

EFFECTS OF PROCESSING METHODS ON THE CHEMICAL COMPOSITION OF FLOUR, MOINMOIN AND AKARA FROM *Mucuna pruriens*

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ABSTRACT

Dry seeds of Mucuna pruriens were processed into two indigenous food products – moinmoin and akara – using the traditional processing methods while varying steaming time for moinmoin and parboiling time of beans for akara. Raw and untreated bean flour (UWMF) served as the control. The nutrient and antinutrient composition of raw beans and processed beans were evaluated. Results showed that for moinmoin, processing caused significant ($p < 0.05$) increase in the protein content (31.50%) of soaked (24h) and dehulled bean flour (SDMF) relative to the raw bean flour (29.87%). The dried moinmoin (MM) samples all had significantly ($p < 0.05$) lower protein content (25.06%-26.00%) relative to the control. Steaming time also significantly improved the protein level relative to the control (UWMF). A significant positive linear relationship was observed between steaming time and the mineral content of the MM samples. For akara processing, the result showed that the parboiling and dehulling caused significant increase in the protein content of the bean flours (31.69% – 31.77%) relative to the control (29.87%). The dried akara (MA) balls however had significantly lower protein levels than the control. Among the MA samples, however, no significant difference in protein content was observed. Parboiling and dehulling led to significant decrease in the mineral content of both the flours and the MA samples. The MA samples differed significantly in their mineral content (except for zinc). The result revealed that all the processing methods employed significantly reduced the antinutrient content of both MM and MA samples. The L-dopa content of the control (6.20%) was higher than both the soaked and dehulled beans flour and the MM samples (4.20% and 3.23%-2.57% respectively). The parboiled and dehulled bean flours contained between 5.30% - 4.60% L-dopa while the akara samples had 3.67%-2.97% L-Dopa.

Kew words: Chemical composition, mucuna, moinmoin, akara, nutrients, antinutrients

INTRODUCTION

Globally, food insecurity is worsening especially in the developing countries. This situation is further threatened, by the current global food crisis caused by such factors as draught, flood, war, etc which has sent the prices of the conventional plant sources of proteins out of the reach of the already impoverished populace of these regions. This unfortunate scenario has escalated the prevalence of malnutrition in these countries. According to WHO (2004) child malnutrition was associated with 54% of child deaths (10.8 million children) in developing countries in 2001. There is therefore an urgent need to find alternative sources of plant protein. Such alternatives must be easily available, cheap and contain a reasonable quantity of protein. One way to achieve this is by promoting the use of plant

biodiversity which ultimately will lead to dietary diversity. In essence, agrobiodiversity represents locally available and affordable resources with untapped potential in grassroots strategies for advancing food security.

One major way of improving the utilization of agrobiodiversity and dietary diversity is through the promotion and utilization of the underutilized crops. The underutilized and underexploited species remain veritable candidates to fill the gap created by high cost of staples. Underutilized species represent a rich array of crops that are used traditionally for their food, fibre, fodder, oil or medicinal properties. They have an under-exploited potential to contribute to food/nutrition security, health, income generation and environmental services. *Mucuna pruriens* belong to the underutilized species that has great prospect for improving food security, by reducing malnutrition and

alleviating poverty especially in developing countries. *Mucuna* is consumed by the people of south eastern Nigeria as a legume of last resort during famine or scarcity of other legumes. It is also used sparingly for thickening sauces and soups in that region (Onweluzo *et al.*, 1994).

Mucuna has been reported to contain approximately 30% crude protein and appreciable amounts of amino acids (Ezeagu *et al.*, 2003). In addition, It has been described as one of the best green manure, cover crops and has the capacity to suppress weeds (Carsky *et al.*, 1998; Ukachukwu *et al.*, 2002). One serious limitation to the attainment of this potential is the fact that *mucuna* is said to contain antinutritive factors such as trypsin inhibitors, phytates, tannins etc, in addition, it contains L-dopa (3,4-dihydroxy-L-phenyl alanine). L-dopa has been reported to cause such toxic effects as vomiting, nausea, anorexia, diarrhoea, aggression, hallucinations and severe depressions when inadequately processed beans are consumed (Duke, 1981; Afolabi *et al.*, 1995; Lorenzetti *et al.*, 1998).

Moinmoin and akara balls are two popular dishes traditionally prepared in Nigeria using cowpea. *Moinmoin* is a gelled product made from steaming wet milled beans, while akara ball is made from deep frying wet milled beans. These two products are enjoyed by majority of the populace in Nigeria especially with the combination of cereal based dishes such as maize gruel (akamu) or maize gelled product (agidi). In order to improve *mucuna* utilization, these two products were prepared using *mucuna* beans. The processing time for the two products were also varied to monitor the effect on level of detoxification of the products with time. The outcome of this work may go a long way to promoting dietary diversification thereby reducing hunger, malnutrition and food insecurity.

MATERIALS AND METHODS

Procurement of *Mucuna pruriens*

Matured seeds of *Mucuna pruriens* (4kg) were purchased from local markets in Nsukka area of Enugu State of Nigeria. The seeds were handpicked to remove impurities. Some of the raw beans were ground into flour, sieved with 1mm mesh screen and kept in air tight plastic containers at -4°C for analysis. The remaining beans were divided into two portions and used for the preparation of two local dishes.

Preparation of *Mucuna Moinmoin*, Boiled *Mucuna Seed Flours* and *Mucuna Akara*

The methods described by Onweluzo and Eilitta (2003) were used to prepare the products. For *mucuna moinmoin* (MMM), 1.5kg

of whole beans were soaked in excess water for 24h, washed and dehulled. The dehulled seeds were ground with 60g fresh pepper, 600g onions and 60g crayfish. Thereafter, the paste was poured into a mortar, mixed and 8 bouillion cubes and 776ml of palmoil were added. The mixture was stirred with the addition of 2L of water, divided into five batches and wrapped with banana leaves. The different batches were steamed for different durations varying from 0hr, 1hr, 1½hr, 2hr and 2½hr. Thereafter the samples were dried in a hot air oven at 50°C and stored at -4°C.

For *mucuna akara*, 2kg of the seeds were divided into four batches and parboiled with excess water for time varying from 20min, 40min, 60mins and 80mins, washed and dehulled. About 100g of beans from each batch was dried in a hot air oven at 50°C, ground to pass through a 1mm mesh screen and stored in airtight plastic containers at -4°C. This sample The remaining beans were ground with 80g pepper and 600g onions and mixed to a smooth consistency with about 2.5L of water. Thereafter the resulting slurry was dropped with a spoon into hot oil and fried until it turned golden brown. The samples were dried in a hot air oven at 50°C and stored -4°C.

Proximate composition

Moisture - Moisture was determined by moisture loss on drying at 130°C in a forced draft oven, (AOAC 1990). Crude protein - Total nitrogen was determined by the Kjeldahl method (AOAC 1990). Protein was calculated from total nitrogen using N x 6.25.

Ash - The sample was charred and ashed to a constant weight at 550°C in a muffle furnace. The residue was quantified and the percentage of ash determined (AOAC 1990).

Crude Fat - Ether-soluble material was extracted from the sample with petroleum ether (B.Pt 40°C -60°C) in a Soxhlet extractor. The ether was volatilized and the dried residue quantified gravimetrically and calculated as the percentage of fat. The method is based on previously published methods (AOAC 1990).

Crude fiber- The sample was dried, to remove excessive moisture, ground to pass a 1.0-mm screen, and extracted with petroleum ether using a Goldfish extractor to remove fat. It was then digested by refluxing with 0.22 mol/L H₂SO₄, filtered, washed and digested by refluxing with 0.30 mol/L NaOH. Following alkaline digestion, the residue was washed, dried, weighed, ignited and reweighed. Crude fiber was calculated from the loss on ignition of the residue (AOAC 1990).

Carbohydrates. (NFE) was calculated by difference.

Determination of minerals

Magnesium determination was carried out using atomic absorption spectrophotometer while zinc and iron were determined using flame photometer (AOAC, 1990).

Determination of Anti-nutrients

Phytic acid was determined by the method of AOAC (1990). Phytic acid was first extracted with dilute hydrochloric acid and separated from inorganic phosphates on an anion exchange column. Phytate was eluted with a sodium chloride solution. The eluate was digested with sulphuric-nitric acid, freeing phosphorus, which was reacted with ammonium molybdate and sulphuric acid solutions to form a blue color complex that was measured spectrophotometrically.

Trypsin inhibitor was determined by the method of Kakade *et al.* (1974). Components that inhibit trypsin activity were extracted at a pH of 9.5 to 9.8 using a sodium hydroxide solution. An aliquot of the sample suspension was mixed with a known volume of trypsin solution and incubated for thirty minutes to allow the trypsin-inhibiting factors to react with the added trypsin. An aliquot of benzoyl-D-arginine-p-nitroanilide (BAPNA) was added to the suspension. Uninhibited trypsin catalyzes the hydrolysis of BAPNA, forming yellow p-nitroaniline. After 10 min of reaction, the hydrolysis was halted by lowering the solution pH with acetic acid, thereby denaturing the enzyme. The solutions were evaluated spectrophotometrically, and trypsin inhibition was evaluated from the difference in the degree of BAPNA hydrolysis between the sample solution and the uninhibited trypsin solution. One trypsin unit is defined as an increase equal to 0.01 absorbance units at 410 nm after 10 min of reaction per 10 mL of final reaction volume, read in 1.27-cm tubes. Trypsin inhibition was calculated as follows $\text{mg TI (trypsin inhibitor)}/\text{g} = (\text{TIU [trypsin inhibitor units]}/\text{mg})/1.9$.

Tannin was determined by the method described by Price and Butler (1977). Ground grains (60mg) was shaken constantly for 60sec with 3ml of methanol in a test tube, and then poured into a Buchner funnel with the suction first turned on. The tube was quickly rinsed with an additional 3ml of methanol and the contents poured at once into the funnel. The filtrate was mixed with 50ml of water and analyzed within an hour.

Three milliliters of 0.1M FeCl_3 in 0.1N HCl was added to the extract, followed

immediately by addition of 3ml of $0.008\text{K}_3\text{Fe}(\text{CN})_6$. The optical density was read after 10min at 720nm using SpectrumLab 21A spectrophotometer. Results were expressed as catechin equivalent using standard curves prepared from commercial D-catechin.

Haemagglutinating activity was determined by the method of Pull *et al.* (1978). Sample extract was prepared by extracting 100mg of finely ground sample with 5ml of 0.005N NaOH for 4h, with mechanical shaking. Each extract was diluted in 2-fold increments to a final dilution of 1:640 using phosphate buffered saline. Portions of each dilution (25ml) was transferred to wells in a microtiter plate and 25ml of 3% suspension of trypsinized type 'B' human erythrocytes was added to each well. Trypsinized type 'B' human erythrocytes was prepared by treatment of a 3% suspension (v/w) of cells in phosphate-buffered saline for 1h with sigma type ix porcine pancreatic trypsin.

One haemagglutinating unit (HU) is defined as the least amount of haemagglutinin that will produce positive evidence of agglutination of a 3% suspension of washed trypsinized type 'B' human erythrocytes after 3h incubation at room temperature.

The method of Arrow (1937) as modified by Ezeagu *et al.* (2003) was used for L-Dopa determination. Samples were ground to pass through 1mm mesh, then 0.1g sample was placed in 50ml centrifuge tubes, with 20ml 0.5N HCl for 2h, at room temperature with manual agitation at 30mins interval. Centrifugation was done at 300G for 20mins. Thereafter, 0.1ml aliquot of extract diluted to 1ml with distilled water was used for the analysis as follows:

- One milliliter of diluted extract was placed in a test tube
- One milliliter of 0.5N HCl was added.
- One milliliter of nitrite molybdate reagent was added. This caused a yellow colour to develop.
- One milliliter of 1N NaOH was added, a red colour was developed.
- The reagent was made up to 5ml and the absorbance read at 510nm using SpectrumLab 21A spectrophotometer against a reagent blank. The concentration of L-Dopa was estimated from the standard curve.

RESULTS AND DISCUSSION

Table 1 shows the effect of soaking, dehulling, and cooking time on nutritional composition of mucuna *moinmoin*. There were significant differences between the control - raw mucuna flour (UWMF) and the processed samples in all the parameters evaluated. The crude protein content (31.50%) of soaked and

dehulled bean flour (SDMF) was higher than those of both the untreated mucuna flour (UWMF) and all the *moinmoin* samples (MM). All the MM samples had lower protein content than the raw flour samples. The protein content of the *moinmoin* samples which ranged from 25.06% - 26.00% increased significantly with cooking time. The higher protein content of SDMF when compared to UWMF could be attributed to dehulling which increased the effective weight of the analysed samples (Bressani *et al.*, 2003). The lower crude protein value of the MM samples could be as a result of dilution effect of cooking oil and other ingredients used in the preparation of *moinmoin*. However, the *moinmoin* samples contained appreciable amounts of crude protein.

Soaking and dehulling caused a significant ($P < 0.05$) decrease in crude fat of SDMF (6.63%) when compared to UWMF (6.52%). The MM samples however had significantly ($p < 0.05$) higher crude fat (31.88% - 31.97%) relative to UWMF. The decrease of crude fat in SDMF relative to UWMF could have been due to dehulling which caused the loss of much of the germs. The addition of cooking oil could have caused high values of crude fat in the *moin moin* samples. The ash

content of SDMF (3.63%) was lower than that of UWMF (4.30%). The ash content of MM samples (7.00 - 7.03%) were significantly higher than those of UWMF and SDMF. Cooking time did not have any significant effect on the ash content of the *moinmoin* samples. Dehulling caused some loss in the mineral content of the mucuna seeds since minerals are known to be concentrated on the seed coats of legumes (Ene-Obong and Obizoba, 1996). This may have caused the decrease in the ash content of SDMF. Addition of mineral rich ingredients like crayfish, pepper, onions etc could have contributed to the high ash content of the MM samples.

In the case of crude fibre, there was a significant decrease in SDMF (3.00%) and MM samples (3.10-3.37%) relative to UWMF (4.63%). This could probably be due to The lower crude fibre content of SDMF resulting from the removal of high fibre seed coats (Ukachukwu *et al.*, 2002). Added ingredients may have caused the higher values observed for the *moinmoin* samples relative to SDMF.

Table 1: Effect of Processing on the chemical Composition of Mucuna *moinmoin*

Component	UWMF	SDMF	MM ₀	MM ₁	MM _{1.5}	MM ₂	MM _{2.5}
Moisture (%)	6.96 _a ± 0.06	7.57 _c ± 0.04	7.00 _a ± 0.07	7.01 _a ± 0.04	7.40 _b ± 0.04	7.37 _b ± 0.05	7.60 _c ± 0.06
Crude Protein (%)	29.87 _a ± 0.35	31.50 _d ± 0.04	25.06 _a ± 0.26	25.65 _a ± 0.28	25.78 _b ± 0.33	25.79 _b ± 0.42	26.00 _b ± 0.22
Crude fat (%)	6.63 _b ± 0.31	6.52 _a ± 0.25	31.88 _c ± 0.67	31.92 _d ± 0.32	31.90 _{cd} ± 0.44	31.92 _d ± 0.28	31.97 _e ± 0.23
Ash (%)	4.30 _b ± 0.27	3.63 _a ± 0.18	7.03 _c ± 0.33	7.04 _c ± 0.35	7.00 _c ± 0.48	7.02 _c ± 0.19	7.00 _c ± 0.28
Crude fibre (%)	4.63 _d ± 0.26	3.00 _a ± 0.29	3.13 _b ± 0.53	3.10 _b ± 0.44	3.20 _c ± 0.23	3.23 _c ± 0.27	3.37 _c ± 0.30
Nitrogen free extract (%)	47.60 _e ± 0.10	47.78 _e ± 0.21	25.90 _d ± 0.29	25.28 _c ± 0.16	24.72 _b ± 0.20	24.67 _b ± 0.34	24.06 _a ± 0.14
Magnesium (g/100g)	0.150 _c ± 0.42	0.137 _a ± 0.32	0.190 _c ± 0.28	0.210 _d ± 0.15	0.250 _e ± 0.20	0.253 _c ± 0.41	0.277 _f ± 0.19
Zinc (mg/100g)	1.73 _a ± 0.38	1.69 _a ± 0.28	1.80 _b ± 0.22	1.83 _b ± 0.63	1.85 _b ± 0.57	1.87 _{bc} ± 0.28	1.88 _c ± 0.35
Iron (mg/100g)	17.00 _d ± 0.06	15.00 _b ± 0.16	14.60 _a ± 0.19	16.80 _c ± 0.29	17.17 _d ± 0.27	17.30 _{ef} ± 0.23	17.43 _f ± 0.17
L-dopa (g/100g)	6.20 _e ± 0.21	4.20 _d ± 0.14	3.23 _c ± 0.12	3.03 _b ± 0.25	2.70 _a ± 0.33	2.70 _a ± 0.12	2.57 _a ± 0.20
Tannin (g/100g)	1.88 _f ± 0.37	0.91 _e ± 0.22	0.86 _d ± 0.46	0.69 _c ± 0.51	0.55 _b ± 0.39	0.45 _a ± 0.34	0.43 _a ± 0.44
Phytate (g/100g)	1.20 _f ± 0.28	0.90 _e ± 0.18	0.88 _d ± 0.17	0.84 _c ± 0.20	0.80 _c ± 0.14	0.73 _b ± 0.09	0.67 _a ± 0.13
Trypsin inhibitor (TIU/mg)	20.00 _g ± 0.43	12.25 _f ± 0.42	10.06 _e ± 0.23	7.41 _d ± 0.40	4.59 _c ± 0.32	4.50 _b ± 0.30	3.4 _a ± 0.28
Haemagglutinating activity (HU/g)	4746.85 _g ± 1.43	3960.90 _f ± 1.57	3164.79 _e ± 1.78	3051.57 _d ± 0.98	2373.51 _c ± 1.88	2071.64 _b ± 1.32	1582.15 _a ± 0.99

Mean ± SD of duplicate values. Values not followed by the same letters in the same horizontal line are significantly different ($p < 0.05$). UWMF – untreated mucuna flour, SDMF – flour from soaked (24hr) and dehulled mucuna beans, MM₀ - uncooked mucuna *moinmoin*, MM₁ - mucuna *moinmoin* cooked for 1hr, MM_{1.5} - mucuna *moinmoin* cooked for 1½ hr, MM₂ - mucuna *moinmoin* cooked for 2hr, MM_{2.5} - mucuna *moinmoin* cooked for 2½ hr.

Soaking and dehulling caused significant reduction of the mineral content of the samples when compared with UWMF. The decrease appeared to be more pronounced for magnesium and iron which were reduced by 8.67% and 11.76% respectively. The *moinmoin* samples had higher mineral content than both the untreated and soaked and dehulled mucuna flours. The removal of seed coats led to reduced mineral content of SDMF while the addition of other food ingredients led to an increase in the mineral content of the *moinmoin* samples.

Mucuna moinmoin has the potentials for reducing hunger and malnutrition prevalent in most developing countries. This is evident from the high levels of crude protein and minerals in mucuna *moinmoin*. These minerals especially iron has been reported to be deficient in the diet of most people in developing countries (Thompson, 2007).

All the processing treatments led to significant decreases in all the anti-nutrients determined. Soaking (24hr) and dehulling caused a 32.25% loss of L-dopa, 51.60% and 26.83% decreases in tannin and phytate, respectively. The respective reduction in trypsin inhibitor activity and haemagglutinating activity were 38.75% and 16.56%. Bressani *et al.* (2003) reported a 62% decrease in L-dopa after soaking and dehulling. This value is higher than 32.25% observed in this study. The difference could have been due to the fact that earlier workers changed the soaking water causing more effective leaching. The high reduction in tannin after soaking and dehulling could be attributed to the fact that most tannins are located in the outer layer of legumes. During decortication of legumes most of them are removed (Bressani, 2002). Most tannins and phytates are soluble in water. Soaking brings about their leaching out into soaking medium (Shi *et al.*, 2004).

There was a slow decline in L-dopa content of the *moinmoin* samples as cooking time increased. Cooking for 2 ½ hr reduced L-dopa by 20.4% relative to the value of the

uncooked sample (MM₀). There was no significant difference between L-dopa level of MM_{1.5} (mucuna *moinmoin* cooked for 1½ hr) and MM_{2.5} (mucuna *moinmoin* cooked for 2½ hr). This implies that the additional fuel, time and water needed for the extra one hour cooking may not be economical since extra time does not bring about a commensurate decrease in L-dopa. The slow decline of L-dopa during cooking seem to confirm the observations of other workers that L-dopa is heat stable, therefore, the most effective means of its detoxification is by soaking during which process much of the antinutrient is leached into the soaking or cooking water (Flores *et al.*, 2002; Janardhanan *et al.*, 2003). Cooking for 2½hr led to significant reductions in the levels of tannin and phytate (50% and 23.86%) when compared to MM₀. Two and halve hours cooking also brought about 66.2% and 50% reduction in the trypsin inhibitor and haemagglutinating activities, respectively. The value for residual tannin is lower than the value (66.2%) reported by Bressani *et al.* (1991) after boiling *P. vulgaris* for 90mins. The fact that the *moinmoin* were wrapped in leaves might have restricted the level of tannin leached into the cooking water. Trypsin inhibitor and lectin are known to be detoxified by heat during cooking (Egbe and Akinyele, 1990; Ukachukwu and Obioha, 2000). This explains the high reduction of these anti-nutrients during cooking. Some lectins are however heat resistant and are not completely eliminated by heat. Ukachukwu and Obioha (2000) reported residual haemagglutinating activity of 1067HU/g after boiling *Mucuna cochinchinensis* for 90min at 100 °C -105°C. The implication of this finding is that processing of mucuna *moinmoin* could greatly reduce some of the anti-nutrients. Some of the anti-nutrients such as L-dopa was moderately reduced. The less than 1% level of L-dopa which is considered the safe level for human consumption was not achieved within the cooking time studied.

Table 2: Effect of Boiling Time and Dehulling on the Chemical Composition of Mucuna Bean Flour

Component	UWMF	BDMF ₂₀	BDMF ₄₀	BDMF ₆₀	BDMF ₈₀
Moisture (%)	6.96 _a ±0.89	7.23 _c ±0.46	7.03 _b ±0.57	6.70 _a ±0.77	7.20 _c ±0.33
Crude protein (%)	29.87 _a ±0.34	31.71 _b ±0.27	31.69 _b ±0.54	31.77 _b ±0.23	31.76 _b ±0.41
Crude fat (%)	6.63 _a ±0.09	6.74 _b ±1.02	6.74 _b ±0.88	6.76 _a ±0.46	6.75 _b ±0.42
Ash (%)	4.30 _b ±0.72	3.50 _a ±0.35	3.40 _a ±0.38	3.50 _a ±0.29	3.40 _a ±0.61
Crude fibre (%)	4.63 _b ±0.36	0.30 _a ±0.41	0.30 _a ±0.26	0.30 _a ±0.56	0.27 _a ±0.22
Nitrogen free extract (%)	47.60 _c ±0.50	50.22 _a ±0.43	50.84 _c ±0.27	50.97 _d ±0.28	50.62 _b ±0.39
Magnesium (g/100g)	0.150 _c ±0.03	0.141 _a ±0.07	0.141 _a ±0.08	0.142 _a ±0.05	0.144 _b ±0.06
Zinc (mg/100g)	1.73 _a ±0.19	1.70 _a ±0.25	1.70 _a ±0.19	1.67 _a ±0.22	1.69 _a ±0.15
Iron (mg/100g)	17.00 _d ±1.13	16.47 _a ±0.97	16.57 _{ab} ±1.01	16.53 _{ab} ±0.86	16.69 _a ±1.01
L-dopa (g/100g)	6.20 _a ±0.74	5.30 _c ±0.51	5.20 _c ±0.64	4.80 _b ±0.39	4.60 _a ±0.78
Tannin (g/100g)	1.88 _e ±0.37	1.28 _d ±0.23	1.24 _c ±0.32	0.95 _b ±0.16	0.86 _a ±0.20
Phytate (g/100g)	1.20 _c ±0.13	1.10 _d ±0.10	0.86 _c ±0.18	0.76 _b ±0.08	0.71 _a ±0.16
Trypsin inhibitor (TIU/mg)	20.00 _e ±1.14	10.50 _d ±1.02	8.45 _c ±1.63	8.00 _b ±1.06	7.70 _a ±1.10
Haemagglutinating activity (HU/g)	4746.85 _c ±3.08	3955.64 _d ±2.17	3162.44 _c ±1.89	2846.45 _b ±2.21	2514.38 _a ±1.99

Mean ± SD of duplicate values. Values not followed by the same letters in the same horizontal line are significantly different ($p < 0.05$). UWMF – untreated mucuna flour, BDMF₂₀ – flour from mucuna beans boiled for 20min and dehulled, BDMF₄₀ – flour from mucuna beans boiled for 40min and dehulled, BDMF₆₀ – flour from mucuna beans boiled for 60min and dehulled, BDMF₈₀ – flour from mucuna beans boiled for 80min and dehulled.

The effect of boiling time and dehulling on the chemical composition of mucuna bean flour is presented in Table 2. Significant differences were observed in all the nutrients/antinutrients determined. Boiling for 80mins followed by dehulling brought about a 6.33% increase in protein content. There was however no significant difference between the boiled and dehulled samples. The increase in crude protein content of the boiled and dehulled samples could be attributed to dehulling which increased the effective weight of the samples. The ash and crude fibre content of the beans were reduced as a result of boiling and dehulling. Decrease in Nitrogen free extract was also observed in the processed samples. Reduction in the values of ash and crude fibre may be due to dehulling leading to loss of fibres and minerals. These results agree with the report of Udedibie *et al.* (1996) who observed a decrease in crude fibre after boiling jackbeans.

There were significant decreases in all the minerals evaluated. This implies that dehulling and boiling led to mineral loss. Among the boiled and dehulled samples there were no significant differences. Removal of tannin and phytate by dehulling could have contributed to the observed

decrease in minerals in the processed samples since many minerals are known to be bound to these compounds (Forbes *et al.*, 1984)

Boiling time and dehulling had a significant decrease in all the anti-nutrients evaluated. Boiling mucuna beans for 80min followed by dehulling (BDMF₈₀) led to a 25.8% decrease in L-dopa content. Reduction in tannin and phytate were 54% and 41%, respectively after 80min boiling. Cooking of soaked and dehulled faba beans caused 32-38% reduction in phytate (Deshphande and Salunkhe, 1982). Trypsin inhibitor activity was reduced by 61.5% while haemagglutinin was inactivated by 47%. Wanjekeche *et al* (2003) obtained 89.7% reduction in trypsin inhibitors after boiling mucuna beans for 1.5h while changing boiling water. Ukachukwu and Obioha (2000) obtained 75% reduction in the haemagglutinin level of mucuna beans after 90mins boiling. From Table 2 it could be concluded that the maximum boiling time of 80 min brought about a reasonable reduction in the anti nutrients.

Table 3: Effect of Boiling Time and Dehulling on the Chemical Composition of Mucuna akara

Component	UWMF	MA ₂₀	MA ₄₀	MA ₆₀	MA ₈₀
Moisture (%)	6.96 _a ± 0.24	7.10 _{ab} ± 0.35	7.20 _{bc} ± 0.63	7.30 _c ± 0.29	7.30 _c ± 0.40
Crude protein (%)	29.87 _a ± 0.88	23.85 _b ± 0.67	24.03 _b ± 0.81	24.08 _b ± 0.65	24.35 _b ± 0.68
Crude fat (%)	6.63 _a ± 0.49	22.03 _b ± 0.28	22.05 _b ± 0.37	22.01 _b ± 0.23	22.02 _b ± 0.42
Ash (%)	4.30 _b ± 0.21	5.80 _{bc} ± 0.26	6.00 _c ± 0.30	5.73 _b ± 0.24	5.90 _{bc} ± 0.27
Crude fibre (%)	4.63 _b ± 0.37	2.70 _b ± 0.17	2.57 _a ± 0.31	2.50 _a ± 0.28	2.50 _a ± 0.32
Nitrogen free extract (%)	47.60 _c ± 0.89	38.52 _d ± 0.78	38.15 _b ± 0.63	38.38 _c ± 0.81	37.93 _a ± 0.76
Magnesium (g/100g)	0.150 _c ± 0.03	0.130 _a ± 0.02	0.127 _a ± 0.02	0.130 _a ± 0.04	0.133 _a ± 0.03
Zinc (mg/100g)	1.73 _a ± 0.18	1.48 _a ± 0.23	1.54 _b ± 0.22	1.54 _b ± 0.25	1.59 _c ± 0.20
Iron (mg/100g)	17.00 _d ± 0.87	15.30 _a ± 1.04	15.33 _a ± 0.69	15.70 _b ± 1.11	15.73 _b ± 0.84
L-dopa (g/100g)	6.20 _a ± 0.44	3.67 _d ± 0.37	3.37 _d ± 0.32	3.27 _b ± 0.27	2.97 _a ± 0.32
Tannin (g/100g)	1.88 _c ± 0.19	0.88 _d ± 0.10	0.85 _c ± 0.21	0.54 _b ± 0.24	0.36 _a ± 0.17
Phytate (g/100g)	1.20 _e ± 0.48	0.79 _b ± 0.26	0.77 _{ab} ± 0.25	0.74 _{ab} ± 0.30	0.70 _a ± 0.32
Trypsin inhibitor (TIU/mg)	20.00 _e ± 1.05	5.56 _a ± 1.22	4.63 _c ± 0.97	3.65 _b ± 1.17	2.40 _a ± 1.03
Haemagglutinating activity (HU/g)	4746.85 _e ± 3.03	2372.95 _d ± 2.19	2121.20 _c ± 2.35	2042.55 _b ± 2.11	1676.87 _a ± 3.00

Mean ± SD of duplicate values. Values not followed by the same letters in the same horizontal line are significantly different (p<0.05). UWMF – untreated mucuna flour, MA₂₀ – akara from mucuna beans boiled for 20min and dehulled, MA₄₀ – akara from mucuna beans boiled for 40min and dehulled, MA₆₀ – akara from mucuna beans boiled for 60min and dehulled, MA₈₀ – akara from mucuna beans boiled for 80min and dehulled.

Data on the effect of boiling time and dehulling on the chemical composition of mucuna akara is presented in Table 3. It would be observed that the processing treatments had significant effects on all the chemical components studied. The protein content of the mucuna akara samples was significantly lower than that of the raw beans. The protein content among the akara samples were however not significantly different. The decrease in protein content of the akara samples could have been due to dilution effect by the other ingredients. The crude fat and ash content of the akara samples (MA) were significantly higher than that in the raw beans. The high fat content of the MA samples can be attributed to absorption of frying oil while that of ash could be due to the mineral containing ingredients such as pepper, onions etc added to the beans slurry prior to frying. Crude fibre level of the MA samples were significantly less than UWMF, this is attributable to dehulling which caused the loss of high fibre seed coats.

Processing treatments for akara led to significant decreases in mineral levels. Among the fried samples, there was no significant difference in the levels of magnesium but this was not the case with zinc and iron where significant increases were observed. The reduction in the mineral levels of the MA samples could be said to be as a result of dilution effect of other ingredients. It is obvious that the akara processed from mucuna could be considered to contain appreciable amounts of protein and minerals which would contribute to alleviating hunger and micronutrients deficiencies in developing countries.

All the anti-nutrients studied were significantly lower in the akara samples. L-dopa level of MA₈₀ was reduced by 52.10% relative to the raw samples. Tannin and phytate levels were decreased by 80.85% and 41.67%, respectively

while trypsin inhibitor activity and haemagglutinin were reduced by 88.00% and 64.67% respectively. The slow decline of L-dopa even after boiling and parboiling confirms the heat stability of L-dopa as reported by Del Carmen *et al.* (2002). It is evident that processing of mucuna to akara could reduce the antinutrient content in mucuna to a large extent.

CONCLUSION AND RECOMMENDATION

The result of this study has shown that high nutrient containing dishes such as *moinmoin* and akara could be prepared from mucuna. In addition, the processing methods for these two products led to a considerable decrease in the antinutrient level of the beans especially L-dopa. The L-dopa level in all samples were not however lowered to the safe level of less than 1%. Mucuna therefore has a great untapped potential of reducing food insecurity especially in developing countries.

It is therefore recommended that researchers should carry out further work on ways of further eliminating L-dopa and other antinutrients in mucuna, since the L-dopa level of mucuna beans was not reduced to human safe levels of <1% (Versteeg *et al.*, 1998). These research works should explore the effect of a combination of different indigenous processing methods on this toxic substance. Work on developing mucuna-based food recipes using mucuna alone as

major source of energy and protein or in combination with other legumes and cereals should be intensified so as to have more traditionally accepted dishes that could be prepared from mucuna. Toxicology research on the effect of long term consumption of mucuna and mucuna products on humans should be undertaken.

Government should map out food/nutrition strategies, policies and programmes that would promote the cultivation, utilization and consumption of mucuna. These programmes should be packaged in such a way as to break the age long aversion for mucuna by people. This can be done by providing agricultural and food extension services such as training to farmers on the numerous agro-economic and nutritional benefits of mucuna, supplying mucuna seeds to farmers and providing incentives such as soft credits to them. Women should be informed and trained on the nutritional advantage of mucuna and taught simple means of processing and utilizing mucuna to prepare dishes that are safe for consumption.

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