Nutritional composition of breadfruits (Artocarpus spp. and Treculia africana) in Ghana

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Abstract

Artocarpus spp. and Treculia africana are underutilized crops found widely in the tropics. In order to expand their use, their potential for use in food systems was determined by evaluating their physico-chemical properties. Standard procedures were used. Selected food products were then formulated using breadfruit flours as a substitute for conventional wheat flours. The study showed that their protein content ranged between 12.23 and 17.72%, whereas the crude fibre content varied between 1.67 and 2.91%; the carbohydrate content was between 57.00 and 70.15%. Potassium was the predominant mineral, ranging from 533.95 mg 100 g⁻¹ in T. africana to 1313.3 mg 100 g⁻¹ in Artocarpus camansi. Sodium content ranged between 37.5 mg 100 g⁻¹ in A. camansi to 54.0 mg 100 g⁻¹ in T. africana. The iron content was highest in Artocarpus heterophyllus (9.38 mg 100 g⁻¹), while A. camansi had the lowest (2.20 mg 100 g⁻¹). The results showed that the breadfruit species had good nutritional properties that vindicate their use as a stop-gap food. Promoting the production and consumption of breadfruits could help to meet the nutritional needs of consumers.

Keywords: breadfruit, nutrient composition, functional properties, food product formulation, sensory attributes

INTRODUCTION

Breadfruits, including Artocarpus altilis, A. camansi and A. heterophyllus, are common in 90 countries in the tropics and subtropics (Ragone, 2007). Treculia africana (African breadfruit), however, grows specifically in Africa. Breadfruits grow under a wide range of ecological conditions with minimal input of labour and materials and require little care. Breadfruits are used as food and may be eaten ripe as fruit or unripe as a vegetable. The importance of breadfruits notwithstanding, they are underutilized and neglected (Omohuwoj, 2007). They are generally considered as unimportant food crops. This has, therefore, led to their neglect by stakeholders. Beyer (2007) reported that breadfruits have the potential to contribute to food security. There is, therefore, the need to assess the nutrient content of the breadfruit varieties to promote their use. Hence, this study.

MATERIALS AND METHODS

Location of study

Determination of proximate composition was carried out at the Crops Research Institute, whereas functional analysis was done at Food Research Institute of Centre for Scientific and Industrial Research in Ghana.

Sample collection and preparation

A. altilis and A. heterophyllus fruits were collected from Kwame Nkrumah University of Science and Technology, Kumasi, while A. camansi fruits were from New Tafo-Akim in the Eastern Region of Ghana. T. africana fruits were obtained from Twifo Praso in the Central Region, Ghana. Fresh, firm and mature A. altilis fruits were harvested, washed with clean water and transported immediately to the laboratory for analyses.
1. *A. altilis.*

Ten fresh, mature, unripe fruits of *A. altilis* were harvested, washed with clean water, peeled and sliced into cubes (about 2 cm$^3$) under running tap water. Five kilograms of the sliced cubes was immediately placed in an oven (Wagtech-Model GP120SSE300HYD) and dried at 60°C for 48 h until crisp based on preliminary investigation. Dried slices were cooled and milled in hammer mill and sieved through 75-µm mesh.

2. *A. camansi, A. heterophyllus* and *T. africana.*

Seeds were extracted by hand from ten fruits each of over-ripe *A. camansi, A. heterophyllus* and *T. africana.* Two kilograms of the extracted seeds was washed in clean fresh water and dried at 600°C in an oven (Wagtech-Model GP120SSE300HYD) for 24 h (Odoemelam, 2005) to facilitate dehusking (endosperm removal). The dried seeds were milled in a hammer mill and sieved using 75-µm mesh to obtain the flours. The flours were packaged in air-tight plastic bottles prior to analyses.

Parameters studied

1. **Proximate composition.**

   Determination of moisture content, ash, crude protein and crude fibre was carried out using methods prescribed by AOAC (1990). Crude fat was extracted using the Soxhlet procedure with petroleum ether (60-80°C) for 16 h. Carbohydrate content was determined by differencing (Kirk and Sawyer, 1991).

2. **Mineral analysis.**

   Two grams of dried, milled samples was ashed in a previously ignited and weighed crucible. The crucible and content were then placed in a Muffle furnace (size 2, England) for 2 h at 600°C. The samples were then allowed to cool in an oven to 100°C for 30 min, cooled to ambient temperature in a desiccator and weighed. Ash was calculated and expressed as percentage of the original weight. Two millilitres of concentrated HCl was poured on selected ashed samples to dissolve the ash in the crucible. Dissolved ash was filtered through filter paper into dilution tubes. Double-distilled water was used to wash leftover ash in the crucible and poured into the dilution tube. This was made up to the 25-mL mark using distilled water prior to analysis (AOAC, 1990).

   Calcium was determined by the $O$-cresolphthalein complexone method using an Optima SP-300 spectrophotometer (Tietz, 1995). Iron content was determined by the 1,10-phenanthtoline method using an Optima SP-300 spectrophotometer (Harris, 2003). Potassium and sodium were determined using a Jenway flame photometer. The Calmagite method was used in the determination of magnesium content and an Optima SP-300 spectrophotometer was used at 520 nm (Tietz, 1995).

**Data analysis**

Physico-chemical, functional and sensory parameters were analysed with the Statistix 9 statistical package. Data obtained for all parameters were reported as mean scores of triplicates. Differences among sample means were separated using least significant difference (LSD) test at P≤0.01 (Snedecor and Cochran, 1976)

RESULTS AND DISCUSSION

**Proximate composition of breadfruit flours**

Moisture content of the nut-derived flours (*A. camansi, A. altilis* and *T. africana*) varied between 7.20 and 10.81% (Table 1). The moisture content of *T. africana* was the highest, significantly (P<0.01) different from the others. The lowest moisture content was from *A. camansi.* The values obtained in this study are lower than the maximum recommended by Butt et al. (2004), which was 10-14%. The lower moisture levels in this study are suggestive of longer shelf-life for the flours. Generally, increased moisture levels in flours are known to
encourage the growth of micro-organisms and consequently microbial spoilage.

Table 1. Proximate composition of breadfruits.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>A. heterophyllus</th>
<th>T. africana</th>
<th>A. camansi</th>
<th>A. altillis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>7.69±0.53c</td>
<td>10.81±0.43a</td>
<td>7.20±0.05c</td>
<td>9.11±0.19b</td>
</tr>
<tr>
<td>Crude protein</td>
<td>12.23±0.12b</td>
<td>17.57±0.45a</td>
<td>17.72±0.62a</td>
<td>3.80±0.61c</td>
</tr>
<tr>
<td>Crude fat</td>
<td>5.57±0.08c</td>
<td>9.08±0.14a</td>
<td>6.33±0.30b</td>
<td>2.26±0.05d</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>2.22±0.09b</td>
<td>2.91±0.08a</td>
<td>1.67±0.10c</td>
<td>3.12±0.08a</td>
</tr>
<tr>
<td>Ash</td>
<td>2.13±0.02d</td>
<td>2.64±0.02b</td>
<td>2.90±0.05a</td>
<td>2.36±0.05c</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>70.15±0.78b</td>
<td>57.00±0.33d</td>
<td>64.18±0.70c</td>
<td>79.34±0.59a</td>
</tr>
</tbody>
</table>

Figures followed by different letters are significantly different at P<0.01.

Crude protein content of the breadfruit species ranged between 12.23 and 17.72%. A. camansi (17.72%) had similar a crude protein content to T. africana (17.57%), which was significantly higher than A. heterophyllus (12.23%). The protein content of the flours was within the range (12-15%) expected for grains and legumes (Ihekoronye and Ngoddy, 1985). Generally, the protein content gives an indication of the nutritional quality of the flour. Proteins are increasingly being utilized to perform functional roles in food formulations. Therefore, the protein content of the flours in this study suggests that they may be useful in food systems where protein functionality is needed, and also contribute to the recommended daily intake of protein for adults (34-56 g day⁻¹) and children (13-19 g day⁻¹) (Food and Nutrition Board, 2002).

Significant differences (P<0.01) were observed between the species with respect to their fat content. T. africana had the highest crude fat content (9.08%), 1.6 times higher than the lowest (5.57%), found in A. heterophyllus. Nelson-Quartey et al. (2007) reported fat contents of 6.68-7.69% for A. camansi and 1.96-2.26% for A. altillis pulp. However, in this study, the fat content of A. camansi was 6.33%. Fats are essential in the diet, as they increase the palatability of foods by absorbing and retaining their flavours (Aiyesanmi and Oguntokun, 1996). Diets high in fat contribute significantly to the energy requirement for humans. Consequently, the high fat content of T. africana make it a better source of fat than A. camansi or A. heterophyllus in food formulations, and it could be a better flavour enhancer.

A. altillis flour had the highest crude fibre content (3.12%). Nelson-Quartey et al. (2007) recorded crude fibre content of 1.30% for A. camansi bean flour. High fibre intake has been linked with decreased chances of colon cancer and associated with reducing constipation. The Codex Alimentarius Commission (2000) indicated that the crude fibre content for weaning foods should not be greater than 5%. Consequently, the low crude-fibre content of the flours in this study suggests that they could be suitable for use in infant formulations.

The ash content of the flours ranged between 2.13 and 2.90%. The ash content of A. camansi (2.9%) was lower than the 3.1% reported by Nelson-Quartey et al. (2007). In contrast, the ash content for A. heterophyllus and A. camansi in this study was lower than the 3.6% reported by Singh et al. (1991). The ash content of the flours was comparable to that of maize, a popular ingredient in weaning foods, which has ash content of 3.3% (Ihekoronye and Ngoddy, 1985).

The carbohydrate content of the flours of the breadfruit species varied from 57.01 to 79.34%. A. altillis had the highest carbohydrate content. The carbohydrate content of the flours was comparable to maize (66.0-75.9%; Ortega et al., 1986). According to Brown (1991), carbohydrates are good sources of energy, and a high concentration is desirable in breakfast meals and weaning formulas. In this regard, therefore, the high carbohydrate content of the flours makes them good sources of energy in breakfast formulations.

**Mineral content of breadfruits flours**

Calcium content of the nut-derived flours of the breadfruit varied between 65.00 mg...
100 g⁻¹ in *A. heterophyllus* and 127.50 mg 100 g⁻¹ in *T. africana* (Table 2). However, the calcium content of the breadfruit flours was lower than for cassava (615 mg 100 g⁻¹; Akindahunsi et al., 1999). The National Academy of Sciences (2004) recommends calcium intake of between 500 and 800 mg day⁻¹ for children (1-8 years old) and 1000-1300 mg day⁻¹ for adults. From the results of this study, consuming 400 g day⁻¹ of *T. africana* flour can provide the complete daily requirement of calcium for children less than 8 years of age.

Table 2. Mineral composition (mg 100 g⁻¹) of breadfruits.

<table>
<thead>
<tr>
<th>Mineral</th>
<th><em>A. heterophyllus</em></th>
<th><em>T. africana</em></th>
<th><em>A. camansi</em></th>
<th><em>A. altilis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>65.00±0.05bc</td>
<td>127.5±0.05a</td>
<td>93.00±0.00b</td>
<td>60.83±0.04c</td>
</tr>
<tr>
<td>Fe</td>
<td>9.38±0.08a</td>
<td>3.75±0.05b</td>
<td>2.20±0.05c</td>
<td>3.91±0.08b</td>
</tr>
<tr>
<td>Mg</td>
<td>92.70±0.011b</td>
<td>167.71±0.06a</td>
<td>10.18±0.07c</td>
<td>90.63±0.05b</td>
</tr>
<tr>
<td>K</td>
<td>588.76±0.01c</td>
<td>533.95±0.05d</td>
<td>1313.30±0.05a</td>
<td>673.50.20b</td>
</tr>
<tr>
<td>Na</td>
<td>53.00±0.00c</td>
<td>54.00±0.00b</td>
<td>38.00±0.00d</td>
<td>69.00±0.00a</td>
</tr>
<tr>
<td>P</td>
<td>226.00±0.00b</td>
<td>440.00±0.00a</td>
<td>201.60±0.06c</td>
<td>140.00±0.00d</td>
</tr>
</tbody>
</table>

Figures followed by different letters are significantly different at P<0.01.

Iron content of the breadfruit flours ranged between 2.20 and 9.38 mg 100 g⁻¹. Iron content was highest in *A. heterophyllus* flour and lowest in *A. camansi* flour. According to the National Academy of Sciences (2004), the recommended daily allowance for iron is between 8 mg day⁻¹ for adult males and 18 mg day⁻¹ for females. *A. heterophyllus* flour could therefore be a better source of iron than *A. camansi* and *T. africana*. The results show that consuming 100 g of *A. heterophyllus* bean flour could be sufficient in meeting the minimum requirement for male adults. Iron is known to be an important constituent of haemoglobin, found in blood, and contributes to the prevention of anaemia.

The magnesium content of the breadfruit bean flours varied (P<0.01) widely, from 10.17 to 167.71 mg 100 g⁻¹. The magnesium content of *T. africana* bean flour (167.71 mg 100 g⁻¹) was 16 times greater than the lowest, from *A. camansi* (10.17 mg 100 g⁻¹). Magnesium is essential in enzyme systems and helps maintain electrical potential in nerves (Ferrao et al., 1987). Nutritionally, *T. africana* flour can be considered as a superior source of magnesium than *A. heterophyllus* or *A. camansi* and, as such, could be used as a supplement in providing the daily recommended intake of magnesium for children.

Potassium was the most predominant mineral in the flours of the four breadfruit species. *A. camansi* flour had the highest potassium content (1313.3 mg 100 g⁻¹), 2.3 times higher than the lowest, in *T. africana* (533.95 mg 100 g⁻¹). In comparative terms, the potassium content of the breadfruit flours was higher than cassava flours (290-498 mg 100 g⁻¹; Adeniji et al., 2007; Akindahunsu et al., 1999) Potassium is an important mineral that helps maintain electrolyte balance in humans and is important in amelioration of hypertension (Whelton et al., 1997).

The sodium content of the breadfruit flours varied between 37.5 and 54.0 mg 100 g⁻¹. *A. altilis* had the highest sodium content (69.00 mg 100 g⁻¹), significantly higher (P<0.01) than *T. africana* (54.00 mg 100 g⁻¹), *A. heterophyllus* (53.00 mg 100 g⁻¹) and *A. camansi* (37.5 mg 100 g⁻¹). The sodium contents of the flours, in this study, were lower than that of cassava (437.5 mg 100 g⁻¹; Akindahunsu et al., 1999). Sodium generally imparts flavour and enhances preservation of foods, but very high levels pose serious health risks. The National Academy of Sciences (2004) recommends a sodium intake of between 1.2 and 1.5 g day⁻¹, being equivalent to 2.5-3.5 kg of breadfruit flour day⁻¹. Since breadfruit flours are not consumed in such large quantities daily, breadfruit flours could be incorporated in the diet without exposing the consumer to sodium-related health risks.

CONCLUSION

The study sought to contribute to the expansion of the use of breadfruit species. *A.*


*camansi, A. heterophyllus* and *T. africana* had high protein contents, and their inclusion in diets could help alleviate protein-deficiency-related conditions such as Kwashiokor. Since the breadfruit species were rich in minerals, especially potassium, they could be used to provide the potassium needs of consumers, especially in rural areas, where protein undernourishment is high.

**ACKNOWLEDGEMENTS**

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**Literature cited**


