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Antinutritional Factors, Proximate Composition and Mineral Elements Content of the Seed Kernel of Three Nigerian Mango (*Mangifera indica* L.) Varieties

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ABSTRACT
A study was conducted to evaluate the antinutritional factors, proximate composition and mineral elements content of three varieties of mango ("Kanbiri" [K], "Yarkamaru" [Y] and "Bakin-aku" [B]) seed kernel (MSK). There was significant ($p<0.05$) decrease in tannin, cyanide and phytate contents in the MSK of the three mango varieties. The percentage reductions of tannin were 76.32%, 61.54% and 72.41%; those of cyanide were 93.33%, 85.71% and 95.00% while those of phytate were 80.00%, 75.00% and 100% for K, Y and B varieties, respectively. For the antinutritional factors, tannin contents ranged from 0.26 – 0.38% for the unprocessed MSK while for the processed MSK ranged from 0.08 – 0.10%. Cyanide contents ranged from 0.15 – 0.21 ppm for the unprocessed MSK while the processed MSK ranged from 0.01 – 0.03 ppm. Phytate contents for the unprocessed MSK ranged from 0.03 – 0.08% while it was between 0.00 – 0.02% for the processed MSK. Proximate analysis indicated that crude protein ranged from 5.99 – 6.80%, nitrogen free extract was from 74.29 – 75.21%, ash ranged from 1.29 – 1.50% and crude fibre was from 1.42 – 1.54% in the processed flour of the three mango varieties. The MSK flour contained various concentrations of calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), sodium (Na), phosphorus (P), copper (Cu), nikel (Ni) and zinc (Zn). Nutritionally, K variety was better than both the Y and B varieties for human consumption considering its larger kernel proportions, quantity of MSK flour yielded, percentage reduction of antinutrients, proximate composition and mineral elements contents.

Keywords: *Mangifera indica*, Seed kernel, Antinutritional factors, Proximate composition, Mineral elements.

INTRODUCTION

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae and is native to Southern Asia, especially Burma and Eastern India (Cangolly, 1957). It spreads to Malaya, Eastern Asia and Eastern Africa. It is a large evergreen tree that can reach 15 to 30 m high (Cangolly, 1957). It is a fast growing erect tree with slender to broad and rounded canopy that can be used for landscape and shade. The trees are long-lived with some still producing fruits at 300 years old (USDA, 2006). The fruit is an irregular egg-shaped and slightly compressed fleshy drupe, 8-12 cm long attached at the broadest end on a pendulous stalk. The underlying yellow-orange flesh varies in quality from soft, sweet, juicy and fiber-free in high-quality selected (clonal) varieties to turpentine-flavoured and fibrous in unselected (wild) seedlings (Samson, 1986). The single, compressed-ovoid seed is encased in a white fibrous inner layer of the fruit.

The fruit is a good source of vitamins A and C. Green mangoes are often cooked and eaten like vegetables or made into delicious chutney or dried and ground into a powder called "amchoor" and used to impart a sour flavour to food (Bally, 2006).

In livestock food, mango leaves are occasionally fed to cattle, but when consumed in large quantities, it can cause death. The fruits are relished by both cattle and pigs; however, the kernels are fairly rich in tannins, which progressively lead to reduced growth rates and

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less efficient feed utilization when included as a major component in diets for pigs and poultry (Samson, 1986). Mangoes that are not fully matured are prepared as silage which can be used for off-season pig feeding (USDA, 2006).

Ethnobotanically, dried mango flowers, containing 15% tannin can serve as astringents in cases of diarrhea, chronic dysentery and urethritis. The bark contains mangiferine which is an astringent employed against rheumatism and diphtheria in India. The resinous gum from the trunk is applied on cracks in the skin of the feet and on scabies, and is believed to be helpful in cases of syphilis. Mango kernel decoction and powder (not tannin-free) can be used as vermifuges and as astringents in diarrhea, hemorrhages and bleeding hemorrhoids. The fat is administered in cases of stomatitis. Extracts of unripe fruits and of bark, stems and leaves have reported to have antibiotic activity. In some of the islands of the Caribbean, the leaf decoction is taken as a remedy for diarrhea, fever, chest pain, diabetes, hypertension and other illnesses (Kostermans, 1997).

The kernel in the seed can be boiled and eaten with greens or ground and eaten roasted, or pickled, but are generally eaten in times of famine or by the poor (Knight and Schnell, 1993).

Although, there has been report on the tannin content of mango seed kernel (MSK) which ranges between 0.19% and 0.44% on dry matter basis (Dhingra and Kapoor, 1985), other antinutrients such as cyanide and phytate which have not been previously reported in any MSK will be determined in this study.

MATERIALS AND METHODS

Reagents:

All the reagents used were of analytical grade obtained from May & Baker Ltd, Dagenham, England; BDH Chemicals Ltd, Poole, England; Johnson Solomon (Export) Ltd, London, England and NAAFCO Scientific Supplies Ltd, London.

Sample Collection:

Fresh ripe mango fruits were purchased from local markets in Zaria, Sabon-Gari and Soba Local Government Areas of Kaduna State. The mango varieties used are: “Yarkamaru” [Y], “Kanbiri” [K] and “Bakin-aku” [B].

Plate 1: “Yarkamaru” (Y)

Plate 2: “Kanbiri” (K)

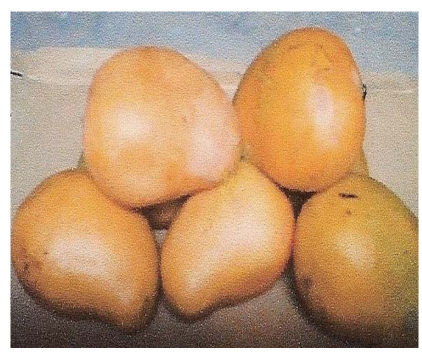

Plate 3: “Bakin-aku”(B)

Sample Preparation

Fresh, ripe mango fruits were depulped by skinning off with knife, leaving the stony hard seeds. The seeds were oven-dried until fully dried. The dried seeds were carefully split open and the kernels obtained. The kernels were further oven-dried until fully dried. The modified method of Dhingra and Kapoor (1985) was used to reduce the tannin content of the mango seed kernels of the three mango variety used for the study.

Proximate analysis

The moisture, crude protein, ether extract (crude lipid/oil), crude fibre, ash and nitrogen free extract (carbohydrate) contents of the samples were determined using the methods described in AOAC (1980).

Determination of antinutritional factors

The tannin content was determined by the method of Allen (1974), the Cyanide content of the samples was determined using the method described by AOAC (1980) and the phytate content of the sample was determined by the method of Reddy (1987).

Determination of mineral elements

The mineral element content of the samples was determined as described by PANalytical, (2007). This was done by the use of Mini Pal. Mini Pal is a compact energy dispersive X-ray spectrometer designed for the elemental analysis of a wide range of samples.

Statistical Analysis

Numerical data obtained were mostly expressed as mean $\pm$ SD (Standard Deviation) and analyzed by one-way analysis of variance (ANOVA), unless otherwise specified. Where the ANOVA shows significant difference ($p<0.05$), Fishers Least Significant Difference (LSD) test for multiple comparison was used (Zar, 1984).

RESULTS AND DISCUSSION

The antinutritional factors determined in this study were tannin, phytate and cyanide and the results of the antinutritional factors in the processed and unprocessed MSK are presented in Table 1. It was observed that phytate was present in non toxic concentrations in all the three MSK studied. Zazueta-Morales (1999) reported the phytate content of Mexican MSK as 1.73% which was higher than values of 0.01 – 0.02% for the MSK reported in this work.

The cyanide content of K variety was also in concentrations lower than that of its toxic level. Cyanide content in the MSK of B variety was in a concentration equal to that of its toxic level while in the MSK of Y variety, cyanide concentration was slightly above that of the its toxic level. Cyanide content of Indian mango variety was reported to be 56.5g/kg (6.64%) (Ravindran and Sivakanesan, 1999) which is higher than the values for the Nigerian mango varieties used in this study. Tannin contents in the MSK of K, Y and B varieties were in concentrations much higher than the tannin toxic level. The MSK of K variety had significantly ($p<0.05$) higher tannin content than those of Y and B varieties. Zazueta-Morales *et al* (1999) reported the tannin content of the Mexican MSK to be 1.28%. This value is higher than those of the three MSK varieties reported in this work. The major problems associated with tannins in food are protein indigestibility caused by the formation of soluble and insoluble tannin-protein complexes as well as tannin induced enzyme inactivation (Milic *et al* 1972; Eggum and Christensen, 1975; Makkar and Singh, 1991). In all the varieties, the method adopted for the reduction of tannin was very effective in reducing both cyanide and phytate concentrations in the MSK. Effective and significant removal of tannin was achieved when the MSK was treated with hot water at 70^0C and 80^0C as reported by Achoba (1994) and Dhingra and Kapoor (1985) respectively. Percentage reduction of the antinutritional factors showed the degree of effectiveness of the method used in removing tannin content and other antinutritional factors. Cyanide and phytate had higher percentage reduction compared to that of tannin. The percentage reduction of tannin in the MSK of K variety was significantly ($p<0.05$) higher than those of the MSK of Y and B varieties. Percentage reduction of tannin in the MSK of K, B and Y varieties were 76.32%, 72.41% and 61.54% respectively.

Proximate composition of the unprocessed and processed MSK of the three mango varieties used for this study is presented in Table 2. The crude protein and NFE of the unprocessed and processed MSK of K variety were significantly ($p<0.05$) higher than the corresponding values for the unprocessed and processed MSK of Y and B varieties. The Ether Extract was significantly ($p<0.05$) higher in the unprocessed and processed MSK of the Y variety compared to the others. The ash content of the unprocessed MSK of K variety was significantly ($p<0.05$) lower than that of the processed MSK of K variety. These indicated that the method adopted for the removal of tannin had some effect on the ash, crude fibre and moisture contents in the MSK of the three mango varieties studied.

The proximate composition of the processed MSK flour is presented in Table 3. The crude protein (CP) content of the MSK flour of K variety was significantly ($p<0.05$) higher than those of the MSK flour of Y and B varieties. MSK flour of K variety had a CP content of 6.80% while those of the MSK of Y and B varieties were 6.01% and 5.99% respectively. These CP values reported for the MSK flour of the three mango varieties were found to be lower than the values of 7.93% reported in Mexican MSK by Zazueta-Morales *et al* (1999). In this case, location and varietal differences may be responsible for observed differences in the CP content. The ether extract (EE) and crude fibre (CF) contents of the MSK flour of Y variety was significantly ($p<0.05$) higher than those of the other varieties. Zazueta-Morales *et al* (1999) reported the EE and CF contents of the Mexican MSK flour to be 6.83% and 1.02% respectively, both values are lower than those of the Nigerian MSK flour used for this study. The high CF content of the Nigerian MSK flour is an indication of its good potentials of being used in formulating diabetic foods. The EE content of the MSK flour of the three mango varieties used were in agreement with the range of 6.8 – 12.6% reported by Van Pee *et al* (1981) for thirteen different mango varieties from India. The MSK flour of K variety had significantly ($p<0.05$) higher NFE and ash contents compared to those of the Y and B varieties. NFE of the MSK flour of the three mango varieties used for this study were in the range of 74.29% to 75.21% and are slightly higher than the values of 73.09% reported by Zazueta-Morales *et al* (1999). The ash content of the Mexican MSK flour was reported to be 2.46% (Zazueta-Morales *et al*., 1999) which was higher than that obtained from the MSK flour of the three mango varieties used for this study. The NFE, CP and EE contents of the MSK flour of the three mango varieties used is an indication that any food product made from the MSK flour could supplement the energy requirement of the consumers.

The mineral elements determination in the processed MSK flour of the three mango varieties used for this study confirmed the availability, in various concentrations, of Calcium (Ca), Copper (Cu), Iron (Fe), Potassium (K), Magnesium (Mg), Sodium (Na), Nickel (Ni), Phosphorus (P) and Zinc (Zn). Manganese (Mn) was completely absent in the processed MSK of the three mango varieties studied. The processed MSK of K variety contained numerically higher concentrations of Fe, K and P than the processed MSK of B and Y varieties (Table 4). MSKs obtained from the three mango varieties are sources of both macroelements and microelements which are needed for growth and organ development. MSK meals have extensively been utilized in feeding chicks (El-Alaily *et al*., 1976; Patle, 1980 and Reddy, 1987), calves and milk cows (Patel *et al*., 1970 and 1971; Reddy and Prasad, 1985) and Sprague dawley rats (Okai and Aboagye, 1990). These reports indicated that inclusion of about 20% MSK into animal feed rations did not affect normal feed utilization as evidenced by both growth and organ development. The processed MSK of B variety had numerically higher concentrations of Ca, Cu, Na, and Ni than those of the MSK of Y and K varieties. Similarly, the processed MSK of Y variety had numerically higher concentrations of Mg and Zn compared to those K and B varieties. Mineral elements are very crucial in biochemical reactions in human bodies where they act as cofactors or coenzymes. Others are very important components of blood plasma where they function in homeostasis. Therefore, MSK of the three mango varieties used for this study are good sources of the above mentioned mineral elements. Phosphate and calcium play significant role in the development of hard tissues while potassium is a component of soft tissues (Stare and Williams, 1984).

Nutritionally, K variety was found to be better than both Y and B varieties for human consumption considering its percentage reduction of antinutrients, proximate compositions and mineral elements contents. The processed MSK flour in composition with whole wheat flour at different levels of substitutions can be used in formulating different types of food products for human consumption.

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Table 1: Antinutritional factors content of the unprocessed and processed MSK

Antinutrient (%)	Unprocessed MSK K	Unprocessed MSK Y	Unprocessed MSK B	Processed MSK K	Processed MSK Y	Processed MSK B
Tannin	0.38±0.02[a]	0.26±0.02[b]	0.29±0.01[b]	0.09±0.01	0.10±0.03	0.08±0.02
% Reduction				(76.32)	(61.54)	(72.41)
Cyanide	0.15±0.03[b]	0.21±0.02[a]	0.20±0.02[a]	0.01±0.01	0.03±0.01	0.01±0.01
% Reduction				(93.33)	(85.71)	(95.00)
Phytate	0.05±0.01[b]	0.08±0.02[a]	0.03±0.01[b]	0.01±0.01	0.02±0.01	0.00
% Reduction				(80.00)	(75.00)	(100)

- Each value is a mean of 3 determinations ± SD
- Values with different superscripts in a row are significantly different ($p<0.05$)

Table 2: Proximate composition of the unprocessed and processed MSK

Proximate Parameter	Unprocessed MSK K	Unprocessed MSK Y	Unprocessed MSK B	Processed MSK K	Processed MSK Y	Processed MSK B
Crude Protein (%)	6.44±0.02[a]	5.75±0.12[b]	5.81±0.01[b]	6.42±0.02[a]	5.69±0.01[b]	5.80±0.03[b]
Ether Extract (%)	12.99±0.03[c]	13.68±0.03[a]	13.09±0.02[b]	12.97±0.02[c]	13.63±0.02[a]	13.06±0.02[b]
NFE (%)	33.48±0.04[a]	33.01±0.02[b]	33.12±0.02[b]	34.01±0.02[a]	33.05±0.06[b]	33.02±0.05[b]
Ash (%)	2.02±0.03[a]	1.95±0.06[a]	1.83±0.02[b]	1.80±0.02[b]	1.95±0.01[a]	1.97±0.02[a]
Crude Fibre (%)	1.95±0.02[b]	2.07±0.01[b]	2.24±0.03[a]	2.02±0.04[b]	1.98±0.02[b]	2.13±0.04a
Moisture (%)	45.05±0.01[c]	45.61±0.03[b]	46.15±0.01[a]	44.80±0.28[c]	45.69±0.01[b]	46.12±0.01[a]

- Each value is a mean of 3 determinations ± standard deviation
- Values with different superscripts in a row are significantly different ($p<0.05$)
- NFE = Nitrogen Free Extract

Table 3: Proximate compositions of the processed MSK flour

Proximate Parameter	MSK Flour K	Y	B
Crude Protein (%)	6.80 ± 0.02[a]	6.01 ± 0.03[b]	5.99 ± 0.02[b]
Ether Extract (%)	14.62 ± 0.03[b]	15.11 ± 0.01[a]	14.89 ± 0.01[b]
NFE (%)	75.21 ± 0.01[a]	74.29 ± 0.01[b]	74.61 ± 0.03[b]
Ash (%)	1.50 ± 0.02[a]	1.34 ± 0.03[b]	1.29 ± 0.01[c]
Crude Fibre (%)	1.42 ± 0.02[c]	1.63 ± 0.01[b]	1.54 ± 0.02[a]
Moisture (%)	3.87 ± 0.01[a]	3.25 ± 0.01[b]	3.22 ± 0.02[c]

- Each value is a mean of 3 determinations ± standard deviation
- Values with different superscripts in a row are significantly different ($p<0.05$)
- NFE = Nitrogen Free Extract

Table 4: Mineral elements content of the processed MSK of the three mango varieties

	Mineral Elements (ppm)									
Mango Variety	Ca	Cu	Fe	K	Mg	MN	Na	Ni	P	Zn
K	1097.95	24.32	270.98	13500.37	1925.96	-	809.58	12.04	2413.26	17.98
Y	550.42	18.46	19.41	9945.64	2069.50	-	864.29	9.53	2191.20	19.05
B	1723.95	24.41	1.34	11460.31	1721.87	-	883.60	13.45	2108.30	14.03

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