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RESEARCH ARTICLE

Chemical Composition and Antinutrient Contents of Yellow Maize, Raw and Processed Composite Mango (Mangifera indica) Seed Kernel from Zaria, Kaduna State Nigeria.

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Abstract

The effects of processing composite raw mango seed kernels by soaking, boiling and calcium hydroxide treatments on proximate compositions, mineral elements, amino acids and antinutritional factors were investigated. The proximate analysis of the yellow maize and processed mango seed kernels (PMSK) showed no significant differences (p>0.05) for moisture (8.33-9.91%), ash (1.16-1.96%), ether extract (6.30-8.50%), crude protein (6.83-8.50%), crude fibre (1.15-2.50%), and nitrogen free extract (71.88-72.98%). The concentration of Ca, Na, K, and Mg in the raw mango seed kernels were increased significantly (p<0.05) after processing while Fe, Zn and P decreased significantly (p<0.05). The results also shows that the effect of processing on raw mango seed kernel had no effect (p>0.05) on its of amino acids contents. The chemical score of yellow maize (28.3%), raw mango seed kernel (23.7%) and processed mango seed kernel (20.9%) indicates that methionine was the limiting amino acid in all the samples. The highest percentage reduction of antinutritional factors in mango seed kernel after processing were 95.8% (tannin), 90.6% (oxalate), 76.7% (cyanogenic glycoside), 76.2% (phytate), 95.1% (flavonoid), 65.1% (alkaloid), 59.0% (saponin) and 100% (trypsin inhibitors). The effect of processing of the raw mango seed kernel effectively enhance the reduction of anti-nutritional factors to the barest minimum.
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INTRODUCTION

The mango tree (Mangifera indica) is found all over Nigeria either as improved variety or in its native forms. After consumption of the juicy mesocarp of the mango, the seeds that contain the kernel are often discarded, unconsumed by man and livestock. Earlier analysis of mango seed kernel meal showed that it contains carbohydrate (69.2 - 80%) protein (7.5 – 13%) fat (7.3 – 14.4%) fibre (2.0 – 4.6%) ash (2.2 – 2.6%) 0.21% calcium, and 0.22% phosphorus, depending on the variety (Fowomola, 2010, Arogba, 1989). The kernel is also balanced in amino acids (Elegbede et al, 1995). There are few reports on the use of mango seed kernel in livestock feeding but the level of inclusion in poultry diets has been low because of high tannins content (Jansman et al, 1995; Teguia, 1995; Diarra and Usman, 2008).

Mango came to Nigeria in the 20th Century through Itinerant Merchant Missionaries and Colonialists where it has become an integral part of indigenous cropping systems. The guinea and sudan savanna zones of Nigeria are credited with producing greater percentage of the fruit in Nigeria, with Benue state topping the list (Ugese et al, 2012). Reports also indicate that some mango varieties were introduced to Yandev Farm Centre by the early Agricultural Officers from Zaria and Ibadan in the 1950s (Nyishir, 2004).

Global production of mangoes is concentrated mainly in Asia and more precisely in India (FAO, 2009). Total world production was 24, 420, 116 metric tonnes in 1999 (FAO, 2000) with developing countries accounting for about 98% of total production. Despite lack of encouragement as to large scale production of tropical fruits in the country, Nigeria still occupies the 9th position in the world ranking of mango producing countries (Ugese et al 2012). The main producing states in the country include Benue, Jigawa, Plateau, Yobe, kebbi, Niger, Kaduna, Kano, Bauchi, Sokoto, Adamawa, Taraba and FCT (Yusuf and Falusi, 2000; Yusuf and Salau, 2007).

Cereal grains, especially maize which form the bulk of energy in poultry feeds are in short supply as a result of industrial and human needs. This has resulted in competition between humans and animals for available feed resources, and hence high cost of animal production (Chiripasi et al, 2013).

Therefore, the objectives of the present work was to determine the proximate composition and antinutrient content of raw and processed mango (Mangifera indica) seed kernel in order to compare them with yellow maize being used in conventional poultry feed.

MATERIAL AND METHODS

a. Mango Seed Collection, Preparation and Processing

Composite mango seed samples were collected from some villages (e.g. Basawa, Agwarimi, Samaru, Hunkuyi, Tohu, Wusasa and Sakadadi) in Zaria, Kaduna State Nigeria during mango production season (April – May). The composite mango seeds were cracked manually and the mango seed kernels (MSK) were divided into two part. Part A was left unprocessed while part B was processed.

Part B was first weight and soaked in water for 24 hours at room temperature, the supernatant was decanted and the residue was washed three times. After soaking, the residue was boiled in water at 100^oC for 30 minutes and then allowed to cool overnight. The supernatant was also decanted and the residue washed three times. Finally, the residue after boiling was soaked in water containing 0.1g hydrated lime ($Ca(OH)_2$) per Litre per Kg MSK for 24 hours at room temperature, the supernatant was decanted and the residue was washed three times. Part A and B were sun-dried, grounded into flour using a mortar and pestle and stored at 10^oC until all analysis were performed.

b. Proximate analysis

Moisture, ash, and crude lipid of yellow maize, raw and processed mango seed kernels were determined according to AOAC (2010); crude protein by Onyeike, and Osuji, (2003); crude fibre was determined according to NIS XXX (2008) and carbohydrate was calculated by difference on both raw and processed MSK. The metabolizable energy (ME) content was calculated according to Diarra et al, (2010) as ME (kcal/kg) = 432 + 27.91 (CP + NFE + 2.25 × EE).

c. Mineral analysis:

Mineral was analyzed from the triple acid digested samples of yellow maize, raw and processed MSK (AOAC, 1990) using an Atomic Absorption Spectrophotometer (AAS) (model Solar 969 unicam) for all elements except sodium and potassium which was determined using flame photometer.

d. Amino acid analysis:

Hydrolysis was carried out on dried samples using the method of AOAC (1990). Finely ground (40 mg) each of both raw and processed MSK was placed in an ampoule, 7 mL 6 N HCl was added and the tube was then flushed with nitrogen sealed and placed in an oven at 110°C for 24 h. The tube was removed, allowed to cool, broken and the resulting suspension filtered under function. The filtrate was evaporated to dryness at 40°C under vacuum in a rotary evaporator. The determination of the amino acid profile was carried out on the reconstituted samples with the column chromatographic techniques using the automated Technicon Sequential Multi-sample (TSM) amino acid analyzer model DNA 0209 (Spackman et al., 1958). Known quantities of internal standard norleucine was included for the determination of acidic, basic and neutral amino acid acids, to enable the calculation of the quantities of other amino acid relative to their peak recovery.

e. Antinutritional factors:

Tannin (Makkar et al., 1993), Saponin (AOAC, 1984), Oxalate (Oke, 1969), Cyanogenic glycoside (Onwuka, 2005), Phytate, (Lucas and Markakas, 1975), Alkaloid (Harbone, 1980), Flavonoid (Boham and Kocipai-Abyazan, 1974) and Trypsin inhibitor (Kakade et al, (1969) were determined on the raw and processed MSK.

RESULTS

Table 1: Proximate Compositions of Yellow Maize, Raw and Processed MSK (% DM Basis).

Parameters	YMZ	RMSK	PMSK
Moisture (%)	9.91±0.12[a]	6.50±0.03[b]	8.33±0.05[a]
Ash (%)	1.16±0.23[a]	2.19±0.16[a]	1.96±0.15[a]

Ether Extract (%)	6.30±0.47[a]	7.40±0.31[a]	8.50±0.38[b]
Crude Protein (%)	8.50±0.12[a]	10.90±0.29[b]	6.83±0.13[a]
Crude Fibre (%)	1.15±0.04[a]	2.82±0.14[b]	2.50±0.02[b]
Nitrogen Free Extract (%)	72.98±5.10[a]	69.93±0.80[b]	71.88±4.12[a]
Metabolizable Energy (ME) (Kcal/Kg)	**3,102**	**3,153**	**3,163**

Means in the same row having different superscripts are significantly different ($p<0.05$)
Values are mean ± SD of triplicate determinations.
YMZ = Yellow maize
RMSK = Raw Mango Seed Kernel.
PMSK = Processed Mango Seed Kernel

Table 2: Mineral elements composition of Yellow Maize, Raw and Processed MSK

Mineral Elements	YMZ (mg/100g)	RMSK (mg/100g)	PMSK (mg/100g)
Calcium (Ca)	54.060 ±5.20[a]	55.776±1.04[a]	158.116 ± 1.17[b]
Sodium (Na)	48.524 ±10.51[a]	18.524±0.51[b]	20.616 ± 0.47[b]
Potassium (K)	254.011 ± 11.10[a]	82.011±2.45[a]	198.059 ± 2.63[b]
Magnesium (Mg)	98.006 ±2.01[a]	30.006±1.01[b]	31.110 ± 1.11[b]
Iron (Fe)	4.845 ± 2.11[a]	77.345±2.11[a]	50.087 ± 1.32[b]
Copper (Cu)	1.263 ± 0.58	1.811±0.11	1.916 ± 0.16
Zinc (Zn)	5.412 ±2.23[a]	10.612±0.23[a]	7.465 ± 0.33[b]
Manganese (Mn)	1.003±0.2[a]	2.998 ± 0.09[b]	2.841 ± 0.10[b]
phosphorus	66.41±1.02	21.16±0.56	15.32±0.32

Values are mean ± SD of duplicate determinations
Means in the same row having different superscripts are significantly different ($p<0.05$
RMSK = Raw Mango Seed Kernel.
PMSK = Processed Mango Seed Kernel

Table 3: Amino acid profile of Yellow maize, Raw and Processed Mango Seed Kernel (g/100g protein)

AMINO ACID	YMZ	RMSK	PMSK
Lysine	2.39	3.35	3.19
Histidine	3.51	2.01	2.07
Arginine	4.59	4.25	3.40
Aspartic acid	7.17	5.20	5.18
Threonine	3.11	2.30	2.10
Serine	3.99	2.70	2.64
Glutamic acid	12.14	8.94	8.39
Proline	3.72	2.55	2.12
Glycine	3.16	3.01	2.87
Alanine	4.86	3.74	4.09
Cystine	1.26	0.73	0.60

Valine	4.03	3.02	3.08
Methionine	0.99	0.83	0.73
Isoleucine	3.11	2.26	2.12
Leucine	12.13	5.55	6.29
Tyrosine	3.54	2.25	3.06
Phenylalanine	4.90	3.44	3.89
Total TAA	78.60	56.13	55.82
Total TEAA	38.76	27.01	26.87
Chemical score(%)	28.29	23.71	20.86
LAA	Met	Met	Met

YMZ = Yellow Maize **RMSK** = Raw Mango Seed Kernel
PMSK = Processed Mango Seed Kernel **TAA =** Total Amino Acid
TEAA= Total Essential Amino Acid **LAA=** Limiting Amino Acid

Table 4: Antinutritional factors of Yellow Maize, raw and processed MSK (%DM Basis).

Parameters	**YM**	**RMSK**	**PMSK**
Tannin (mg/100g)	1.78±0.20	0.41±0.02^a	0.017±0.15^b
% Tannin reduction		-	**95.8**
Saponin (%)	0.24±0.23	10.50±0.25^a	4.30±0.05^b
% Saponin reduction		-	**59.0**
Oxalate (mg/100g)	2.54±0.07	1192.50±0.22^a	112.50±0.06^b
% Oxalate reduction		-	**90.6**
Phytate (mg/100g)	150.00±4.50	487.30±0.51^a	116.00±0.05^b
% Phytate reduction		-	**72.2**
Cyanogenic Glycoside (mg/100g)	1.60±0.31	14.10±0.15^a	3.40±0.63^b
% Cyanogenic Glycoside reduction		-	**76.2**
Alkaloid (%)	0.20±0.04	6.30±0.20^a	2.20±0.01^b
% Alkaloid reduction		-	**65.1**
Flavonoid (%)	0.30±0.06	12.20±0.18^a	0.60±0.13^b
% Flavonoid reduction		-	**95.1**
Trypsin Inhibitor (mg/g)	0.36±0.31	27.50±0.09^a	0^b
% T I reduction		-	

Means in the same row having different superscripts are significantly different ($p<0.05$)
Values are mean ± SD of triplicate determinations.
YMZ = Yellow Maize
RMSK = Raw Mango Seed Kernel.

PMSK = Processed Mango Seed Kernel

DISCUSSION

The proximate composition and the metabolizable energy of yellow maize, the composite raw and processed mango seed kernel are shown in Table 1. The percentage crude protein of processed MSK (6.83±0.13%) was significantly ($P<0.05$) lower than that of the raw MSK (10.90±0.29%) and yellow maize (8.50±0.12%). This trend of decrease is similar to the observation made by Obasi and Wogu (2008), who reported decrease in protein content in yellow maize after soaking. The reduction in the protein content of the processed MSK may be attributed to the leaching out of the nitrogenous substances during soaking and boiling of the raw mango seed kernel. The same trend of reduction was observed in the other parameters like fat, ash and crude fibre. Udensi et al (2010) and Mbajunwa (1995) also reported the leaching of soluble minerals in water. This may explain the lower values recorded for the ash and crude fibre contents obtained for the processed MSK compared to the raw one. The carbohydrate content of the processed MSK is comparable to that of yellow maize used for poultry diet

The mineral elements of the yellow maize, raw and processed (MSK) mango seed kernels are shown in Table 2. Minerals found in feedstuffs include: calcium, manganese, copper, iron, zinc, magnesium, potassium, and sodium (Mohammed, 2006). The concentrations of manganese, copper, zinc and potassium in processed mango seed kernel (PMSK) and yellow maize in the present study shows that the PMSK contained very vital or essential mineral elements which are required by animals like poultry for growth and development. The higher concentration of calcium in the PMSK may be due to residual $Ca(OH)_2$ used in processing. Calcium and iron were higher in PMSK than yellow maize while sodium and magnesium were lower in PMSK than yellow maize. This indicates that PMSK is a good source of calcium and iron while yellow maize is a good source of sodium and magnesium. Calcium and magnesium plays a significant role in carbohydrate metabolism, bone and teeth development, enzyme activity and regulating the acid-alkaline balance in the body (Scalbert, 1991; Brody, 1994). Potassium and iron are essential nutrients and has an important role in blood formation and synthesis of amino acids and proteins (Kittiphoom, 2012). The phosphorus content is significantly lower ($p<0.05$) than that of yellow maize.

The amino acid profile of yellow maize (MZ), raw mango seed kernel (RMSK) and processed mango seed kernel (PMSK) are shown in Table 3. In all the samples, 17 difference amino acids were detected among which 9 are essential amino acids. Results clearly show that glutamic acid, aspartic acid and leucine are the most abundant amino acid in the samples. Similar finding has been reported on raw mango seed kernel and yellow maize by Udayasekhara, (1994) and Fowomola, (2010) and Youssef, et al (2009) respectively. The essential amino acid content of the processed MSK (26.87%) is similar to that of raw MSK (27.01%) but lower than that of yellow maize (38.76%). The result of amino acid contents of yellow maize analyzed is in agreement with that reported by NRC, (1994). Similarly, the amino acid contents of RMSK reported by Fowomola, (2010) compared favourably with the result obtained in this study on RMSK.

The presence of anti nutritional factors in yellow maize, raw and processed Mango seed kernels are showed in Table 4. Raw mango seed kernel contained antinutritional substances such as tannin, saponin, oxalate, phytate, cyanogenic glycoside, alkaloids, flavonoid and trypsin inhibitor in varied quantities. The removal of the undesirable components is essential to enhance and improve the nutritional quality of mango seed kernels. In this way, these could effectively be utilized to their full potential as livestock feed. In many instances, usage of only one method may not impart the desired removal of antinutritional compounds and a combination of two or more methods is required. Hence, soaking, boiling and calcium hydroxide treatment was used for the processing of mango seed kernels for poultry feed. There was general reduction in the antinutritional factors as a result of the processing. This is in line with the earlier observation by Joseph and Abolaji (1997), Dakare et al (2011) and Nwaoguikpe et al (2011) that the levels of antinutrients are reduced during boiling. Further treatment with chemical such as hydrated lime ($Ca(OH)_2$) further reduced antinutrients in mango seed kernel. Reduction up to 96%, 59%, 91%, 76%, 77%, 65%, 95% and 100% was observed for tannin, saponin, oxalate, phytate, cyanogenic glycoside, alkaloid, flavonoid and trypsin inhibitors respectively.

The 90.6% reduction for oxalate shows the degree of thermolability of oxalate. However, the residual levels of oxalate and saponin contents in the processed MSK is higher than that obtained in yellow maize but below the lethal levels of 2-5g/100g sample (oxalate) and 1.0g/Kg body weight (saponin) as reported by Munro and Bassir (1969) and Alexander et al (2009) respectively. This implies that feeding of this processed MSK meal will not have the possibility of formation of any insoluble complex of calcium oxalate which has been reported by Olomu (1995) to cause irritation of the gut and deficiency of calcium in experimental animals. Saponin followed the same trend like oxalate with the highest reduction of 59.0% occurring in seed treated with $Ca(OH_2)$. This reduction is lower than that reported by Nwaoguikpe et al, (2011). The phytate reduction followed similar trend like that of oxalate and

saponin with the highest reduction of 76.2% occurring in $Ca(OH_2)$ treated MSK. The phytate reduction was also similar to that reported by Ocheme and Mikailu, (2011) that soaking in hydrated lime significantly ($p<0.05$) decreased the phytate content. The reduction in phytic acid as a result of soaking in lime may be due to degradation of phytic acid by the enzyme phytase which is usually activated by soaking. It has been reported that high consumption of phytate can reduce absorption of essential elements like zinc, calcium, iron and magnesium (Plaami and Kumpulainen, 1995). The level of phytate in the processed MSK (SBC-MSK) suggest that it will not render several minerals especially zinc, calcium, iron and magnesium biologically unavailable to the poultry that feed on it.
Cyanogenic glycosides yield hydrogen cyanide (HCN) upon hydrolysis and thus toxic at certain concentrations. It's also a known inhibitor of the respiratory chain inhibiting cytochrome oxidase (Montgomery 1980). Short term exposure to high levels of HCN produces almost immediate collapse, respiratory arrest and death. In the present study, the level of cyanogenic glycoside was reduced from 14.1mg/100g to 3.4mg/100g (76.2% reduction) as a result of boiling and soaking in lime. This reduction is higher than that reported by Ocheme and Mikailu (2011) and Patil et al (1982). This value is below the toxicity level of 50-60mg/Kg body weight as reported by Oke (1969). A significant amount of alkaloid and flavonoid were removed from the raw MSK following soaking, boiling and chemical treatment. Protease inhibitors in diet lead to formation of irreversible trypsin enzyme-trypsin inhibitor complex, causing a trypsin drop in the intestine. This decreases digestibility of diet protein, resulting to slower animal growth. The organism in this situation increases the secretory activity of the pancrease, which could cause pancreatic hyperplasia. The 100% reduction in trypsin inhibitor in this study confirms the reports of Ocheme and Mikailu (2011), Akanji et al (2003) and Liener (1980) that water and hydrated lime soaking or heat treatment significantly ($p<0.05$) decreased trypsin inhibitor activity. This implies that protein digestibility will not be hindered when processed mango seed kernels are fed to livestock or poultry. Also, the problem of pancreatic hypertrophy due to trypsin inhibitor will not likely occur (Akinmutimi, 2006).

CONCLUSION

Based on the significant reduction of antinutritional factors, rich sources of carbohydrate, mineral elements (calcium, magnesium, potassium, sodium and iron) and essential amino acids in the processed MSK, the processed mango seed kernel is a good potential substitute for maize in poultry rations which could reduce competition and feed cost since feed cost account for 60 – 70% of the total cost of production with maize.

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