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Proximate and Mineral Composition of *Artocarpus altilis* Pulp Flour as Affected by Fermentation

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Abstract: A study was carried out on to assess the effect of fermentation on proximate composition of *Artocarpus altilis* pulp flour with the aim of expanding its use. Flours of unfermented and fermented *A. altilis* pulp were produced and standard procedures used to determine their proximate and mineral composition. Fermentation resulted in marginal increase in crude protein (from 3.80-4.43%) and ash (from 2.37-2.38%) content whereas, there was a marginal decrease in crude fibre (from 3.12-3.00%) and carbohydrate (from 79.24-76.71%) content. Fermentation resulted in significant decrease in calcium, iron, potassium, sodium and phosphorus contents of *A. altilis* flour. However, magnesium content was not affected by fermentation. This study shows that *A. altilis* pulp flour has good carbohydrate and mineral content and may therefore, be used as staples, to provide the energy and mineral needs of consumers. They would be useful in ensuring food security if promoted.

Key words: *Artocarpus altilis*, proximate composition, mineral content, fermentation

INTRODUCTION

Breadfruit (*Artocarpus altilis*) is an important food in the Pacific (Taylor and Tuia, 2007). It is widely distributed in the tropics although native to Malaysia, Papua New Guinea and Philippines. Breadfruit trees grow easily in a wide range of ecological conditions with minimal input of labour or materials and require little attention or care (National Tropical Botanical Garden, 2009). Breadfruits are found from sea level to about 1,550m elevation. The latitudinal limits are approximately 17°N and S, but maritime climates extend that range to the Tropics of Cancer and Capricorn (Ragone, 2007). In Africa, breadfruits are found in Senegal, Guinea-Bissau, Cameroun, Sierra Leone, Nigeria, Liberia and Ghana (Burkill, 1997).

According to Orwa *et al.* (2009), *A. altilis* is also used as food, fodder, fuel, timber, gum, dye for textiles and medicine. It is high yielding with an average sized tree producing 400-600 fruits per year (NTBG, 2009). Yields are superior to other starchy staples with a single tree producing between 150 and 200 kg of food (Singh, 2009). In Ghana, breadfruits are consumed as snacks by many rural inhabitants and have been used to as a food security crop. Although it is common and used as food in Ghana, it is regarded as unimportant produce resulting in its neglect.

Breadfruits, generally, are not grown in Ghana as a food crop. They usually grow wild and are left unprotected. As a result, important assertions might be lost. Breadfruits are covered by the International Treaty on Plant Genetic Resources for Food and Agriculture (Ragone, 2007) and are considered threatened.

Breadfruit has however, been reported to be a good source of nutrients (Orwa *et al.*, 2009). In order to promote its cultivation and use as food, knowledge of its nutritional composition need to be generated.

This study was therefore carried out to determine the proximate and mineral composition of pulp flour of *Artocarpus altilis* found in Ghana in order to assess its nutritional benefits, when used as food. In the study the effect of fermentation on proximate and mineral composition of the breadfruit flour was assessed.

MATERIALS AND METHODS

Experimental locations: All proximate determinations were carried out at the Biochemistry Department of the Crops Research Institute of the Centre for Scientific and Industrial Research at Fumesua. Mineral analysis was carried out at the Food Research Institute of Ghana, Soil Chemistry Laboratory and Biochemistry laboratory of School of Medical Sciences, KNUST, Kumasi, Ghana.

Sample collection and preparation: *Artocarpus altilis* fruits were collected from the Republic Hall of Kwame Nkrumah University of Science and Technology. Fresh firm and mature *A. altilis* fruits were harvested washed with clean water and transported to laboratory for analyses.

Unfermented *Artocarpus altilis* flour preparation: The freshly harvested *Artocarpus altilis* fruits were peeled and sliced into cubes (2 cm^3) under running tap water. The sliced pieces were dried in an oven (Wagtech oven (Model GP120SSE300HYD) at 50°C till crisp and then

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cooled to room temperature (28°C). A hammer ill was used to mill the dried chips. The resultant flour was sieved through 75 µm mesh and packaged in a sealed plastic bottle prior to analysis.

Fermented *A. altilis* flour preparation: Slices of *A. altilis* pulp were placed in distilled water in a ratio of 1:1 (w/v) for 12 h and allowed to ferment spontaneously under ambient conditions (28°C). Fermentation was continued for another 12 h after decanting the water. The slices were then dried in an oven (Wagtech oven (Model GP120SSE300HYD) at 50°C till crisp. The dried chips were then milled in a hammer mill and sieved through 75 micometer mesh sieve. The flour was then packaged in plastic bottles prior to analyses.

Determination of proximate composition: Determination of moisture content, ash, crude protein and crude fibre were 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 difference (Kirk and Sawyer, 1991).

Determination of mineral composition

Sample preparation: Two grams of dried milled samples was ashed in previously ignited and weighed crucible. The crucible and content were then placed in 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 milliliters of concentrated HCl was poured on selected ashed samples to dissolve ash in crucible. Dissolved ash was filtered through filter paper into dilution tubes. Double distilled water was used to wash left over ash in crucible and poured into dilution tube. This was made up to 25 ml mark using distilled water prior to analysis (AOAC, 1990).

Calcium was determined by O-cresolphthalein complexone method using Optima SP-300 spectrophotometer (Tietz, 1995). Iron cotent was determined by the 1, 10-phenanthtoline method using Optima SP-300 spectrophotometer (Harris, 2003). Phosphorus was determined by Ascorbic acid molybdate method using Optima SP-300 spectrophotometer. Potassium and sodium was determined by the method Taffouo *et al.* (2008) using Jenway Flame photometer. The Calmagite method was used in the determination of Magnesium content and Optima SP-300 spectrophotometer used at 520 nm (Tietz, 1995).

RESULTS AND DISCUSSION

Proximate composition: Fermentation resulted in marginal increase in crude protein (3.80-4.43%) and ash (2.37-2.38%) content whereas there was a marginal decrease in crude fibre (3.12-3.00%) and carbohydrate (79.24-76.71%) content as presented in Table 1. However, there was a significant ($p<0.01$) increase in crude fat content from 2.36-2.91%. This probably could be attributable to the fermentative activity of fermenting organisms resulting in ease of release of fat from cells within the pulp. Generally, the moisture content of the flours was within acceptable levels (10-14%) for flours (Butt *et al.*, 2004). Since the unfermented flour had lower moisture content (9.11%) it is expected to have longer shelf life. Higher moisture content in flours have been reported to enhance spoilage through creating favourable conditions for microbial proliferation as well as enhance enzymatic deterioration (Oduro *et al.*, 2009). The protein content (4.43%) of the fermented *A. altilis* was higher than the unfermented in this study but lower the 6.06% reported by Nelson-Quartey *et al.* (2007). Furthermore, the protein content of the pulp flour was also lower than wheat flour (9.8%; Akubor and Badifu, 2004) and pearl millet (11.4%; Oshodi *et al.*, 1999) as well as *Dioscera alata* (water yam; 4.7-15.6%) reported by Treche and Agbor-Egbe (1995). However the protein content was higher than cassava (1.7%; Gomez and Valdivieso, 1983). Consequently, *A. altilis* pulp cannot be considered as a good source of protein.

As regards the fat content, the amount ranged between 2.36 and 2.91%. These were higher than that the 0.09-0.20% reported for *D. alata* (Opata *et al.*, 2007). The fermented flour had significantly higher crude fat content than the unfermented. Similar observation has been made by other authors in fermentation of cassava (Oboh *et al.*, 2003; Akindahunsi *et al.*, 1999). The low fat content of *A. altilis* suggests it would not be a good source of oil. The crude fibre content (3.0-3.12%) of the pulp was higher than the 0.66% reported for yam flour (1.65%; Jimoh and Olatidoye, 2009) as well as cassava (1.00%; Ihekoronye and Ngoddy, 1985). The observed differences between the unfermented and the fermented flours were not significant. Fibre is reported to have beneficial effects on preventing cancer (Shankar and Lanza, 1991). *Artocarpus altilis* flour could be composited with cassava flour in the bread industry to increase its fibre content.

Artocarpus altilis pulp flour had ash content ranging from 2.37 and 2.38%. The ash content of *A. altilis* flours were lower than *Prosopis africana* flour (4.4%; Aremu *et al.*, 2006) and millet flour (3.7%; Onweluzo and Nwabugwu, 2009) but higher than cassava (1.0%; Aryee *et al.*, 2006) and yam flour (2.03%; Jimoh and Olatidoye, 2009). Fermentation did not significantly ($p>0.01$) change the ash content of the flours. The good ash content suggests that *A. altilis* pulp flour could be a good source of minerals.

The carbohydrate content of the *A. altilis* pulp flours were high (76.71-79.24%) compared to *Bilphia sapida* pulp flour (6.53%; Akintayo *et al.*, 2002). The decrease in carbohydrate content with fermentation was marginal.

Table 1: Proximate composition of *A. altilis* pulp flours (%)

	Moisture	C. Protein	C. Fat	C. Fibre	Ash	Carbohydrate
Unfermented	9.11±0.19b	3.80±0.61a	2.36±0.05b	3.12±0.09a	2.37±0.05a	79.24±0.59a
Fermented	10.57±0.32a	4.43±0.38a	2.91±0.30a	3.00±0.08a	2.38±0.06a	76.71±0.52a
p-value	0.0050	0.201	0.008	0.168	0.736	00.011

Figures bearing different alphabets are significantly different at p<0.01

Table 2: Mineral composition of *A. altilis* pulp flours

Treatment	Unfermented	Fermented	p-value
K	673.50±0.09a	348.64±02.5b	0.000
Na	69.00±0.00a	52.00±0.00b	0.000
Fe	3.91±0.08a	1.56±0.08a	0.021
Mg	90.63±0.05a	92.71±0.08a	0.043
P	140.00±0.00a	134.00±0.00a	0.412
Ca	60.83±0.43a	52.50±0.05a	0.492
K:Na	9.76±0.04a	6.71±0.03b	0.000
Ca:P	0.45±0.05a	0.39±0.09a	0.623

Figures bearing different alphabets are significantly different at p<0.01

The high carbohydrate content observed indicates that *A. altilis* pulp flour could be a good source of energy. This probably explains its use as a staple in the Caribbean (Roberts-Nkrumah, 2005).

Mineral composition of *A. altilis* flours: Calcium, iron, potassium, sodium and phosphorus contents were higher in the unfermented *A. altilis* flours than the fermented flours (Table 2). Fermentation resulted in significant decrease in calcium, iron, potassium, sodium and phosphorus contents of *A. altilis* flour. However, magnesium content was not affected by fermentation.

Potassium was found to be the predominant mineral (673.5 mg/100 g sample) in the *A. altilis* flours. Fermentation resulted in significant (p<0.01) reduction in potassium content from 673.5-348.64 mg/100 g flour sample. The K content of the unfermented flour was higher than in cassava (103.7-554 mg/100 g; Charles *et al*., 2005) but comparable to *P. africana* (617 mg/100 g; Aremu *et al*., 2006). Potassium has been reported to be an important mineral that help in maintaining electrolyte balance in humans (NTBG, 2009) and its presence in *A. altilis* indicates *A. altilis* is a good source of potassium.

The sodium content (52-69 mg/100 g) was comparable to sweet potato (54 mg/100 g; Ihekoronye and Ngoddy, 1985) but higher than cassava (36-50 mg/100 g; Charles *et al*., 2005). There was a significant reduction in sodium content as a result of fermentation. Morgan (1999) indicated that reducing intake of sodium ameliorates the development of hypertension. The moderate sodium content, therefore, suggests that *A. altilis* pulp is a low-sodium food and could be consumed without apprehension of consuming excess sodium.

The iron content of the unfermented flour was marginally higher (3.91%) than the fermented flour (1.56%). The iron content of the flours was lower than cassava 32 mg/100 g (FAO and IFAD, 2004). According to National Academy of Science (2004) the recommended daily allowance of iron is between 8-18 mg/day. Consuming unfermented *A. altilis* pulp could help provide the daily requirement for iron. Iron is an important constituent of haemoglobin found in blood. De Villota *et al.* (1981) emphasized the importance of iron in oxygen carriage in blood.

The magnesium content in the *A. altilis* flours were higher (90.63-92.7 mg/100 g) than cassava (36.58-37.71 mg/100 g; Nassar *et al*., 2003) but lower than fermented maize flour (460 mg/100 g) (Mbata *et al*., 2009; Osabor *et al*., 2009). Magnesium is essential in enzyme systems and helps maintain electrical potential in nerves (Ferrao *et al*., 1987). Since *A. altilis* flours have moderate magnesium content, they could be considered as moderate sources of magnesium.

The phosphorous content of the *A. altilis* flours (134-140 mg/100 g) were higher than sweet potato (28 mg/100 g) but lower than maize (300 mg/100 g) and rice (290 mg/100 g) as indicated by (Ihekoronye and Ngoddy, 1985). *Artocarpus altilis* could be a moderate source of phosphorus for both adults and children. According to Vitabase (2009) phosporus is essential for the process of bone mineralization as well as a role in the structure of cellular membranes, nucleic acids and nucleotides, including adenosine triphosphate.

The calcium levels (52.50-60.83 mg/100 g) in the flours were lower than that reported by Charles *et al.* (2005) for cassava flour. The flour could be a moderate source of supplementing intake of calcium for children.

The K:Na ratio (6.71-9.76) was close to the recommended 5.0 (Szentmihalyi *et al*., 1998). Dietary changes leading to reduced consumption of potassium than sodium have health implications. Diets with higher ratio K:Na are recommended and these are found usually in whole foods (Arbeit *et al*., 1992). Foods naturally higher in potassium than sodium may have a K/Na ratio of 4.0 or more (CIHFI, 2008). The high K:Na suggests that the flours of *A. altilis* could be suitable in helping to ameliorate sodium-related health risk.

Excessive dietary P intake alone can be deleterious to bone through increased Parathyroid Hormone (PTH) secretion, but adverse effects on bone increase when dietary Ca intake is low (Kemi *et al*., 2010). McDowell (2003) indicated that the recommended Ca:P is 1:1 (1.0). However, according to SCSG (2007) a good menu should have a Ca:P ratio over 1. Foods high in phosphorus and low in calcium tend to make the body over acid deplete it of calcium and other minerals and increase the tendency towards inflammations. It has been established that if there is more phosphorus than calcium in the diet, the body takes calcium from its own reserves (the bones) to compensate for the difference. Over a period, this may affect dramatically the bones in a negative way. This has prompted nutritionists to recommend a Ca:P ratio of at least 1:1 (Patenaude, 2007). Since the flours of *A. altilis* pulp recorded a Ca:P ratio of 0.39-0.45, the implication is that diets that are based only on *A. altilis* pulp flour needs supplementation with calcium to prevent mineral and osmotic imbalance.

Conclusion: *A. altilis* pulp flour is a good source of carbohydrate and therefore could be useful in providing the energy requirements of its consumers. The high carbohydrate content and the tuberous nature of the fruit make it a potential staple that could be used to combat hunger and provide food security. The high fibre content makes *A. altilis* pulp flour a potential for enhancing the fibre content of low-fibre flours. The flour of *A. altilis* fruit pulp is a good source of minerals containing good amount of potassium as well as phosphorus. The use of fermentation in processing *A. altilis* pulp was not useful in improving the proximate components except for crude fat. This study has shown that *A. altilis* has the potential to be useful as a staple in regions where they are found since they have high carbohydrate and mineral content. The use of *A. altilis* as food could help provide the needed energy and mineral nutrition and help combat malnutrition.

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