Nutritional and Sensory Evaluation of Rice-Based *Masa* Enriched with Soybean and Crayfish

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Abstract

*Masa* is a cereal based snack made from rice, maize or millet. It is popularly consumed in the northern regions of Nigeria. The objective of this work was to assess the nutritional and sensory properties of the rice-*masa*, enriched with soybean and crayfish. The enriched rice-*masa* produced were labelled sample A (100% rice), sample B (rice: soybean blend (80:20), sample C (rice: crayfish blend (80:20) and sample D (rice: soybean: crayfish (80:10:10). The proximate and mineral composition was evaluated according to standard methods. Anti-nutrient content was also determined. Sensory evaluation was carried out to assess the acceptability of the enriched rice-*masa*. The chemical analysis showed that protein, fibre, iron, zinc and vitamin A and beta carotene contents were highest in sample D with values 8.35 (±0.08) g/100g, 1.08 (±0.02) g/100g, 2.82 (±0.03) mg/100g, 4.20 (±0.03) mg/100g, 602.3 (±1.28) μg/100g and 420.2 (±0.98) μg/100g respectively, while calcium was highest in sample C with a value of 27.34 (±0.06) mg/100g. Moisture and ash contents increased from 47.4 (±0.50) g/100g to 50.9 (±0.80) g/100g and 0.40 (±0.01) g/100g to 1.15 (±0.01) g/100g respectively, while carbohydrate and energy contents decreased from 28.1 (±0.03) g/100g to 21.9 (±0.04) g/100g and 308.42 kcal/100g to 285.64 kcal/100g respectively. The sensory evaluation showed that with regards to taste, aroma, texture and overall acceptability, the sample enriched with soybean was more preferred to that enriched with crayfish, or a combination of both. Enrichment of *masa* could contribute to improvement of nutritional status if promoted as a nutritious, healthy indigenous snack not only where *masa* is already widely consumed, but also in other parts of Nigeria where it has not found wide acceptance.

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Keywords

Indigenous Snacks, Rice, Masa, Soybean, Crayfish, Enrichment

1. Introduction

Globally a nutrition transition is occurring, as shown by swift and widespread shifts in food consumption patterns towards the western diet and lifestyle. Accompanying this is an increased prevalence of diet-related diseases. Developing countries are gradually experiencing a shift from the utilization of indigenous snacks in favour of pastries and western type of snacks especially amongst urban and peri-urban dwellers. In Nigeria, there exist a variety of indigenous snacks such as "Aadun", a maize-based snack, "Ojojo" made from water yam, "Kulikuli" from groundnuts, and "Masa", a muffin-like snack made from cereals, among several others. The consumption of these and other snacks dates back several decades in the country’s history, especially among the low income populace, thus contributing to the overall dietary nutrient intake [1]. However, some indigenous snacks are deficient in one or more essential nutrient. There is therefore a need to improve their nutritional quality thus providing a nutritious and healthier alternative to western snacks which can be acceptable by the consumers.

Masa is a yeast-fermented product which is round in shape, and is prepared in Nigeria and some other West African countries from the flour from millet, maize or rice flour [2]. The product is cooked in a pan with individual cuplike depressions, and is consumed in various forms by all age groups in the Northern states of Nigeria [3], but less so in the Southern and eastern states, except for few rural communities in south western Nigeria where northern immigrants are found. Masa is served either as breakfast, a snack item or sometimes with local soup as a muffin [2]. Like most single cereal based products which are generally low in protein and micronutrients [4], rice-masa is no exception as it is deficient in amino acid lysine [5]. Studies have been done on the enrichment of masa using cereal legume combinations [2] [3] [5] with the results indicating a significant improvement in nutritional quality.

Nigerian cereal products have been successfully enriched using legumes, in particular, soybean. Soy-enriched maize pap ("soy-ogi") was developed by the Federal Institute of Industrial Research, Oshodi Nigeria (FIIRO), and has established processed technologies for soy-ogi production for both infants and adults [6]. Samuel and Otegbayo also evaluated the chemical and sensory properties of "ogi" enriched with soybean and crayfish, showing that supplementation with legume and animal-based protein-rich foods increased the nutritive value of ogi [7]. Nkama and Malleshi had earlier pointed out that though masa is as popular as ogi (fermented cereal gruel), it receives very little attention [3]. The work of Ayo et al. [2] [8] extended the knowledge frontier on masa, however, review of recent literature showed that there is room for more research on enrichment of masa.

The aim of this study was to evaluate the nutrient, anti-nutrient and sensory properties of rice-based masa enriched with soy flour and crayfish flour.
minutes to inactivate its trypsin inhibitor activity and reduce the beany flavour [11]. The boiled beans were de-hulled by abrasion. The dehulled soybean was dried, roasted and then milled into flour to obtain soybean flour. For enrichment, the soybean flour was mixed with the rice flour (ratio 80:20) to obtain composite flour.

Crayfish enriched masa: Crayfish enriched masa was prepared by substituting portions of rice flour with crayfish flour in the ratio 80:20. The crayfish was sorted, cleaned and sundried. The dried crayfish was milled and sieved with 30mm particle size sieve to obtain crayfish flour.

Soybean and crayfish enriched masa: The soybean and crayfish enriched masa was prepared by substituting portions 20% of rice flour with 10% soybean flour and 10% crayfish flour (i.e. ratio 80:10:10 respectively). Figure 1 shows the flowchart for the production of rice-masa.
Table 1. Recipe for the production of rice-masa.

| Raw material (g) | Sample A | Sample B | Sample C | Sample D |
|------------------|----------|----------|----------|----------|
| Rice (g)         | 500      | 400      | 400      | 400      |
| Soybean (g)      | -        | 100      | -        | 50       |
| Crayfish (g)     | -        | -        | 100      | 50       |
| Water (cm³)      | 600      | 600      | 600      | 600      |
| Sugar (g)        | 30       | 30       | 30       | 30       |
| Trona (cm³)      | 10       | 10       | 10       | 10       |
| Yeast (g)        | 5        | 5        | 5        | 5        |
| Frying oil (cm³) | 12       | 12       | 12       | 12       |
| Salt             | Pinch    | Pinch    | Pinch    | Pinch    |

*20% solution of Trona.

2.3. Chemical Analysis of Samples

The proximate and mineral composition as well as anti-nutritional properties of the samples were determined according to methods described by AOAC [12]. The energy content was calculated by multiplying the nutrient content by factors 4, 4 and 9 for carbohydrate, protein and fat respectively. All the analyses were done in triplicate. The mean scores were compared using one way analysis of variance (ANOVA), bonferroni multiple comparison test.

2.4. Sensory Evaluation

The sensory evaluation of the samples were carried out for consumer acceptance and preference using 20 panelists who were randomly selected from among students and staff of the Department of Human Nutrition, University of Ibadan, Nigeria. University of Ibadan is located in the South-Western part of the country, where masa is not widely consumed. A 9-point hedonic scale, where “1” representing “extremely dislike” and “9” representing “extremely like” was used. The mean scores were differentiated using analysis of variance methods. The qualities assessed include colour, taste, odour, texture, appearance and general acceptance. Coded samples of the same size and temperature (29°C) were served on a (white) coloured plate to judges in each panel.

2.5. Data Analysis

The mean and standard deviation of the triplicate determinations of the nutrient, anti-nutrient, functional and sensory values were calculated. One-way analysis of variance was used to test for significant differences in the nutrient, anti-nutrient and sensory properties of the snack samples.

3. Results and Discussion

3.1. Proximate Composition

The proximate composition of traditional rice-masa and enriched rice-masa samples as well as the cooked rice sample are shown in Table 2.

The energy content of the masa samples (A, B, C, D) were higher than the energy content of the cooked rice. The same was observed for protein, fat and ash. The fibre and carbohydrate contents of samples A, B and D was higher than that of the cooked rice. Sample C on the other hand, had the same values as cooked rice in both carbohydrate and fibre. It can be observed that local rice produced in form of masa, provides higher nutrients than its traditional cooked form. The moisture content of sample A, B, C, D, as shown in Table 2, ranged between 47.4% and 50.9%. These values are slightly lower than the moisture content of traditionally baked masa, which was about 56% as reported by Nkama and Malleshi [3]. The moisture content of 100% rice masa reported in this study was higher than reported by Ayo et al. [2] for rice-masa. Moisture content was highest in sample C and lowest in sample A. Significant difference (P < 0.05) was observed between the means. The moisture content of the cooked rice was significantly higher than those of the masa samples. The carbohydrate content of the four
Table 2. Proximate composition of rice-masa and enriched masa samples.

|                      | Sample A          | Sample B          | Sample C          | Sample D          | Sample E          |
|----------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| % Moisture content   | 47.4 ± 0.50*      | 48.8 ± 0.41b      | 50.9 ± 0.80c      | 48.7 ± 0.10b      | 72.7 ± 0.08d      |
| % Crude protein      | 4.23 ± 0.72a      | 7.12 ± 0.67b      | 7.21 ± 0.07c      | 8.35 ± 0.08c      | 2.90 ± 0.04d      |
| % Crude fat          | 19.9 ± 0.04a      | 20.8 ± 0.01b      | 18.8 ± 0.04c      | 18.4 ± 0.43c      | 2.23 ± 0.03d      |
| % Ash                | 0.40 ± 0.01a      | 0.52 ± 0.01b      | 1.15 ± 0.01c      | 0.92 ± 0.05d      | 0.20 ± 0.01e      |
| % Fibre              | 0.34 ± 0.01a      | 0.89 ± 0.03b      | 0.62 ± 0.01c      | 1.08 ± 0.02d      | 0.62 ± 0.01e      |
| % Carbohydrate       | 28.1 ± 0.03a      | 22.7 ± 0.08b      | 21.9 ± 0.04c      | 23.8 ± 0.07d      | 21.9 ± 0.02e      |
| Energy (kcal/g)      | 308.42            | 306.48            | 285.64            | 294.2             | 119.51            |

Mean scores having the same alphabet along the same row are not significantly different (P = 0.05); Values are means ± standard deviation of triplicate determination; KEY: Sample A = 100% rice masa; Sample B = 80% rice:20% soybean masa; Sample C = 80% rice:20% crayfish masa; Sample D = 80% rice:10% soybean: 10% crayfish masa; Sample E = cooked polished rice.

Samples varied from 21.9% to 28.1%, with sample A having the highest value compared with samples B, C, D, with significant difference (P < 0.05) was observed between the means. Protein content of the masa samples increased significantly (P < 0.05) from 4.23% to 8.35%. Sample D had significantly higher protein content than all the samples, this significant increase is due to the addition of both plant (soybean) and animal sources (crayfish) of high quality protein. The protein content of sample A (100% rice masa) was lower than 7.59% reported by other studies [2] [3] [13]. The variation in the protein content of the rice masa reported by the authors may due to differences in the chemical composition of variety of rice that was used. The protein content of enriched masa samples was significantly higher than that of 100% rice masa sample. Hence the addition of soybean or crayfish to rice-masa significantly increased the protein content of the snack. The protein, carbohydrate and energy content of the enriched samples were also lower than that of rice masa supplemented with cowpea and groundnut [3]. Fat content varied between the samples from 18.4% to 20.8%, and this was significantly higher in rice-masa than what was previously reported [2]. The fat content was highest in the soybean enriched masa (sample B), this could be attributed to the high fat content of soybean. However, a major contributor of fat in the masa samples is the vegetable oil that was used in frying. The ash and fibre content of the masa samples varied between 0.4% to 1.15% and 0.34% to 1.08% respectively, these varied significantly among the four samples. The enriched masa samples still had higher ash content than the rice masa with the highest in sample D, though the ash content of the masa samples were lower than what was reported in literature [2] [13].

3.2. Micronutrient Composition

Table 3 shows the micronutrient content of the samples. The iron content of the samples ranged from 0.03 mg/100g to 2.82 mg/100g. Masa samples enriched with crayfish showed higher iron contents. However the combination of both soybean and crayfish gave the highest iron hence the addition of crayfish to the soybean enriched masa samples would lead to a significant increase in iron content of the snack. The calcium content of the four samples varied from 13.15 mg/100g to 27.34 mg/100g. Significant difference (P < 0.05) was observed between the means. The calcium content of the crayfish enriched masa was higher than that of the soybean enriched masa and this could be attributed to the higher calcium content of the crayfish compared to soybean which is a legume and has lower calcium.

Zinc content of the samples varied from 1.51 mg/100g to 4.20 mg/100g, with higher values observed in samples C and D. Zinc was highest in sample D, having a mean value of 4.20 mg/100g with a significant difference between the means of the other samples. Sample D had the highest values for both zinc and iron. The zinc and iron content of the soybean and crayfish enriched masa was significantly higher than the report for cowpea enriched masa [3]. Vitamin A values were not determined for sample A and B, since they do not contain animal source of food, rather beta-carotene was determined. The beta-carotene content increased from 388.5 µg/100g to 420.2 µg/100g and was highest in the sample D. Significant difference (P < 0.05) was observed between the means.
Table 3. Micronutrient composition of rice-masa and enriched masa samples.

| Sample | Vitamin A (µg/100g) | Beta carotene (µg/100g) | Calcium (mg/100g) | Iron (mg/100g) | Zinc (mg/100g) |
|--------|----------------------|-------------------------|-------------------|----------------|----------------|
| A      | ND                   | 388.5 ± 0.81            | 13.15 ± 0.04      | 1.94 ± 0.03    | 1.51 ± 0.02    |
| B      | ND                   | 413.8 ± 0.37            | 14.08 ± 0.03      | 0.03 ± 0.00    | 1.58 ± 0.03    |
| C      | 595.6 ± 1.12         | ND                      | 27.34 ± 0.06      | 2.54 ± 0.02    | 1.68 ± 0.04    |
| D      | 602.3 ± 1.28         | 420.2 ± 0.98            | ND                | 2.82 ± 0.03    | 4.20 ± 0.03    |

Mean scores having the same alphabet along the same column are not significantly different P = 0.05; ND: Not determined; Values are means ± standard deviation of triplicate determination.

3.3. Anti-Nutrient Composition

It has been well documented that raw soybeans contain anti-nutritional compounds, which can be removed by various methods of processing. The anti-nutrient content of rice-masa and enriched rice-masa samples is shown in Table 4. The trypsin inhibitor was only determined in samples containing soybean, which has been reported to contain trypsin inhibitor [14] [15]. The mean values for Trypsin Inhibitor Units (TIU) per milligram were quite low, ranging from 0.10 to 0.12 per mg of each sample; and TIU was not determined for two samples which are the samples that lack soybean as part of their constituents. Phytate, on the other hand, ranged from 0.002 to 0.006 percent while oxalate ranged from 0.005 to 0.009 percent. Phytates and oxalates were highest in sample A and lowest in sample C, though at levels safe for consumption. There was a significant difference (P < 0.05) in the phytate and oxalate content among all the samples. Oxalates form complexes with calcium, magnesium and iron leading to formation of insoluble salts and resulting in the formation of oxalates stones, and has also been known to inhibit potassium and sodium.

3.4. Sensory Attributes

Mean scores of all sensory attributes for each of the samples as evaluated by the panelists are shown in Table 5. The overall acceptability of the four samples showed that sample A was the most accepted while sample C, the rice-masa with crayfish was the least accepted of the four samples with mean scores of 7.05 and 3.90 respectively, rated on the basis of the score of “1” being “extremely dislike” and “9” being “extremely like”.

Specifically, for appearance, scores of the four samples ranged from 5.80 to 6.80 with samples C and D rating the lowest and highest respectively, however there was no significant difference among the samples in terms of their appearance. Taste of the four samples differed significantly, and ranged from 3.65 to 6.85 with samples C and A rating the lowest and highest respectively. For aroma, samples C and A rated lowest and highest respectively. The mean score also shows that sample A was rated highest and sample C lowest in terms of taste and aroma. This could be associated to the fermentation of crayfish alongside rice for 12 hours, during the production of masa. This result does not agree with the recommendation that fermentation of rice, soybean and crayfish can attain 24 hrs [16] as taste is a very important factor in ensuring consumer acceptance and willingness to adopting enriched foods. Although sample A was the most preferred in texture with a mean score of 5.85, there was no significant difference in the mean scores for texture, showing that enrichment did not significantly alter the texture of masa.

4. Conclusions

This study shows that soybeans and crayfish can be employed as enrichment materials in the production of traditional rice-based masa. Although the crayfish enriched masa gave more desirable results in improving the protein as well as micronutrient content of the snack, its sensory attributes were poorer than that of soy enriched sample. On the other hand, enrichment of masa with full fat soy flour considerably improved the nutrient content in terms of protein, fat and micronutrients; the sensory characteristics were rated acceptable by panel lists, and were safe for consumption giving the low level of anti-nutrients.

As an indigenous food sold in a ready-to-eat form, enriched masa has potential to be promoted as a nutritious, healthy food choice for breakfast or as a snack not only where masa is already widely consumed, but also in other parts of Nigeria where it has not found wide acceptance. Part of the applicability of this research lies in the
Table 4. Anti-nutrient composition of rice-masa and enriched masa samples.

|                      | Sample A      | Sample B     | Sample C     | Sample D     |
|----------------------|---------------|--------------|--------------|--------------|
| Trypsin inhibitor (TIU/mg) | ND            | 0.12 ± 0.11  | ND           | 0.10 ± 0.01  |
| Phytate (%)           | 0.006 ± 0.00abc | 0.003 ± 0.00a | 0.002 ± 0.00b | 0.004 ± 0.00c |
| Oxalate (%)           | 0.009 ± 0.05a  | 0.006 ± 0.00b | 0.005 ± 0.00b | 0.007 ± 0.02d |

ND: Not determined; Values are means ± standard deviation of triplicate determination.

Table 5. Sensory properties of rice-masa and enriched masa samples.

|                      | Sample A      | Sample B     | Sample C     | Sample D     |
|----------------------|---------------|--------------|--------------|--------------|
| Appearance           | 6.26 ± 1.41a  | 6.65 ± 1.49a | 5.80 ± 1.43a | 6.80 ± 1.32a |
| Taste                | 6.85 ± 0.98a  | 5.25 ± 1.73ab | 3.65 ± 2.30b | 4.15 ± 2.22b |
| Aroma                | 6.60 ± 1.09a  | 5.60 ± 1.53a  | 4.05 ± 2.21b | 5.15 ± 1.78b |
| Texture              | 5.85 ± 1.38a  | 5.30 ± 1.80a  | 5.30 ± 1.75a | 5.39 ± 2.07a |
| Overall acceptability| 7.05 ± 0.99a  | 5.90 ± 1.71a  | 3.90 ± 2.33b | 5.05 ± 1.90bc |

Mean scores having the same alphabet along the same row are not significantly different P = 0.05; Values are means ± standard deviation of triplicate determination.

Possibility of promoting enriched masa as an underutilized yet nutritious food product among populations where it remains largely unexploited. Consumption of indigenous foods and snacks is gradually being abandoned by urban and peri-urban dwellers in Nigeria, in favour of pastries and western type of snacks. For future research, masa can be improved and promoted not only for poor rural dwellers, but also as a street food for urban and peri-urban dwellers of different socio-economic status. Urban dwellers are often regular consumers of processed or fast foods, given the pressures of city life and being away from home for a greater part of the day, leaving little or no time to shop for foodstuffs or to prepare wholesome meals. Hence, the enrichment of masa could contribute significantly as a means of tackling undernutrition, as well as improving nutritional status when promoted in Nigeria.

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