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EFFECT OF TIME DURATION OF THERMAL TREATMENTS ON THE NUTRITIVE VALUE OF *Mucuna cochinchinensis*

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ABSTRACT

The effects of varying time duration of three thermal processing methods on the nutritive value of *Mucuna cochinchinensis* were investigated. The processing methods were toasting, boiling and boiling with pre-soaking. Toasting lasted 30, 45 and 60 minutes at 105^0 to 110^{0}C respectively. Boiling at 100^0 to 105^{0}C lasted for 30, 60 and 90 minutes respectively. Boiling of 12 hour-soaked seeds lasted for 30, 45 and 60 minutes at 100^0 to 105^{0}C respectively. Increased time duration of boiling and boiling with pre-soaking caused significant reductions in crude protein (CP) ($P<0.01$) and crude fibre (CF) ($P<0.05$) but increased the nitrogen-free extract (NFE) of the seeds. Ether extract (EE), ash and gross energy (GE) components of the seed were however, not significantly affected. Also, increasing time duration of toasting caused significant reduction of CF ($P<0.05$) and EE ($P<0.01$) and an increase in percent NFE ($P<0.01$). CP, ash and GE were not significantly affected. As it relates to the anti-nutritional factors, increasing time duration of boiling pre-soaked and non-soaked seeds progressively detoxified ($P<0.05$ trypsin inhibitor, cyanide and haemagglutinin. Increasing toasting time duration significantly ($P<0.05$) detoxified only trypsin inhibitor and haemagglutinin but did not affect cyanide and tannin constituents. The time duration that achieved the highest level of detoxification of anti-nutritional factors in their respective groups were toasting for 60 minutes, boiling for 90 minutes and boiling 12 hour-soaked seeds for 60 minutes. In relative terms, the wet-heat treatments (boiling and soaking-and-boiling) appeared more effective than toasting (a dry-heat treatment).

Keywords: *Mucuna cochinchinensis,* time duration, thermal processing, nutritive value.

INTRODUCTION

Mucuna cochinchinensis (Lyon's bean) has been reported to contain some antinutritional factors like antitrypsin, hemagglutinin, cyanide and others (Hashim and Idrus, 1977; Ukachukwu and Obioha, 1997a). These factors are toxic and they inhibit nutrient utilization by animals in whose diet this feed ingredient is included. These inhibitory substances are known to be heat labile (Lloyds *et al.*, 1978; Nelson *et al.*, 1978; Church and Pond, 1974, Arnold *et al.*, 1971). However, various types of heat treatments may achieve detoxification of the toxic factors to varying degrees. Oke *et al.*(1996) autoclaved milled raw cowpea and reported 61.92% detoxification of HCN, 14.73% of Tannin and 100% of trypsin-inhibitor and hemagglutinin. Ukachukwu and Obioha (1997b) employed toasting, boiling and soaking-and-boiling in the thermal processing of *M. cochinchinensis*. They reported that boiling was most effective in detoxifying HCN, hemagglutinin trypsin inhibitor and tannin constituent of *Mucuna cochinchinensis* seed, followed by soaking-and-boiling, while toasting had the least effect.

It is also believed that different durations of heat treatment have varying effects on the detoxification of antinutritional factors of legume seeds and improvements of their nutritive values. Udedibie and Nwaiwu (1987) reported that cooking for 60 minutes did not significantly destroy the antinutritional factors of Jackbean. However, by increasing the cooking time of Jackbean to 90 minutes Udedibie *et al.*, 1996 reported better utilization of the bean by chicks, suggesting a higher degree of improvement of its nutritive value. Heating for too long a period (coupled with too high an oven temperature) may influence feed efficiency by tying up nutrients and hence making them unavailable (Arnold *et al.*, 1971; Renner *et al.*, 1953; Hayword *et al.*, 1936). While Church and Pond (1974) recommended that the appropriate heating temperature and period for soyabean should be 110^{0}C for 3 minutes, Matami (1980) recommended at 112^{0}C for 5 to 40 minutes. IFSP (1988) recommended compulsory cooking of soyabean for 20 minutes while Nelson *et al.*, (1978) suggested a time range of 20 –30 minutes. Hill and Renner (1963) had earlier suggested steam-heating at 240^{0}F for 45 minutes while Saxena *et al.* (1963) recommended autoclaving for 30 minutes at atmospheric pressure.

It is therefore, clear that thermal treatment for different time durations will have different effects on the improvement of the nutritive value of feed stuffs that contain antinutritional factors. In a previous study the authors employed three types of heat treatment for only 30 minutes on *M. cochinchinensis*.

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They reported some levels of elimination of the inhibitory substances of the seeds and some changes in the proximate composition . The aim of the present study is therefore to assess the effects of different durations of three thermal treatments (toasting, boiling and boiling with pre-soak) on the antinutritional factors and proximate compostition of *Mucuna cochinchinesis* vis-à-vis the improvement of its nutritive value as feed stuff.

2.0 MATERIALS AND METHODS

2.1 Processing of Seeds

Seeds, bought from markets in Nsukka area of Enugu State and Igala area of Kogi State, were divided into four lots. Three lots were subjected to three thermal processing methods, viz: boiling, toasting and boiling with pre-soaking. The fourth was left raw.

(a) **Boiling:** Boiling lasted for three different time durations of 30, 60 and 90 minutes. In each case, water was brought to boil at 100°C and the seeds poured in. Boiling continued at 100 - 105°C for the respective time durations starting from the time the seeds were poured in. At the end of boiling, water was drained off using local basket. Thereafter, boiled seeds were dried in a forced-draught oven at 60°C.

(b) **Boiling with pre-soaking:** Seeds were soaked for 12 hr and water drained off by means of local basket. The seeds were then divided into three aliquot parts. These were boiled for 30, 45 and 60 minutes respectively in the same way as in (a) above. Decanting of water and drying of seeds also followed the same procedure as in (a) above.

(c) **Toasting:** Toasting lasted for three different time durations of 30, 45 and 60 minutes. Seeds were toasted in sand inside *Agbada* (local frying pan) at temperatures that fluctuated between 105 and 110°C. The sand was sieved to remove organic matter. There was turning for 3 minutes at short intervals of two minutes. Temperature was read off at intervals of five minutes. After toasting the sand was immediately sifted out by means of a sieve.

Preparation of seeds for sample analyses

From each of the processed lot including the raw stock aliquot samples of about 200g were collected, ground and bottled in air-tight container for subsequent assay for proximate composition, gross energy content, mineral content, and anti-nutritional constituents.

Proximate composition and Energy Determination

Determination of proximate composition of the sample was by A. O. A. C. (1990) procedure, employing the micro-Kjeldahl method for crude protein (CP) and Soxhlet extraction method for ether extract (EE). The gross energy of the sample was assayed using the adiabatic oxygen bomb calorimetry technique.

Mineral

The ground raw seeds was subjected to wet digestion with perchloric and nitric acids by the Johnson and Ulrich (1959) method. Following the digestion, the mineral content was determined by atomic absorption spectrometry. The phosphorus content was determined on a spectronic 20 spectrophotometer following development of colour with ammonium molybdate. The result was expressed on dry matter basis.

Anti-nutritional Factors and Toxicants

Some of the anti-nutritional factors common with other *Mucuna* species were investigated. These include cyanide, hemagglutinin, trypsin inhibitors, and tannins. The alkaline titration method of A. O. A. C. (1990) was used to determine the hydrocyanic acid content in the seed. Hemagglutinin extract was prepared by the method of Liener (1955) with some modification. To 2g of raw flour sample in a stoppered bottle was add 20ml normal saline and shaken vigorously for one minute. Samples were set in refrigerator overnight and centrifuged at 2000rpm for 10 minutes using a Dynac Centrifuge. The supernatant was collected and used as the crude agglutinin extract. Red blood cells of rabbit and broiler were prepared by the method of Grist *et al* (1970), using EDTA as anticoagulant. Hemagglutinating activity of the extract was tested by the method of Lis *et al* (1966), using washed trypsinized and untrypsinized erythrocytes of rabbits and broiler bird, and employing the two fold serial dilution technique of Kabat and Mayer (1961). The method of Hoff and Singleton (1977) was employed in the determination of tannin content of the sample. For trypsin-inhibitor assessment, the chemical method described by Kakade *et al* (1974) was used.

Statistical Analyses

Generated data were statistically evaluated by analysis of variance (Steel and Torrie, 1980) while the Duncan's new multiple range test (Duncan, 1955) was used to detect differences among means , where necessary.

RESULTS AND DISCUSSION

Increased duration of the thermal treatments caused noticeable changes in the proximate composition of the resulting meals (Table 1). Reduction ($P<0.01$) in crude protein (CP) was observed only when boiling time was increased to 90 minutes. Reduction in crude fibre (CF) was produced ($P<0.05$) by increasing the boiling time to 60 minutes whereas further cooking did not produce further reductions of CF. Increasing the cooking time to 60 and 90 minutes caused an increase ($P<0.01$) in the nitrogen-fee extractives (NFE). The increased boiling time did not significantly affect ether extractives (EE), ash and gross energy (GE). Ukachukwu and Obioha (1997b) attributed the initial increase in the CP when the seeds were subjected to 30-minutes cooking to loss of testa. They argued that since testa contribute proportionately less CP to the total protein of the seed, loss of these testa

Table 1: Chemical Composition of *Mucuna cochinchinensis* as influenced by various durations of different thermal treatments

	Treatments									
	Raw	Boiling time (min)			Toasting time (min)			Boiling time (min) Of 12-hour presoaked seeds		
Nutrient Components		30	60	90	30	45	60	30	45	60	SEM
CP, %	30.06^{e}	31.98^{c}	32.03^{c}	31.82^{d}	32.00^{c}	31.96^{c}	31.95^{c}	32.42^{a}	32.20^{b}	31.96^{c}	0.018**
CF,%	9.04^{a}	7.87^{b}	7.60^{ef}	7.57^{f}	7.74^{c}	7.67^{d}	7.65^{de}	7.69^{cd}	7.65^{de}	7.60^{ef}	0.018*
EE,%	4.52^{b}	3.93^{d}	3.95^{d}	3.93^{d}	4.84^{a}	4.42^{c}	4.40^{c}	3.96^{d}	3.97^{d}	3.97^{d}	0.013**
Ash, %	4.52^{b}	3.93^{e}	3.90^{e}	3.93^{e}	4.80^{a}	4.82^{a}	4.80^{a}	3.91^{e}	3.92^{e}	3.91^{e}	0.026**
NFE,%	51.86^{c}	52.29^{b}	52.58^{a}	52.69^{a}	50.62^{e}	51.13^{d}	51.20^{d}	52.01^{c}	52.26^{b}	52.56^{a}	0.052**
GE, kcal/g	4.60^{a}	4.51^{b}	4.55^{ab}	4.54^{b}	4.32^{c}	4.33^{c}	4.31^{c}	4.51^{b}	4.49^{b}	4.53^{b}	0.018**
Calcium	0.08	007	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	
Phosphorus	1.07	0.90	0.88	0.88	0.97	0.95	0.95	0.92	0.90	0.90	
Magnesium	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	
Sodium	0.93	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	

Values on the same row having different superscripts are statistically different from each other at * (P<0.05) or ** (P<0.01)

% - Percentage
CP - Crude protein
CF - Crude fibre
EE - Ether extractive
NFE - Nitrogen-free extractive
GE - Gross energy
Kcal/g - Kilocalories per gramme
Min - minutess

would lead to increase in the total CP. In the present study, increasing the cooking time to 60 minutes did not produce any further significant effect. However, when the duration of boiling was increased to 90 minutes a significant reduction was obtained. The dehulling effect must have predisposed the seeds to some kind of leaching or solubilization. This effect could become significant only with prolonged boiling time, but with respect to phosphorus, it became evident from the 30 minutes cooking duration. Reduction in CF could be solely attributable to loss of hulls of the seeds in course of cooking and decanting of water. Increase in NFE can be as a result of the reduction in CF.

Increasing toasting time from 30 to 45 minutes produced further reduction in the amounts of CF ($P<0.05$) and EE ($P<0.01$) contained in the seeds. Further increase in the toasting time from 45 to 60 minutes did not produce further significant reduction. Conversely increasing toasting time from 30 to 45 minutes resulted to an increase ($P<0.01$) in percent NFE. However, further increase in toasting time from 45 to 60 minutes did not produce any further significant increase. The reduction in CF content of the seeds subjected to increased toasting duration could have been brought about by loss of testa during the process of sifting out sands after toasting. There was increased detachment of the seed coats when toasting duration was increased from 30 minutes to 45 minutes. Reduction in the EE content could be due to some volatilization of fats and oil in the test ingredient.

Increase in the boiling time of the pre-soaked seeds progressively produced significant reductions ($P<0.01$) in percent CP of the seeds. The reduction in the percent CF of the pre-soaked seeds due to the increases in the boiling time is significant ($P<0.05$) only when 30 minutes and 60 minutes boiling treatments are compared. On the other hand, there was a progressive increase in NFE contents of the pre-soaked test ingredient as the boiling time increased. The decrease in the CP content could be due to progressive solubilization and leaching out of nitrogenous substances in the ingredient, while the reduction in CF content could be attributable solely to loss of seed coat in cooking and decanting of water. The loss of testa conversely led to increase in NFE, which is mainly the more digestible carbohydrate component. The testa constituted mainly the CF that is the less digestible carbohydrate component.

Table 2 shows the effect of the increased duration of thermal treatments on the antinutritional factors of *M. cochinchinensis* seed. Increasing boiling time from 30 to 60 and to 90 minutes resulted to progressive significant decreases ($P<0.05$) in trypsin inhibitor and cyanide contents of the test ingredient. After the 60 minutes boiling treatment, no further reduction was observed in tannin level of the seed, while further reduction in haemagglutinin constituent manifested only after 90 minutes.

Increasing boiling time of pre-soaked seeds also had progressive significant ($P<0.05$) reduction effect on trypsin inhibitor and cyanide contents. The increase in the boiling time did not produce any significant reduction effect on tannin content until the 60 minutes boiling time. For haemagglutinin, after the 45 minutes boiling treatment no further reduction was observed. Udedibie and Nwaiwu (1987) had reported no significant reduction of antinutritional factors in jackbean by cooking for 60 minutes

Table 2: Effect of various time durations of the different thermal treatments on the anti-nutritional factors of *M. cochinchinensis*

Anti-nutritional Factors	Treatments										
	Raw	Boiling time (min.)			Toasting time (min.)			Boiling time (min.) of 12 hour Presoaked seeds			
		30	60	90	30	45	60	30	45	60	SEM
Trypsin inhibitor(mg/g)	7.47^{a}	4.25^{f}	4.17^{g}	4.08^{h}	4.92^{b}	4.92^{b}	4.48^{de}	4.60^{c}	4.52^{d}	4.43^{e}	0.026*
Tannin(mg/g)	5.54^{a}	4.98^{c}	4.37^{e}	4.37^{e}	4.37^{e}	4.41^{e}	4.44^{e}	5.30^{b}	5.37^{b}	3.91^{f}	0.032**
Haemagglutinin(Hu/g)	4267	2133	2133	1067	4267	4267	2133	3133	1067	1067	
Cyanide(mg/kg)	40.00^{a}	30.00^{cd}	25.00^{ef}	21.00^{g}	35.00^{b}	35.00^{b}	33.00^{bc}	27.00^{de}	23.00^{fg}	20.00^{g}	1.033*

Values on the same row having different superscripts are significantly different from each other at *(P<0.05) and ** (P<0.01).

SEM - standard error of mean
Hu - haemagglutinating unit
Mg - milligramme
Kg - Kilogramme
G - gramme
Min - minutes

However, when the cooking time was increased to 90 minutes, Udedibie *et al.* (1996) observed higher degree of improvement in the nutrive value of Jackbean.

Varying toasting time did not produce any significant effect on cyanide and tannin constituents of the seeds. However, when the toasting time was increased to 60 minutes significant (P<0.05) reduction was observed in trypsin inhibitor content of the seeds and haemagglutinin level decreased from 4267Hu/g to 2133Hu/g.

Boiling and pre-soaking-and-boiling, which are both wet-heat treatments therefore, appeared to be better thermal treatments to detoxify cyanide and haemagglutinin. This could be so because of the combined effect of temperature and leaching (or solubilization which wet-heat treatment offers. Boiling also showed some superiority over toasting in the detoxification of trypsin inhibitor. Wet-heat has been proved to produce higher detoxification of anti-nutritional factors than dry-heat (Ukachukwu and Obioha, 1997b; Anumnu, 1990; IFSP, 1988; Nelson *et al.*, 1978). This could be because, generally speaking, moist heat is hotter and has greater penetration rate than dry-heat.

In conclusion, when various time duration were considered, it was obvious that boiling for 90 minutes, toasting for 60 minutes and boiling 12 hour-soaked seeds for 60 minutes produced the highest level of detoxification in their respective groups. For improved nutritive value therefore, it is recommended that boiling for time duration of about 90 minutes can process *Mucuna cochinchinensis*. In the alternative, it can be pre-soaked for 12 hours and boiled for about 60 minutes. If the interest is in toasting, it should be toasted with sand in frying pan for about 60 minutes with turning at very short intervals. Selection of any of the three recommended processing methods as the best processing method would require biological evaluation.

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