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Dynamics of Phytate-Zinc/Calcium Balance of Processed African Breadfruit (*Treculia africana* Decne) Seeds

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ABSTRACT

Fresh and processed (boiled; boiled with trona – a seasoning agent and tenderizer) African breadfruit (*Treculia africana* Decne) seeds were analysed for their calcium, zinc, and phytate composition, all of which decreased with boiling and boiling with trona. The decrease in phytate concentration during boiling (1466.69 to 902.58 mg/100 g) is thought to be beneficial, since a reduction in phytate concentration will bring about availability of divalent metals such as Fe, Ca, Zn, Mg etc. The inhibitory effect of phytate on calcium and zinc absorption predicted using the calculated [Ca] [Phytate]/[Zn] ratios indicated that the bioavailability of calcium and zinc was not decreased by phytate concentration and that the processing method does not alter the bioavailability of these minerals.

Keywords: availability, boiling, metals, trona

INTRODUCTION

Treculia africana (Decne) fruit is a large seeded fruit known as the African breadfruit (Enibe *et al*. 2003). It is a tropical tree crop which belongs to the family, Moraceae (Tindal 1965). The breadfruit is believed to be native to a vast area extending from New Guinea through the Indo-Malay Archipelago to Western Micronesia (Morton 1987). It is widely cultivated in several tropical countries like the West Indies, Ghana, Nigeria, Sierra Leone and Jamaica (Dailziel 1955). It can be propagated from seed which must be planted when fairly fresh as it loses viability in a few weeks (Morton 1987). *T. africana* produces fruits up to 2 or 3 times in a year (Soetjipto and Kubis 1981).

It is an important staple food of high economic value (Soetjipto and Kubis 1981) and a good source of carbohydrate which forms a portion of the diet in several countries (Purseglove 1968). It is also rich in fat, ash, fibre and protein (Tindall 1965). Along with the nutrients, *T. africana* also contains some antinutrients such as oxalates, phytates, tannin and hydrocyanic acid (Fasasi *et al*. 2004). Antinutrients are a diverse range of natural compounds present in plant foods, which act to reduce nutrient utilization and food intake resulting in impaired growth in animals. Phytic acid (*myo*-inositol 1,2,3,4,5,6 hexakis dihydrogen phosphate) is an important storage form of phosphorus found in plant foods: certain legumes, cereals and foliage plants (Aletor 1993). Phytic acid has the ability to chelate Ca, Zn, Fe and other divalent minerals, thereby reducing their bioavailability (O'Dell and Sewage 1960; Davis and Olpin 1979; Lopez *et al*. 2002). This renders them unavailable for intestinal uptake since the first step in mineral absorption requires that they remain in an ionic state, as the phytic acid content of the diet increases absorption of the metal cations decreases. The antinutritional effects of phytate primarily relate to the strong chelating ability associated with its six reactive phosphate groups (Idvegi and Asztity 2002).

In a report by Fasasi *et al*. (2004) Zn was revealed as the most predominant mineral in *T. africana* flour. Zn is one of the important metals that can bind to phytic acid.

The importance of a foodstuff as a source of dietary Zn depends upon both the total Zn content and the level of other constituents in the diet that affect Zn bioavailability. Oberleas (1983) reported that phytic acid might reduce the bioavailability of dietary Zn by forming insoluble mineral chelates at physiological pH. The formation of chelates depends on relative levels of both Zn and phytic acid (Davis and Olpin 1979). The critical Zn:phytate molar ratio may also depend on dietary Ca levels. A kinetic synergism exists between the Ca and Zn ions resulting in a Ca:Zn:phytate complex which is less soluble than phytate complexes formed by either mineral alone (Oberleas 1983).

Breadfruit can be pounded, fried, boiled or mashed to make porridge (Amusa *et al*. 2002). It has been reported that methods such as toasting, boiling and autoclaving, fermentation, malting and hydrothermal processing reduce phytate content of *T. africana* (Sunday *et al*. 2001; Lonnerdal 2002; Fasasi *et al*. 2004). In Southern Nigeria, *T. africana* seeds are commonly processed for consumption by boiling with trona, a popular seasoning agent used as a tenderizer of food materials such as pulses, cereals, meat and vegetables (Ankara and Dovlo 1978). There is dearth of information on the effect of boiling *T. africana* seeds with trona on the phytate content. The present study was therefore aimed at establishing the effect of boiling *T. africana* seeds with trona on their phytate content and the consequent effect on Zn bioavailability.

MATERIALS AND METHODS

Source of *T. africana* seeds

Fresh seeds of *T. africana* were bought at Oba market, Akure, Nigeria. The seeds were transferred to the laboratory in a sterile polythene bag.

Treatment of seeds

The seeds were divided into 3 separate portions. The first portion (A) was analyzed immediately to determine the phytate and mineral (Zn and Ca) contents. This serves as the control. The second portion (B) was boiled for 30 min after which it was left for 6

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hours for adequate cooling. Trona was weighed and 0.2 g added to the third portion (C) which was also cooked for 30 min after which it was left for 6 hrs to cool. The average time for cooking *T. africana* by local consumers is around 30 minutes.

Chemical analyses

Phytate concentration of samples A, B, and C was evaluated by the method of Wheeler and Ferrel (1971). Zn and Ca concentrations of samples A, B, and C were determined on aliquots of the solution of the ash, prepared from 1 g of the samples, by established flame atomic absorption spectrophotometry procedures using a Perkin-Elmer atomic absorption Spectrophotometer, Model 372 (Perkin-Elmer 1982). Lanthanum chloride (1%) was added to both samples and standard solutions for calcium determination to overcome phosphorus interference. The method described by Ferguson *et al*. (1988) was used to calculate [phytate]:[Zn], [Ca]:[phytate] and [Ca]:[Phytate]/[Zn] molar ratios used in the prediction of Zn bioavailability in the raw, boiled and seeds boiled with trona.

Analysis of data

Each treatment in the different analyses carried out consisted of three replicates. The data gathered were processed using a one-way analysis of variance (ANOVA) and the means were compared using Duncan Multiple Range Test (SPSS version 11).

RESULTS

Table 1 shows the Zn, Ca and phytate content of raw *T. africana* seed (A), boiled seed of *T. africana* (B), and *T. africana* seed boiled with trona (C). The Zn content of the raw seed (97.0 mg/100 g) was the highest followed by the boiled seed; seed boiled with trona had the lowest level (23.0 mg/100 g). The same trend was also observed for the Ca content of all the samples, i.e. the raw sample had the highest Ca content (290.0 mg/100 g). The phytate content of the raw seed (1466.7 mg/100 g) was significantly higher ($P \leq 0.05$) than the boiled seed (902.6 mg/100 g) and seed boiled with trona (733.3 mg/100 g).

The calculated [phytate]:[Zn], [Ca]:[phytate] and [Ca]:[phytate]/[Zn] molar ratios are presented in **Table 2**. The [phytate]:[Zn] ratio was highest in the seed boiled with trona, while the [Ca]:[phytate]/[Zn] ratio was not significantly different between all the samples.

Table 1 Calcium, zinc and phytate contents (mg/100 g) of raw and processed *Treculia africana*.

Sample	Calcium	Zinc	Phytate
Raw (A)	290.00 ^{c} ± 0.10	97.00 ^{c} ± 0.01	1466.69 ^{c} ± 0.06
Boiled (B)	262.00 ^{b} ± 0.08	50.00 ^{b} ± 0.03	902.58 ^{b} ± 0.00
Boiled with trona (C)	150.00 ^{a} ± 0.04	23.00 ^{a} ± 0.10	733.34 ^{a} ± 0.00

Values represent the means of triplicates. Values with different superscripts are significantly different ($P \leq 0.05$).

Table 2 Calculated phytate/Zn, Ca/phytate and (Ca):(phytate)/(Zn) molar ratios of raw and processed *Treculia africana* seeds.

Samples	[Phytate]/ [Zn]	[Ca]/ Phytate]	[Ca] [Phytate]/ [Zn]
Raw (A)	1.44 ^{a} ± 0.02	3.21 ^{a} ± 0.00	0.11 ^{b} ± 0.00
Boiled (B)	1.78 ^{b} ± 0.01	4.66 ^{b} ± 0.00	0.05 ^{a} ± 0.02
Boiled with trona (C)	2.99 ^{c} ± 0.04	3.26 ^{a} ± 0.06	0.11 ^{b} ± 0.00

Values represent the means of triplicates. Values with different superscripts are significantly different ($P \leq 0.05$).

DISCUSSION

Phytic acid is a common form of phosphorus in seeds and in a few tubers and fruits (Idvegi and Asztity 2002). The complexing of phytic acid with nutritionally essential minerals and the possibility of interference with proteolytic digestion have been suggested to be responsible for its antinutritional activity (Idvegi and Asztity 2002; Lonnerdal 2002). Phytic acid also interferes with Ca, Fe, Mg, and Zn absorption because of its ability to chelate divalent cationic minerals (Nelson *et al*. 1968).

The result of the present study revealed a decrease in the phytate content of the boiled seed (902.58 mg/100 g) and seeds boiled with trona (733.34 mg/100 g) as compared with the raw seed (1466.69 mg/100 g). There might have been leakage of this antinutrient into the cooking broth. It has been reported that processing methods such as frying, toasting and boiling can reduce the antinutrient content of cassava, African breadfruit and bean (Hahn 1992; Fasasi *et al*. 2004; Shi *et al*. 2004).

The inhibitory effect of phytate on Ca and Zn absorption has been quantified by the critical molar ratio of 15:1 for phytate:Zn (Gibson *et al*. 1997) and 6:1 for Ca:phytate (Wise 1983). In the present study, the ratios (0.11, 0.05, 0.11 mol/kg) obtained for the raw, boiled and boiled with trona *T. africana* seeds respectively.were below the critical values (0.5 mol/kg), For further clarification, the [Ca]:[phytate]/[Zn] molar ratio, which is considered a better predictor of increased risk to reduced Zn bioavailability (Davies and Warrington 1986) was calculated. All the values obtained for the [Ca]:[Phytate]/[Zn] molar ratios were below the 0.5 mol/kg critical value, thus predicting the bioavailability of dietary Zn. Although, the phytate:Zn and Ca:phytate ratios obtained for the unprocessed seeds were lower (1.44 and 3.21, respectively) than for the processed seeds (1.78, 2.99 and 4.66, 3.26 for phytate:Zn and Ca:phytate, respectively), all values were below the critical level. However, processsing had no significant effect on the [Ca]:[phytate]/[Zn] molar ratio since all samples analyzed were far below the critical level of 0.5 mol/kg, thus predicting dietary Zn bioavailability irrespective of the cooking method. The calculated [Ca]:[phytate]/[Zn] molar ratio is a better index for predicting Zn bioavailability because the [Ca]:[Zn]:[phytate] complex is less soluble than the phytate complex formed by either ion alone (Oberleas 1973). Processing of *T. africana* seeds had no appreciable effect on the [Ca]:[phytate]/[Zn] molar ratio.

Our study suggests that boiling *T. africana* seeds with trona further reduced the phytate content more than boiling without the addition of trona. Hence, boiling with trona improves Zn and Ca bioavailability which is nutritionally beneficial. Phytate is capable of chelating cationic metals; hence a reduction in phytate content will make Zn and Ca available for use (Lopez *et al*. 2002). In humans, the absorption of Fe can be decreased significantly in diets high in phytate (Brune *et al*. 1989). Moreover, complexes formed between phytic acid and mineral interferes with proteolytic digestion ultimately making it nutritionally inferior (Idvegi and Asztity 2002). Further work to confirm this is a subject of *in vivo* studies.

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