in protein (9-10%) and secondly, it does not provide the essential amino acids (lysine and tryptophan) in sufficient quantities to meet the nutritional needs of infants. Thus, as far as protein quality is concerned, the common maize variety has poor protein quality [8-10]. Therefore, the use of quality protein maize in place of common maize is a worthy exercise. Quality protein maize is an improved variety of maize which contains higher amount of lysine and tryptophan with lower amount of leucine and isoleucine in the endosperm than those contained in common maize. Such balanced combination of amino acids in the endosperm results into its higher biological value ensuring more availability of protein to human and animal than common maize or even all cereals and pulses [11].

The utilisation of a mixture of quality protein maize and cowpea in production of complementary foods for infants has not been documented. Cowpea a legume commonly consumed in Nigeria is high in protein, carbohydrate, ash and other nutrients; its combination with quality protein maize will no doubt offer a complementary food that can substantially reduce the rate of malnutrition which has accounted for high infant mortality and morbidity in Africa [11]. Therefore, the objective of the study was to produce a high nutrient dense complementary food from a composite flour of malted quality protein maize and cowpea.

Materials and Methods

Materials

The quality protein maize (Obatampa) used for this study was supplied by the Obafemi Awolowo University, Research farms, Ile-Ife and the Cowpea (Ife brown) was purchased at the Central Market, Ile-Ife, Nigeria.

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Methods

Production of unmalted and malted quality protein maize flour: Maize grains were cleaned and sorted to remove grains that were mouldy, spoilt and broken. The good grains were washed, conditioned, decorticated, milled, sieved and then packaged to obtain unmalted maize flour (Figure 1). The malted flour was produced by steeping a portion of the cleaned grains for 8 hours to increase the moisture content for good sprouting. The steeped grains were spread in the germinating chamber of the Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife for 72 hours with watering twice a day. Germination was discontinued by oven-drying. Separation of sprout was done by applying soft abrasion on the seed in between palms. It was later milled, sieved and packaged to obtain the malted QPM flour (Figure 1) [12].

Production of cowpea flour: Cowpea seeds (Vigna unguiculata) were cleaned, sorted, soaked for 20 minutes so as to soften the hull for easy dehulling. It was then steamed (30 mins) in order to precook the dehulled cotyledons, and dried in an oven for 12 hours. The dried cowpea seeds were then milled (Attrition mill), sieved and then packaged.

Formulation of complementary diets: The quality protein maize and cowpea flours were mixed in ratios of 100:0; 70:30 w/w [13]. The cowpea seeds were then milled (Attrition mill), sieved and then packaged.

Proximate composition determination: Moisture, ash, crude fibre and fat of the diets were determined using the methods of AOAC [14]. Crude protein (N x 6.25) was determined using micro-Kjeldahl method. This method entails digestion of the sample, neutralization of the solution from the digested sample by addition of sodium hydroxide, which converts the ammonium sulphate into ammonia gas, the nitrogen content is then estimated by titration of the ammonium borate formed with standard sulphuric or hydrochloric acid, using a suitable indicator to determine the end-point of the reaction. The following equation was used to determine the nitrogen concentration of the sample that weighed m grams using x M HCl acid solution for the titration:

\[
\% N = \frac{x \text{ moles} \times (v_s - v_b) \text{cm}^3}{1000 \text{cm}^3 \times mg} \times 14 g \times 100
\]

Where vs and vb are the titration volumes of the sample and blank, and 14 g is the molecular weight of nitrogen N. The nitrogen content determined was converted to a protein content using the appropriate conversion factor: %Protein=6.25 × %N [14].

The carbohydrate was obtained by difference (%Carbohydrate=% protein+%fat+%crude fibre+%ash+%water). The gross energy values were calculated by multiplying the values of crude protein, fat and carbohydrate by their respective physiological fuel values of 4, 9 and 4 respectively.

Sensory evaluation: The various formulations were subjected to sensory evaluation. The products were reconstituted, coded and served warm to the semi trained and literate sensory panelists consisting of ten nursing mothers. The formulations were rated for colour, taste, smoothness/texture, flavour, constituency and overall acceptability. The panelists were made to assess the samples and recorded their observations using a 5-point hedonic scale where, 5=like extremely, 4=like moderately, 3=neither like nor dislike, 2=dislike moderately, and 1=dislike extremely [15].

Functional properties of the complementary foods:

i) Determination of bulk density: The bulk density of each of the samples was determined by the method described by Okaka and Potter [16]. Sample (50 g) was measured into 100 ml graduated cylinder and tapped for 50 times. The density was expressed as mass of flour per unit volume (g/ml).

\[
\text{Bulk density} = \frac{\text{Weight of sample}}{\text{Volume of sample}}
\]

ii) Determination of water absorption capacity: The water absorption capacity was determined using the method of Quinn and Paton [17]. Five grams of sample was weighed into a transparent (poly carbonate) 50 ml centrifuge tube and the tube and its content weighed. Distilled water (25 ml) was added gradually and the mixture vigorously stirred with spatula after each addition. The process was repeated until the mixture was thoroughly mixed and acquired a paste-like consistency. The tube was centrifuged (Gallenkamp centrifuge) at 12,000 x g r.p.m. for 10 minutes. The supernatant was discarded and the tube was weighed again. The difference in weight was recorded and expressed as percentage water absorption capacity.

\[
\text{Water absorption capacity} = \frac{\text{Initial water added} - \text{Supernant}}{\text{Weight of sample}} \times 100
\]

iii) Determination of oil absorption capacity: The oil absorption capacity was determined by the method of Sosulski et al. [18] as reported by Ikujenlola [12]. The sample (2.0 g) was mixed with 20 ml refined soy bean oil (density 0.9 g/ml) and allowed to stand at ambient temperature (30 ± 2°C) for 30 minutes, then centrifuged for 30 minutes.
at 12,000 × g r.p.m. Oil absorption capacity was expressed as percent oil bound per gram flour.

\[
\text{Oil absorption capacity} = \frac{\text{Initial oil added} - \text{Supernatant weight}}{\text{Weight of sample}} \times 100
\]

iv) Pasting characteristics determination: The pasting profile was studied using a Rapid Visco Analyser (RVA) series 4 (New Port Scientific NSW, Australia). The sample 3.0 g was weighed and 25 ml of distilled water was dispensed into a canister. Paddle was placed inside the canister this was placed centrally onto the paddle coupling and then inserted into the RVA machine. The measurement cycle was initiated by pressing the motor tower of the instrument. The 12 minute profile was used. The time-temperature regime used was idle at temperature 50°C for 1 min., heated from 50°C to 95°C in 3 min 45 s, then held at 95°C for 2 min 30 s the sample was subsequently cooled to 50°C over 3 min 45 s period followed by a period of 2 min where the temperature was controlled at 50°C [19].

t) Mineral determination: The mineral contents of the formulated diets were determined by atomic absorption spectrophotometry for Calcium, Magnesium and Iron. Potassium and Phosphorus were determined by flame photometry and colorimetry methods respectively [20].

vi) Statistical analysis: The data obtained were analysed using Analysis of Variance (ANOVA). Duncan Multiple Range Test was used in separating the means. Significant difference was accepted at 5% level (p>0.05). All the experiments were conducted in triplicate.

Results and Discussion

Table 2 showed the results of the proximate analysis of the flours. The protein content of the formulated diets ranged between 7.80 and 15.21%. The 30% substitution of Cowpea led to appreciable increase in the level of the protein content of the formulated diets. Apart from the quantity of the protein that was enhanced, the quality of the protein in the fortified formulated diets would be better owing to the fact that quality protein maize contains both lysine and tryptophan at appreciable level [12,21]. The addition of Cowpea further enhances the quality of the protein in terms of the amino acids quality. Complementary food that will meet infant’s nutritional requirements must supply all the amino acids in the right quality and quantity. The fortified diets met the recommended protein content for complementary food [13]. The protein content of the control was not significantly different (p>0.05) from those of fortified diets.

Moisture content of the samples ranged between 5.68 and 10.32%. The moisture content is a function of the drying time and loading depth (p>0.05) from those of fortified diets.

The protein content of the formulated diets ranged between 7.80 and 15.21%. The 30% substitution of Cowpea led to appreciable increase in the level of the protein content of the formulated diets. Apart from the quantity of the protein that was enhanced, the quality of the protein in the fortified formulated diets would be better owing to the fact that quality protein maize contains both lysine and tryptophan at appreciable level [12,21]. The addition of Cowpea further enhances the quality of the protein in terms of the amino acids quality. Complementary food that will meet infant’s nutritional requirements must supply all the amino acids in the right quality and quantity. The fortified diets met the recommended protein content for complementary food [13]. The protein content of the control was not significantly different (p>0.05) from those of fortified diets.

Table 3 showed the results of the functional properties of the formulated complementary diets. The functional property of a food determines the contribution of the food for the nutrition and the technology required to process the food for human use. The oil absorption capacity of the flours ranged between 4.00-15.50%. The values are lower than the energy of the control diet (397.00 kcal/100 g). The proximate composition of the composite flour obtained in this study was comparable to values reported by Sodipo and Fashakin [20] and Ikujenlola and Fashakin [23] who worked on similar products.

Table 4 showed the result of the selected functional properties of the formulated complementary diets.
Legumes reduce bulk and viscosity with an increase in nutrient density. The consisting of ungerminated cereal or root crop flour and sometimes Sajilata et al. [33] that adding germinated cereal flour to weaning food reduction in viscosity. It was also reported by Gimbi et al. [32] and Ikujenlola [12,27] who reported that the energy density increased two to three times by germination which also involved a considerable production of complementary foods with minimum paste viscosity, germination is a practical, cost-effective, and sustainable process for high energy and nutrient dense. Complementary foods with a higher pasting characteristics of the diets followed same trend and it was observed that both reduced in germinated diets. Temesgen [28] reported that the energy density increased two to three times by germination which also involved a considerable reduction in viscosity. It was also reported by Gimbi et al. [32] and Sajilata et al. [33] that adding germinated cereal flour to weaning food consisting of ungerminated cereal or root crop flour and sometimes legumes reduce bulk and viscosity with increase nutrient density. The pasting characteristics of the diets are displayed in Table 5. Sample Colour Smoothness Flavour Taste Consistency General acceptability

<table>
<thead>
<tr>
<th>Sample</th>
<th>Colour</th>
<th>Smoothness</th>
<th>Flavour</th>
<th>Taste</th>
<th>Consistency</th>
<th>General acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.71 ± 0.56c</td>
<td>2.00 ± 0.53c</td>
<td>1.71 ± 0.28c</td>
<td>2.14 ± 0.73c</td>
<td>2.43 ± 0.61b</td>
<td>2.29 ± 0.71c</td>
</tr>
<tr>
<td>B</td>
<td>2.43 ± 0.43a</td>
<td>2.29 ± 0.28b</td>
<td>2.29 ± 0.42b</td>
<td>2.71 ± 0.36a</td>
<td>2.29 ± 0.36c</td>
<td>2.86 ± 0.34a</td>
</tr>
<tr>
<td>C</td>
<td>2.14 ± 0.40a</td>
<td>2.00 ± 0.22c</td>
<td>2.14 ± 0.40ab</td>
<td>2.00 ± 0.21c</td>
<td>2.86 ± 0.14a</td>
<td>2.29 ± 0.38c</td>
</tr>
<tr>
<td>D</td>
<td>2.00 ± 0.31b</td>
<td>3.00 ± 0.39a</td>
<td>2.86 ± 0.59a</td>
<td>2.43 ± 0.48b</td>
<td>2.29 ± 0.42c</td>
<td>2.57 ± 0.36b</td>
</tr>
</tbody>
</table>

Values with different subscripts in a column are significantly different (p<0.05).

Key:
A=100% unmalted QPM.
B=100% malted QPM.
C=70% unmalted QPM+30% Cowpea.
D=70% malted QPM+30% Cowpea.

Pasting characteristics of the dieth

The pasting characteristics of the diets are displayed in Table 5. The result showed the effect of the germination on the pasting characteristics of the diets. The peak (34.67-208.67) and final (84.08-319.17) viscosities of the diets followed same trend and it was observed that both reduced in germinated diets. Temesgen [28] reported that germination is a practical, cost-effective, and sustainable process for production of complementary foods with minimum paste viscosity, high energy and nutrient density. Complementary foods with a higher energy density of an acceptable apparent viscosity could be prepared from germinated cereals. This result agrees with Hansen et al. [31] and Ikujenlola [12,27] who reported that the energy density increased two to three times by germination which also involved a considerable reduction in viscosity. It was also reported by Gimbi et al. [32] and Sajilata et al. [33] that adding germinated cereal flour to weaning food consisting of ungerminated cereal or root crop flour and sometimes legumes reduce bulk and viscosity with increase nutrient density. The pasting temperatures ranged between 81.42 and 85.12°C. The result showed that there was significant difference (p<0.05) in the pasting temperatures of the diets. Pasting temperature is the temperature at which the starch gelatinizes.

Sensory evaluation of the complementary diets

The result of the responses of the panelists who assessed the organoleptic properties of the complementary diets from a blend of quality protein maize and cowpea is presented in Table 5. All the samples were acceptable to the nursing mothers who served as the panelists. The panelists opined that germinated diets were better than the ungerminated diets in terms of smoothness, flavour, taste and general acceptability. The consistency of the ungerminated diets was preferred to the germinated diets, because the gruel of the germinated diet was too thin and the nursing mothers believed that it will not satisfy the infants’ requirement during feeding. Although this is true, but the thin gruel is advantageous in that more flour could be added to achieve the desired consistency/viscosity and by doing this more energy and other nutrients are being added. This would ensure giving the infants a high nutrient dense diet in Table 6.

Table 5: Pasting characteristics of the formulated samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Peak</th>
<th>Trough1</th>
<th>Breakdown</th>
<th>Final viscosity</th>
<th>Setback</th>
<th>Peak time</th>
<th>Pasting temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>208.67b</td>
<td>140.75b</td>
<td>67.92a</td>
<td>226.08b</td>
<td>85.33b</td>
<td>6.23</td>
<td>83.66b</td>
</tr>
<tr>
<td>B</td>
<td>37.83c</td>
<td>32.67c</td>
<td>5.17c</td>
<td>85.08c</td>
<td>52.42c</td>
<td>6.25</td>
<td>85.12a</td>
</tr>
<tr>
<td>C</td>
<td>267.75a</td>
<td>225.58a</td>
<td>42.17b</td>
<td>319.17a</td>
<td>95.58a</td>
<td>5.22</td>
<td>81.42b</td>
</tr>
<tr>
<td>D</td>
<td>34.67c</td>
<td>30.42c</td>
<td>4.25c</td>
<td>84.08c</td>
<td>53.67c</td>
<td>6.42</td>
<td>81.42b</td>
</tr>
</tbody>
</table>

Values with different subscripts in a column are significantly different (p<0.05).

Key:
A=100% unmalted QPM.
B=100% malted QPM.
C=70% unmalted QPM+30% Cowpea.
D=70% malted QPM+30% Cowpea.

Conclusion

This study has elucidated the possibility of producing high nutrient dense complementary food from malted quality protein maize and steamed cowpea. The products resulting from this study were of high protein, good mineral content and low bulk density, low water absorption and low viscosity. The properties of these products encouraged the addition of more solid and this amounted to adding more energy and nutrients to the consumers. Moreover, this study offers an opportunity to increase the utilisation of both quality protein maize and cowpea.

References

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