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<td>Author 2</td>
<td>NWOKOCHA, M. O.</td>
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Chemical and organoleptic evaluation of biscuits made from mixtures of hungry rice, acha (Digitaria exilis) sesame; (Sesamum indicum); and breadfruit (Artocarpus altilis) flours

N.M. NNAM and M.O. NWOKOCHA
Department of Home Science and Nutrition, University of Nigeria, Nsukka

Abstract. The proximate, mineral and vitamin compositions of the biscuits prepared from mixtures of unprocessed and processed hungry rice (acha), sesame and breadfruit flours were evaluated. Processing included sprouting acha for 48 h, dehulling sesame and boiling breadfruit for 10 min. The samples were milled into fine flours and combined in ratios of 70:15:15, 60:25:15 and 60:15:25 (protein basis) of sesame, acha and breadfruit. Biscuits developed from the composite flours were chemically and organoleptically evaluated using standard methods. The biscuits contained appreciable quantities of phosphorus, calcium and ascorbate and fair levels of protein (9.02-14.30%). The biscuit from the processed 70:15:15 mixture had the highest (p < 0.05) protein level. Processing improved flavor and general acceptability of the biscuits. Biscuits from the processed 60:25:15 and 60:15:25 mixtures were preferred over others in terms of organoleptic attributes.

Key words: Acha or hungry rice, Breadfruit, Nutrients, Organoleptic attributes, Sesame

Introduction

Protein-energy malnutrition (PEM) and micronutrient deficiencies in infants and young children are the major nutritional problems in developing countries [1]. About one of every five persons in the developing world is chronically undernourished, while 192 million children suffer from PEM and over 200 million experience micronutrient deficiencies [1]. Data from around the world show that the major cause of most nutrition problems is inadequate dietary intake [1]. A food based approach appears to be the most practical solution in addressing the root causes of the deficiencies [2]. Nutrition education, on the most appropriate ways of processing and combining the local staples in the region, is especially necessary. This will help the populace, particularly women, in achieving and insuring good nutrition.

In Nigeria, hungry rice, sesame and seedless breadfruit are some lesser known but locally available food crops whose processed blends could be...
valuable in the fight against malnutrition. Hungry rice, also known as acha, is a nutritious cereal rich in methionine and cystine [3]. The total sulphur aming acid content of 7.3% makes it an excellent complement to legumes [3]. Acha contains 10.5% protein, 1.89% fat and 75.0% carbohydrate and has a remarkably high content of potassium (1090.0 mg/100 g) [4]. Sesame, simsim (benniseed in West Africa), is an oil seed rich in protein (26%), fat (50%), calcium (1160.00 mg/100 g) and phosphorus (616 mg/100 g) [1, 5]. Seedless breadfruit is a good source of minerals (iron, calcium, phosphorus) and vitamins (ascorbic acid and provitamin A) [6]. The blends of these food crops would have promising nutrient potentials. However, adequate processing is essential to ensure maximum availability of nutrients. The objectives of this study were to:

1. develop biscuits from different mixtures of unprocessed and processed 'acha', sesame and breadfruit flours and
2. examine the nutrient composition and organoleptic acceptabilities of the biscuits.

Materials and methods

Materials

Acha (Digitaria exilis) and sesame seeds (Sesamum indicum) used for the study were purchased from the Lafia market in Nasarawa State, Nigeria. The seedless breadfruit (Artocarpus altilis) was obtained from the Egbema market in Imo State, Nigeria. The samples were used immediately for the study.

Preparation of materials

Four kilograms of sesame seeds were cleaned and divided into two portions of 2 kg each. One of the portions was not processed (UDS). The remaining portion was dehulled mechanically (DS) using a laboratory dehulling machine (Model 200 LO90, Bental Superb, England) and winnowed to remove the hulls.

Five kilograms of acha grains were cleaned and divided into two equal portions of 2.5 kg each. One of the portions was not sprouted (unsprouted acha; USA). The other portion was soaked for 8 h in cold deionized water (28 ± 2 °C) in a ratio of 1:3 (w/v) grain to water. After soaking, the grains were spread on wet jute bags and covered with muslin cloth moistened with deionized water to sprout for 48 h at an average room temperature of 28.0 ± 2 °C. The grains were washed twice daily with deionized water to avoid the growth of mold. After sprouting, the grains were dried in a hot air oven
(Model No. 320, Gallenkamp, England) at 55 °C for 12 h to 96% dry matter. The unprocessed and processed samples of sesame and acha were milled separately in a laboratory hammermill (Model ED-5, Thomas Wiley, England) to a fine flour (70 mm mesh screen). The samples were kept separately in Kilner jars at room temperature (28 ± 2 °C) for chemical analyses and formulation of composites.

Ten kilograms of breadfruit were washed, hand peeled and divided into two equal portions of five kilograms each. One portion was boiled with deionized water in a ratio of 1:2 (w/w) breadfruit to water (BB). The mixture was put in a covered aluminium sauce pan and boiled for 10 min using a thermostatically controlled water bath set at 100 °C. The other portion was not boiled (UBB). Both samples were dried and milled as described for the acha grains. The flours were kept separately in Kilner jars at room temperature (28 ± 2 °C) before the formulation of the composite flours.

**Formulation of composite flours**

The crude protein level of each flour was estimated by the microKjeldahl procedure [7]. The composite flours were formulated in ratios of 70:15:15, 60:25:15, 60:15:25 (protein basis) of unprocessed and processed sesame, acha and breadfruit, respectively. Six composite flours were formulated as follows:

1. (1) undeheulled sesame, unsprouted acha and unboiled breadfruit – 70:15:15
2. (2) dehulled sesame, sprouted acha and boiled breadfruit – 70:15:15
3. (3) undeheulled sesame, unsprouted acha and unboiled breadfruit – 60:25:15
4. (4) dehulled sesame, sprouted acha and boiled breadfruit – 60:25:15
5. (5) undeheulled sesame, unsprouted acha and unboiled breadfruit – 60:15:25

**Preparation of biscuits**

Biscuits were produced from each of the six composite flours using the following formulation: 300 g of composite flour, 100 g of margarine, 100 g of granulated sugar, 35 ml of deionized water, 6 g of double acting baking powder and 12 g of egg. All the dry ingredients were blended together by stirring 12 strokes with a wooden spoon. Fat was rubbed into the flour mixture until the consistency of bread crumbs was achieved. The egg was whisked for 3 minutes and folded into the flour mixture. Deionized water was added to the mixture and a wooden spoon was used to stir 10 strokes to get a homogeneous dough. The dough was rolled on a pastry board with a rolling pin to 3 mm thickness. The flat dough was then cut into shapes using a 4.5 cm (diameter) biscuit cutter. The biscuits were baked on an aluminium baking pan slightly greased with margarine in a gas oven at 200 °C for 15 minutes.
The samples were removed and cooled on a rack for 5 minutes before the sensory evaluation.

**Sensory evaluation**

A nine point hedonic scale [8] was used to test for flavor, texture, color and general acceptability of the biscuits. The degree to which a product was liked was expressed as like extremely (9 points), like very much (8 points), like moderately (7 points), like slightly (6 points), neither like nor dislike (5 points), dislike slightly (4 points), dislike moderately (3 points), dislike very much (2 points) and dislike extremely (1 point). Like extremely to like slightly constituted good while dislike slightly to dislike extremely constituted poor. One hundred mothers were selected through random sampling from the Mother and Child Health (MCH) clinic of the Bishop Shanahan Hospital, Nsukka, for the sensory evaluation. The mothers were divided into four groups for the evaluation. Morning and afternoon evaluation sessions were organized for the groups for two days. Each group participated in one of the evaluation sessions. The testing was conducted in the food research laboratory of the Department of Home Science and Nutrition, University of Nigeria, Nsukka. Each of the panelists was seated in an individual compartment with fluorescent lighting and free from distraction. The six biscuit samples were presented separately to each of the panelists on six small white plastic plates for evaluation. Room temperature (28 ± 2°C) was maintained throughout the testing session.

**Chemical analysis**

Each of the biscuit samples was dried separately in a hot air oven (Model No. 320, Gallenkamp, England) at 55 °C for 12 hr to 96% dry matter. The dried samples were milled separately in a laboratory hammermill (Model ED-5, Thomas Wiley, England) to a fine flour (70 mm mesh screen). The samples were stored in separate Kilner jars at room temperature (28 ± 2°C) for chemical analyses. All the determinations were done in triplicate using the AOAC [7] standard methods. Crude protein was determined by the microKjeldahl method (Method 981.10); crude fiber was by acid hydrolysis (Method 962.09E); fat was by the Soxhlet extraction method (Method 960.39); ash by dry ashing method (Method 900.01D); while carbohydrates were determined by difference. Ascorbic acid was determined using the 2,6 dichlorophenol indophenol method (Method 971.30) while minerals were determined by atomic absorption spectrophotometry (Model 3030 Perkin-Elmer, Norwalk, USA) (Methods 902.27 and 986.24).
All the data were subjected to one way analysis of variance. Duncan's New Multiple-Range Test (DNMRT) \([8,9]\) was used to separate means. Significance was accepted at \(p \leq 0.05\).

Results and discussion

The nutrient compositions of biscuits from unprocessed and processed sesame, acha and breadfruit composite flours are presented in Table 1. The protein level of the biscuits ranged from 10.17\% in the product made from the 70:15:15 unprocessed composite flour to 14.30\% in the product with the processed 70:15:15 blend. Relative to the unprocessed samples, processing improved protein level only in the biscuit from 70:15:15 composite. This might have been due to the increased amount of dehulled sesame in the blend. Dehulling increased protein level because the hulls, which were removed, contained less protein with more concentration of this nutrient in the cotyledons.

Fat levels of the biscuits varied. The biscuits from processed flours contained lower \((p < 0.05)\) fat than those from the unprocessed. The decrease in fat due to processing might have been due to (a) leaching of the nutrient in boiling water, (b) loss of the nutrient during the dehulling process, and (c) enzymatic breakdown of fat during sprouting. The biscuit made from the unprocessed 70:15:15 mixture had the highest \((p < 0.05)\) fat level probably because of the higher level of sesame in the mixture. The fat content of all the biscuits were high irrespective of treatment. This might be attributed in part to the high fat level of sesame \([1]\) and the fat used in the preparation of the biscuits.

The ash levels of the biscuits were influenced by processing and the protein ratios of the blends. The ash value of the biscuits prepared from the unprocessed 60:25:15 mixture was the lowest \((p < 0.05)\). This was because of the higher amount of acha flour (25\%) in this blend than in the other composites, and the low level of ash in acha (1.3\%) \([3]\).

All the biscuits from the processed flours contained lower \((p < 0.05)\) fiber than the products from the unprocessed flours. The lower fiber levels of the biscuits from the processed flours might be attributed to the processing methods (sprouting, boiling and dehulling) employed during the preparation of the flours. It is known that during sprouting of seeds, amylolytic enzyme activity increases to hydrolyze complex carbohydrates to simpler and more absorbable sugars \([10]\). This causes a decrease in fiber levels. Fiber might also have been lost with the hulls during the dehulling of sesame. FAO \([5]\)
<table>
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<tr>
<th>Nutrient</th>
<th>USS-5+4 A</th>
<th>USS-5+4 B</th>
<th>USS-5+4 C</th>
<th>USS-5+4 D</th>
<th>USS-5+4 E</th>
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<tr>
<td>Protein (%)</td>
<td>23.2 ± 0.98</td>
<td>23.1 ± 0.98</td>
<td>23.1 ± 0.98</td>
<td>24.6 ± 0.98</td>
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<td>Fat (%)</td>
<td>15.9 ± 0.09</td>
<td>15.9 ± 0.09</td>
<td>15.9 ± 0.09</td>
<td>16.0 ± 0.09</td>
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<td>Ash (%)</td>
<td>2.17 ± 0.3</td>
<td>2.17 ± 0.3</td>
<td>2.17 ± 0.3</td>
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<td>Fiber (g)</td>
<td>3.19 ± 0.09</td>
<td>3.19 ± 0.09</td>
<td>3.19 ± 0.09</td>
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<td>Total P (mg)</td>
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<td>Total Se (mg)</td>
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1. Data weighted means. Means followed by the same letter in the same row were not significantly different (p < 0.05) from each other.
reported that the sesame hull, which forms about 12% of the seed, is rich in fiber. The lower fiber levels of the biscuits from the processed flours might be of interest, particularly in feeding the infant and the young child. Fiber is known to contribute to dietary bulk with a subsequent decrease in nutrient and energy densities of the products [11].

Processing had varying effects on the carbohydrate (CHO) levels of the products. Carbohydrate content ranged from 55.51% in the biscuit from the processed 70:15:15 composite to 65.93% in the product from the processed 60:25:15 mixture. The CHO levels of all the biscuits were low due to the high fat level of sesame and the fat added in the biscuit formulation. This might be of interest since fat supplies more than two times the energy obtained from CHO.

Processing was not beneficial in improving copper (Cu) levels. The product from the unprocessed 70:15:15 composite flour contained more (p < 0.05) Cu than the others. Iron (Fe) appeared to follow the same trend as Cu with the highest (p < 0.05) level occurring in the product from the unprocessed 60:25:15 composite flour. The lower levels of Cu and Fe in the biscuits made from the processed blends might have been due to leaching of the nutrients during processing. However, the higher levels of the minerals in the biscuits made from the unprocessed flours do not imply higher availability because of the presence of antinutrients—phytate and tannin. They potentially bind the minerals and make them nutritionally unavailable for utilization [12].

There were traces of iodine in some of the biscuit samples. The processed 60:25:15 flour mixture produced biscuits with the highest iodine. Traces of zinc (Zn) occurred only in the product made from 60:25:15 unprocessed composite flour. The highest (p < 0.05) Zn level was observed in the product from the processed 60:25:15 composite. The traces of iodine and Zn observed in the biscuits could be attributed to low extractability of the minerals which might have been in bound form or leaching of the minerals during processing.

The biscuits appeared to be high in magnesium (Mg), phosphorus (P) and calcium (Ca). Processing increased (p < 0.05) Mg levels of the biscuits except for the product from the 70:15:15 flour mixture. Processing also caused significant (p < 0.05) increases in the P level of the biscuits with the highest increase occurring in the products from the 60:25:15 flour mixture. The higher P levels in the processed products compared to the unprocessed might be attributed to sprouting of the acha seed. During sprouting of seeds, the enzyme phytase, is activated to hydrolyze phytic acid with the release of free P. The Ca levels of the products varied. The unprocessed 60:25:15 product contained higher (p < 0.05) Ca than the others. This might be attributed to the high Ca level of sesame (1160.00 mg/100 g) [5], most of which
is present as oxalate in the seed coat. The seed coat was not removed in the unprocessed composite to reduce Ca level.

All the biscuit samples contained high levels of ascorbate (125.00-324.67 mg/100 g). The highest ($p < 0.05$) level was observed in the product made from the unprocessed 60:15:25 flour mixture. The higher level of ascorbate for this composite might have been due to the higher amount of breadfruit relative to other components. Ascorbic acid is found in significant amounts in fruit [12] and breadfruit is in this food group. Processing decreased ($p < 0.05$) the ascorbate levels of the products. This was probably due to boiling of the breadfruit since heat treatment tends to oxidize ascorbic acid and lead to total loss of the vitamin.

**Organoleptic attributes of the biscuits**

The organoleptic properties of the biscuits from unprocessed and processed sesame, acha and breadfruit composite flours are shown in Table 2. The panelists liked the color of all the biscuits, however, they preferred that of the products from the processed and unprocessed 60:15:25 flour mixture and the processed 60:25:15 composite. The possible reason for the preference might be due to an increased quantity of breadfruit in the 60:15:25 flour mixture and a decreased level of sesame in the 60:25:15 composite. Breadfruit had an attractive white color similar to wheat flour, while sesame had a dull brownish color. This might also explain the lower color scores for the products from the 70:15:15 flour mixtures. The color of the products from the processed flours were preferred over those of their unprocessed counterparts. This showed the beneficial effect of dehulling to remove the seed coat and improve color.

The panelists preferred the flavor of the products from processed composites over those from the unprocessed. The flavor of the products from the processed 60:25:15 and 60:15:25 composites were liked moderately while the products from their unprocessed counterparts were neither liked nor disliked. Again, this shows the advantage of processing which removed undesirable flavoring substances. Suberbie et al. [13] noted that germination processes were developed in part, to overcome the undesirable flavor of legume seeds and improve nutrient quality.

Processing improved the texture of the biscuits. The biscuits from the processed 60:25:15 and 60:15:25 flour mixtures were liked moderately by the mothers while the products from the unprocessed mixtures were liked slightly. The panelists liked the texture of all the products but preferred that of the processed 60:25:15 and 60:15:25 blends. This might be attributed to lower fat levels in the blends as a result of loss of this nutrient during processing and the reduced amount of sesame in the composites. Sesame, as an oil seed contains unrefined oil which might have affected the texture of
Table 2. Organoleptic properties of biscuits from unprocessed and processed sesame, acha and breadfruit composite flours

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<tbody>
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<td>Color</td>
<td>5.30 ± 0.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.73 ± 0.29&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.87 ± 0.26&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.50 ± 0.21&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>7.40 ± 0.23&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.87 ± 0.14&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Flavor</td>
<td>4.67 ± 0.44&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.60 ± 0.29&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>5.83 ± 0.42&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.53 ± 0.24&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>5.87 ± 0.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.17 ± 0.29&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>Texture</td>
<td>6.10 ± 0.30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.80 ± 0.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.80 ± 0.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.40 ± 0.23&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>6.63 ± 0.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.73 ± 0.10&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>General acceptability</td>
<td>5.30 ± 0.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.10 ± 0.34&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.67 ± 0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.67 ± 0.28&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.21 ± 0.42&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.47 ± 0.29&lt;sup&gt;c&lt;/sup&gt;</td>
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1 Scores are based on a 9 point hedonic scale where scores of 9 = Like extremely 5 = Neither like or dislike 1 = Dislike extremely.

Means not followed by the same letters in the same row are significantly (p < 0.05) different from each other.

UDS = Undehulled sesame; USA = Unsprouted acha (hungry rice); UBB = Unboiled breadfruit.

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Table notation:
- **UDS**: Undehulled sesame.
- **USA**: Unsprouted acha (hungry rice).
- **UBB**: Unboiled breadfruit.
- **DS**: Dehulled sesame.
- **SA**: Sprouted acha (hungry rice).
- **BB**: Boiled breadfruit.
the biscuits. Unrefined oil produces biscuits that are crumbly instead of good quality biscuits which are flaky.

The general acceptability of the products were influenced by processing, the ratio of ingredients in the flour mixtures and the organoleptic attributes of flavor, texture and color. All the products from the processed flour mixtures were liked moderately while those from the unprocessed were liked slightly except the 70:15:15 product which was neither liked nor disliked. In terms of overall acceptability, the panelists preferred the products from the processed composites over those from the unprocessed. This could be attributed to the beneficial effects of processing (sprouting, dehulling and boiling) which improved color, texture and flavor of the products. All the biscuit samples were acceptable, except the product from the unprocessed 70:15:15 flour mixture. The acceptability of the products, particularly those from the processed flour mixtures, indicates possible opportunities for further use of the flour mixtures in confectionery products and formulation of complementary foods.

As judged from the results, biscuits prepared from composite flours contained appreciable amounts of nutrients particularly the macroelements, ascorbate and the energy yielding nutrients. Processing of the food ingredients upgraded the levels of some of the nutrients and improved the general acceptability of the biscuits. The biscuits made from the processed flour mixtures, especially those from the 60:25:15 and 60:15:25 combinations were preferred by the panelists over those from the unprocessed. Use of the processed blends should be explored in other food products particularly for weaning infants because of their promising nutritive contents.

References


