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Effect of Cooking Methods on the Nutrient, Phytochemical and Anti-Nutrient Composition of Raw Bread Fruit (*Artocarpus communis*) Pulp

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Abstract: The study evaluated the chemical composition of raw breadfruit (*Artocarpus communis*) pulp as affected by boiling, steaming and roasting. Fresh ripe fruits were harvested, prepared and subjected to standard chemical analysis for nutrients, anti-nutrients and phytochemicals. Data was analyzed using means and standard deviation while Duncan's Studentized New Multiple Range Test was used to separate the means. Cooking losses were observed except for moisture that increased from 57.34% in the raw sample to 62.42 and 60.62% in the boiled and steamed samples, respectively, fibre increased from 0.41% in the raw to 0.66% in the roasted sample, carbohydrate increased from 38.32% in the raw sample to 53.93% in the roasted sample. All the vitamins and phytochemicals analysed were negatively affected by cooking except for flavonoids. Mineral losses were also observed in the boiled, steamed and roasted samples except for zinc. The three cooking methods reduced the anti-nutrients concentration of the fruit with boiling as the most effective method. Based on the result, steaming of raw bread fruit pulp should be encouraged over the traditional cooking method (boiling) for better nutrient retention.

Key words: Boiling, roasting, steaming, chemical composition, *Artocarpus communis*

INTRODUCTION

Food security was defined at the World Food Summit held in Rome, 1996, as "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life" (World Bank, 2007). During this meeting, representatives from 185 countries pledged to reduce world hunger to 50% of 1990-1992 levels by the year 2015. However, since after this meeting, there has been an unfortunate increase in hunger worldwide (FAO, 2008). The estimated number of undernourished people have increased to a record as high as 1.02 billion, approximately 1 in every 6 people (FAO, 2009a). One of the myriad factors responsible for this trend is the dramatic increase in food prices that occurred during the last decade (Jones *et al*., 2011). Since 2000, the overall food price index has increased to 120% led by an increase of 184% for cereals (FAO, 2008). In addition to overall undernourishment, specific vitamin and mineral deficiencies are prevalent in many regions and represent a significant threat to food security (Jones *et al*., 2011). Seventy percent of the undernourished population live in the rural areas of developing nations and depend primarily on agriculture for their livelihood (World Bank, 2007). Agricultural development must therefore play a leading role in the alleviation of world hunger.

Breadfruit (*artocarpus communis*) is an underutulized Oceanic staple crop long recognized for its potential to alleviate hunger in tropical climates. Breadfruit can be grown sustainably with minimal agricultural inputs and can be multicropped with high value cash crops such as coffee, pepper or vanilla (Jones *et al*., 2011). Breadfruit yields of 6t/ha (edible dry weight) have been reported (Sauerborn, 2002). This is an impressive yield compared to the current predominant staple crop, with average yields of 4.11t/ha for rice (2005), 4t/ha of corn (1990-20000) and 2.6t/ha of wheat (1990-2000) (Calpe, 2007; FAO, 2009c,d).

Breadfruit is one of the lesser-known tropical fruits that has been successfully introduced to the forest zone of the South-eastern and South-western Nigeria. While every measure is being taken by various levels of government to boost food production by conventional agriculture, a lot of interest is currently being focused on the possibilities of exploiting the vast numbers of less familiar plants resources of the wild (Anhwange *et al*., 2004; Abdullahi and Abdullahi, 2005). Many of such plants have been identified, but lack of data on the chemical composition and proper processing methods have limited the prospect of their utilization (Baumer, 1995). Many reports on some lesser-known seeds and fruit indicate that they could be good sources of nutrients to both man and livestock (Elimo *et al*., 2002; Adekunle and Ogerinder, 2004).

In an attempt to contribute to the growing body of knowledge on this subject, this study assessed the chemical composition of raw breadfruit subjected to different processing methods (boiling, steaming and roasting), respectively.

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MATERIALS AND METHODS

Sample collection: Ripe breadfruits were harvested from a breadfruit tree in a rural community in Nsukka, Enugu State of Nigeria.

Sample preparation: The breadfruits were washed, peeled, cored and rewashed. The washed samples were homogenised and divided into four portions. The first three portions were boiled, steamed and roasted respectively while the fourth portion was left raw. Five hundred grams each were boiled, steamed and roasted. Boiling was done in a 6 by 6 inches pot with 1000 g of distilled water over moderate heat for 10 min, drained and cooled. Steaming was done in a 6 by 6 inches steamer over moderate heat for 15 min while roasting was done in an open flame for 15 min. All the samples were packaged in air-tight containers and sent for chemical analyses. The four samples were subjected to standard chemical analysis for nutrients, anti-nutrients and phytochemicals.

Nutrient analysis

Proximate analysis: This refers to the determination of major constituents of food. The five constituents measured for compositional analysis were: moisture, ash, crude fibre, fat and protein. Moisture, ash, protein, fat and crude fibre were determined using the methods described by Pearson (1976). Moisture was by the hot air oven method, protein was determined using the Kjekdhal technique while fat was analysed using the soxhlet extraction method. To determine the fibre content, the protein, starch, fat and other digestible carbohydrates were hydrolyzed out leaving the residue which is the crude fibre. Carbohydrate content was obtained by subtracting the values of other nutrients that make up the proximate composition form 100, i.e.: % available carbohydrate = 100 - (% moisture + % ash + % protein + % fibre).

Vitamin determination: The quantity of beta carotene in the samples was determined using Harborne method as described by Pearson (1976). Vitamin B_1 was done using the method described by Pearson (2000). Vitamin B_2 was determined by the Onwuka (2005) method. Vitamin B_3 was determined by the method described by Okwu and Okwu (2004). Ascorbic acid was determined with the method given by Barket *et al.* (1973).

Mineral determination: Iron was determined using the phenanthroline method as described by AOAC (2000). Calcium, potassium, zinc and sodium were done using the AOAC (1995) method while magnesium was determined by Pearson (1976) method.

Anti-nutrient determination: The phytic acid content of the samples was determined using the method described by AOAC (2000). Oxalic acid determination was done using the method described by Pearson (2000). Tannin was analysed with the Van-Burden and Robinson (1981) method.

Pytochemical analysis: The spectrophotometric method of Association of Analytical Chemists (AOAC, 1989) was used to determine the saponin content. Flavonoids was done using Boham and Kocipiah (1974) method and alkaloids was analysed using Harborne (1973) method.

Statistical analysis: Data was analysed using means and standard deviation while Duncan's Studentized New Multiple Range Test was used to separate the means.

RESULTS AND DISCUSSION

The result revealed that protein was more in the raw sample than in the cooked samples. Steaming (2.26%) and roasting (2.33%) retained protein more than boiling (1.93%). The higher protein content in the steamed and roasted samples could be due to the fact that they contain lower moisture than the boiled sample. According to Ene-Obong (2001), food containing lower moisture content contains higher dry matter. The low protein content of the boiled sample could also be attributed to leaching loss and solubility of nitrogen as explained by Edijale (1980). The fat content was highest in the raw sample (0.83%) and lowest in the boiled sample. This could be due to volatilization of fat during cooking as reported by Ikya *et al.* (2013). Boiling had the least fibre value (0.29%). This could also be attributed to loss in solid particles by boiling (Okorie, 2010). The ash content of the raw sample was statistically higher than others. The boiled sample had the least ash content which could be due to the leaching of nutrients into the cooking water (Reinagel, 2008). The boiled sample had the highest moisture. This increase in moisture content in the boiled sample was due to the absorption of water by crops through simple diffusion as reported by Rosatio and Flores (1981). The roasted sample had the highest carbohydrate values (53.93%) while the boiled sample had the least (34.38%). The high carbohydrate content in the roasted sample agreed with that reported by EneObong (2001) that foods with low moisture will contain high dry matter of which carbohydrate in one.

The vitamin values were higher in the raw than in the boiled, steamed and roasted samples. The decrease shown in the vitamin content may be due to the susceptibility of the vitamins to oxidation and heat leading to their destruction and degradation. The drastic decrease in vitamins content in the boiled sample was attributed to leaching of vitamins into the boiling water (Reinagel, 2008). This result was also in line with Colia (2010) who reported that some vitamins such as the B vitamins and vitamin C are water soluble and are

Table 1: Mean proximate values of raw, boiled, steamed and roasted breadfruit pulp (%)

Sample	Protein	Fat	Fibre	Ash	Moisture	Carbohydrate
Raw	2.39±0.01^{c}	0.83±0.01^{c}	0.41±0.00^{b}	0.70±0.00^{b}	57.34±1.15^{b}	38.32±1.11^{b}
Boiled	1.93±0.00^{a}	0.41±0.02^{a}	0.29±0.01^{a}	0.56±0.02^{a}	62.42±0.49^{c}	34.38±0.43^{a}
Steamed	2.26±0.02^{b}	0.62±0.02^{b}	0.41±0.01^{b}	0.65±0.00^{ab}	60.62±0.011^{bc}	35.44±0.04^{ab}
Roasted	2.33±0.04^{c}	0.76±0.06^{c}	0.66±0.06^{c}	0.63±0.06^{ab}	41.67±2.17^{a}	53.93±1.96

Values with different superscript in the same column are significantly different ($p<0.05$)

Table 2: Vitamins composition of raw, boiled, steamed and roasted breadfruit pulp

Sample	Beta carotene (IU)	Vitamin B_1 (mg)	Vitamin B_2 (mg)	Vitamin B_3 (mg)	Vitamin C (mg)
Raw	44.41±0.46^{d}	0.06±0.00^{c}	0.04±0.00^{c}	0.30±0.03^{c}	3.18±0.03^{d}
Boiled	4.82±0.07^{a}	0.01±0.00^{a}	0.00±0.00^{a}	0.07±0.00^{a}	1.43±0.03^{a}
Steamed	10.2±0.38^{b}	0.03±0.00^{b}	0.02±0.00^{b}	0.19±0.00^{b}	1.95±0.06^{b}
Roasted	20.34±0.07^{c}	0.04±0.00^{b}	0.03±0.00^{bc}	0.22±0.01^{b}	1.97±0.06^{c}

Values with different superscript in the same column are significantly different ($p<0.05$)

Table 3: Mineral values of raw, boiled, steamed and roasted breadfruit pulp (mg/100 g)

Sample	Iron	Calcium	Magnesium	Potassium	Zinc	Sodium
Raw	1.40±0.03^{d}	0.05±0.00^{b}	0.03±0.00^{c}	17.95±0.04^{d}	0.01±0.00^{a}	0.17±0.00^{d}
Boiled	0.57±0.04^{a}	0.04±0.00^{a}	0.01±0.00^{b}	10.61±0.09^{a}	0.03±0.00^{b}	0.08±0.00^{a}
Steamed	0.87±0.01^{b}	0.05±0.00^{ab}	0.02±0.00^{b}	14.65±0.07^{b}	0.06±0.14^{c}	0.12±0.00^{b}
Roasted	1.17±0.02^{c}	0.05±0.00^{ab}	0.02±0.00^{bc}	17.30±0.13^{c}	0.09±0.00^{d}	0.15±0.00^{c}

Values with different superscript in the same column are significantly different ($p<0.05$)

Table 4: Anti-nutrient and phytochemincal values of raw, boiled, steamed and roasted breadfruit pulp

	---------------------- Anti-nutrients (mg/100 g) ----------------------			---------------------- Phytochemical (%) ----------------------		
Sample	Phytic acid	Oxalic acid	Tannin	Alkaloids	Flavonoids	Saponin
Raw	73.69±0.69^{d}	353.45±5.30^{d}	103.65±0.59^{d}	1.83±0.05^{c}	3.18±0.18^{b}	1.04±0.02^{c}
Boiled	16.73±0.19^{a}	36.90±0.12^{a}	10.14±0.09^{a}	1.48±0.02^{b}	4.45±0.12^{c}	0.23±0.03^{a}
Steamed	60.73±0.41^{c}	221.28±1.59^{c}	31.66±0.16^{c}	1.38±0.08^{b}	8.17±0.12^{d}	0.87±0.02^{bc}
Roasted	41.82±0.87^{b}	146.87±1.35^{b}	19.74±0.12^{b}	1.09±0.06^{a}	1.87±0.12^{a}	0.80±0.11^{b}

Values with different superscript in the same column are significantly different ($p<0.05$)

destroyed when submerged in water. This result was in line with the report of Virgina (1995) that raw fruits and vegetables generally retain more vitamins than the cooked ones.

The iron potassium, sodium and magnesium content of the fruit were higher in the raw than in the boiled, steamed and roasted samples, the boiled sample being mostly affected. In the case of calcium, steaming and roasting had little or no effect on it but it was reduced in the boiled sample. The reason for the decrease shown in the mineral content was due to their susceptibility to heat leading to their destruction as discussed by Lopez *et al*. (1980). The drastic decrease in the mineral content of the boiled samples was attributed to leaching of minerals into the boiling water (Reinagel, 2008). This study disagreed with the report of Virgina (1995) that cooking does not reduce the amount of mineral in foods including calcium, iron, magnesium, sodium, etc., the zinc content showed a different trend since it was higher in the cooked than in the raw sample. This increase could be as a result of phytic acid removal. This finding did not agree with the reports of Lopez *et al*. (1980) and Reinagel (2008) since cooking did not reduce the amount of zinc content rather it was increased by cooking.

The phytic acid, oxalic acid and tannin content of the breadfruit was reduces by cooking. The phtic acid result contradicted that of Oladunjoye and Olaniyi (2010) who reported that phytic acid content of breadfruit was not affected by cooking. However, the oxalic acid and tannin results agreed with the above study since they found out that oxalic acid and tannin in breadfruit were reduced by cooking. The phytic acid, oxalic acid and tannin content were lower in the boiled sample when compared with the steamed and roasted samples which suggests that boiling is the most effective way of reducing these anti-nutrients among the three cooking methods.

The alkaloids and saponin content of the raw sample were higher than the boiled steamed and roasted samples. However, the steamed sample had higher flavonoids than the raw sample. The result observed in the alkaloids, saponin and flvonoids content of the boiled and roasted samples, agreed with that of Brown and Arthur (2001) who found out that phytochemicals are reduced by cooking. The flavonoids concentration of the steamed sample contradicts the above study since it was higher than the raw sample.

Conclusion: There were more nutrient and anti-nutrient losses in boiled than steamed and roasted samples. Cooking losses of the phytochemicals were more in the roasted than boiled and steamed samples. Steaming raw breadfruit pulp should therefore be encouraged over boiling and roasting. More effective means of anti-nutrient reduction or elimination in the fruit that will not lead to nutrient losses should however be explored.

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