IBADAN JOURNAL OF AGRICULTURAL RESEARCH

VOLUME 13
ISSUE 1
2017

ISSN 0794-5442

IBADAN JOURNAL OF AGRICULTURAL RESEARCH (IJAR)

An International Journal

ISSN-0794-5442

A Publication of the Faculty of Agriculture and Forestry,
University of Ibadan, Ibadan, Nigeria

2017

Volume 13 **Issue 1**

Nutritive Evaluation of Differently Processed Mucuna Seeds for Ruminants

Ososanya, T. O.*[1] and Inyang, U. A.[2]
Animal Production and Management Unit,
[1]Department of Animal Science, University of Ibadan, Ibadan
[2]Department of Animal Science, University of Uyo, Uyo
*Corresponding Author E-mail: *tososanya85@gmail.com*

Abstract

Mucuna as a feed has great ability to serve as a source of energy and protein in dry season feeds due to the fact that it has high crude protein content comparable to other well known legumes. The study was designed to evaluate the nutritive compositions of Mucuna beans subjected to various treatments: roasting, boiling, autoclaving and raw. Thereafter, the proximate composition, in vitro gas production and fermentative characteristics of the treated beans were undertaken. Result showed significant differences in the roasted beans for dry matter (DM) and crude protein (CP) values of 96.97 and 36.86 %, respectively. Other proximate parameters (crude fibre, ash and nitrogen free extract) were similar for all treated beans. In vitro gas production after 24 hours showed that autoclaved (32.75 mL), boiled (32.25 mL) and raw beans (29.75 mL) were similar ($p>0.05$) and more utilizable as ruminant feed compared to the roasted form. Roasted beans recorded the least (11.00 mL) gas production. Roasting affected the fermentation characteristics significantly ($p<0.05$) by lowering its organic matter digestibility (OMD, 42.20 % DM), short chain fatty acids (SCFA, 0.31 mmol/L), metabolizable energy (ME, 5.71MJ/Kg DM) and methane gas (MG, 7.75 mL/200 mg DM). Roasting perhaps affected the fibre structure thereby making it unavailable for microbes to act on as evident in results from in vitro gas production and fermentative characteristics. However, other treatments (excluding raw) posits a potentiality of Mucuna as a source of energy for ruminants' especially in dry season when there is scarcity of dietary energy sources.

Keywords: Autoclaving, boiling, Mucuna bean, raw, roasting.

Introduction

As a result of challenge experienced during the dry season in the tropics as it concerns ruminants there is the need to search for alternative feed sources that are relatively unknown. Mucuna bean is a product of *Mucuna pruriens* (L.) DC variety *utilis*, a leguminous vine which presents itself as a possible option. Mucuna beans are variable in colour, ranging from glossy black to white or brownish with black mottling (FAO, 2011). In addition, it usually produces 200 to 600 kg of seeds per hectare which are very rich in protein (24-31%). Mucuna bean has been noted in its utilization as a supplement to ruminants fed poor quality roughage diets in many tropical countries (Castillo-Caamal *et al.*, 2003). Mucuna is an excellent cover crop and soil improver (Osei-Bonsu *et al.*, 1995; Carsky *et al.*, 1998). However, the regular use of Mucuna bean for soil fertility enhancement is hampered by lack of appropriate processing technique of the seeds (Versteeg *et al.*, 1998). Like many other grains, Mucuna beans contains several anti-nutritional factors (phenols, L-DOPA, lectins, enzyme inhibitors and lignin), which have to be reduced to safe levels before it can be used as feed for non-ruminants. There is however, no detrimental effect of these compounds when fed to ruminants (Castillo-Caamal *et al.*, 2003).

Mucuna grains and husks have good

nutritional characteristics (Ayala – Burgos *et al*., 2003) with which to support ruminant livestock in critical periods. The organic matter digestibility from bean and husk were 96.02 and 78.85 % respectively (Ayala – Burgos *et al*., 2003) while Burgos *et al.* (2002) and Sandoval-Castro *et al.* (2003) reported 11.90 and 13.90 MJ/Kg dry matter (DM) respectively as metabolizable energy (ME) for Mucuna bean. This study was proposed to determine the nutritional composition and *in vitro* gas production of Mucuna seed subjected to different processing methods.

Materials and Methods

Bean procurement and treatment

Mature Mucuna beans were obtained from International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria. The beans were exposed to four different treatments (roasting, boiling, autoclaving and raw) modified from those of Siddhuraju *et al*. (1996). The various treatments described were carried out at the Department of Animal Science, University of Ibadan, Nigeria. A weighing scale was used to measure 250g of *Mucuna pruriens* beans for each treatment. After each treatment, seeds were milled to powder form using a hammer mill.

Roasting: *Mucuna pruriens* beans were weighed into a circular pan over fire for one hour thirty minutes and continuously stirred until both the testa and the seeds developed a brownish color.

Boiling: *Mucuna pruriens* beans were weighed and immersed in an aluminium pot (20 litre capacity) half filled with distilled water and boiled for 45 minutes. After boiling, the water was poured out and the seeds were then soaked in a plastic bucket (20 litre capacity) filled with water for 15 minutes. Furthermore, the water was decanted and the seeds were dried till a constant weight was achieved in an oven.

Autoclaving: *Mucuna pruriens* were weighed into a 250 mL beaker and covered with allumnium foil and then placed in an autoclave for 15 minutes. The autoclave had a temperature of 121 ^{0}C and pressure of 15 Kgf/cm^2. After removal from the autoclave, the sample was allowed to cool for 5 minutes before milling.

Proximate analysis and in vitro gas production procedures

For each treatment, four replicates were collected for chemical analyses and values obtained used for statistical analysis. Dried milled samples of the treated seeds were analysed for their proximate composition using the procedure of AOAC (1990) at the Department of Animal Science, University of Ibadan, Nigeria. The *in vitro* gas production was determined as outlined by the procedure of Orskov and McDonald (1979) while Metabolizable energy (ME, MJ/Kg DM) and organic matter digestibility (OMD, %) were estimated as established by Menke and Steingass (1988) and the value of short chain volatile fatty acids (SCFA, mmol/L) was calculated (Getachew *et al*., 1998).

Statistical analysis

Data obtained were subjected to one-way analysis of variance using ANOVA procedure of SAS (1999) version 8. Means were compared using the Duncan Multiple Range Test of the same package.

Results

Proximate composition of treated Mucuna beans

Table 1 shows the proximate composition (% DM) of differently treated *Mucuna pruriens* beans.

The result obtained for dry matter ranged from 78.44 % for raw *Mucuna* beans to 96.97 % for roasted *Mucuna* seeds while that of the autoclaved and boiled beans were 80.19% and 84.36% respectively. The crude protein (CP) content ranged from 30.19% in the autoclaved beans to 36.86% in the roasted beans. It was observed that boiling increased the CP in Mucuna by 8.90% while roasting brought about an increase in the crude protein content (21.20%) of the raw sample. However, the values obtained for boiled and raw beans were 33.14 and 30.41%, respectively. The crude fibre content varied from 13.00% in roasted and raw beans to 15.00% in the autoclaved beans. Autoclaving Mucuna seeds also brought about a 15.38% increase in crude fibre content, 75% increase in ash content and 0.72% reduction in crude protein content of raw Mucuna seeds. The ash content ranged from 4.00% in the raw beans to 7.50% in the boiled beans. The nitrogen free extract ranged from 44.59% (boiled beans) to 51.82% (raw bean).

Table 1: Proximate composition of differently treated *Mucuna pruriens* seeds

	Treatment				
Proximate values (%)	Roasted	Autoclaved	Boiled	Raw	SEM
Dry Matter	96.97^{a}	80.19^{b}	84.36^{b}	78.44^{b}	1.16
Crude Protein	36.86^{a}	30.19^{b}	33.14^{a}	30.41^{b}	1.03
Crude Fibre	13.00	15.00	14.00	13.00	0.07
Ash	4.50	7.00	7.50	4.00	0.03
Nitrogen Free Extract	44.82	47.01	44.59	51.82	0.18

a,b means in the same row followed by the same letter were not significantly different at $p < 0.05$

Table 2: Gas Production at 24 hours of differently treated *Mucuna pruriens*

	Treatment				
Time (Hrs)	Roasted	Autoclaved	Boiled	Raw	SEM
3	3.75^{b}	7.25^{a}	7.75^{a}	5.25^{ab}	0.99
6	4.25^{b}	11.75^{a}	12.50^{a}	10.00^{a}	0.82
9	5.00^{b}	16.50^{a}	12.50^{a}	15.50^{a}	0.01
12	5.75^{b}	20.00^{a}	19.75^{a}	18.00^{a}	1.17
15	7.25^{b}	24.25^{a}	24.75^{a}	23.75^{a}	1.23
18	7.50^{b}	28.25^{a}	28.25^{a}	26.50^{a}	1.43
21	10.00^{b}	32.00^{a}	31.00^{a}	28.25^{a}	1.39
24	11.00^{b}	32.75^{a}	32.25^{a}	29.75^{a}	1.40

a,b Means in the same row followed by the same letter were not significantly different at $p < 0.05$ by Duncan's Multiple Range Test. The data were means of four replications.

***In vitro* gas production**

Presented in Table 2 is the gas production of the variously treated Mucuna beans at 24 hours incubation. Roasted Mucuna beans produced the lowest (P<0.05) amount of gas at all periods of reading when compared with other methods of processing, except at the first reading (i.e. 3 hours), where a slight departure was observed with raw Mucuna. Total gas production at 24 hour for autoclaved, boiled and raw Mucuna beans (32.75, 32.25 and 29.75 mL, respectively) was unaltered (P>0.05) by treatment throughout the period of 24 hours but significantly different from roasted bean (11.00 mL). In addition, gas volume increased with increasing hours for all the treatments signifying a high microbial action on the substrates except for the roasted beans which increased at a slow rate.

Fermentative characteristics of treated Mucuna beans

Table 3 shows the Organic Matter Digestibility (OMD), Short Chain Fatty Acids (SCFA), Metaboizable Energy (ME) and Methane production of the ifferently treated Mucuna beans. The OMD ranged from 42.20 % in roasted beans to 59.95 % in boiled beans. The ME values ranged from 5.71 MJ/kgDM in roasted beans to 8.32 MJ/kgDM in boiled beans. The SCFA values ranged from 0.31 mmoL in roasted beans to 0.84 mmol/L in autoclaved beans. Methane gas values ranged from 7.75 mL in roasted beans to 17.25 mL in boiled beans and this could be due to the digestibility of the treated beans, with roasted beans showing the lowest value. The result of autoclaved, boiled and raw mucuna beans showed no significant difference (p>0.05) in their OMD, SCFA, ME and Methane gas production.

Table 3: Organic matter digestibility, short chain fatty acids, metabolizable energy and methane gas production of differently treated Mucuna pruriens

	Treatment				
Parameter	**Roasted**	**Autoclaved**	**Boiled**	**Raw**	**SEM**
OMD (%)	42.20^{b}	58.94^{a}	59.95^{a}	56.19^{a}	1.29
SCFA (mmol/L)	0.31^{b}	0.84^{a}	0.83^{a}	0.77^{a}	0.03
ME (MJ/kgDM)	5.71^{b}	8.22^{a}	8.32^{a}	7.84^{a}	0.19
Methane (mL/200 mg DM)	7.75^{b}	17.00^{a}	17.25^{a}	17.25^{a}	2.18
A mL	4.25^{b}	7.25^{a}	7.75^{a}	5.25^{ab}	0.85
B mL	6.75^{b}	25.50^{a}	24.50^{a}	24.50^{a}	1.53
A + B mL	11.00^{b}	32.75^{a}	32.25^{ab}	29.75^{ab}	2.98
Y mL	0.19^{b}	0.37^{a}	0.54^{a}	0.50^{a}	0.14
T	19.50^{a}	14.25^{b}	10.50^{b}	13.00^{b}	2.79
C	0.07^{b}	0.05^{b}	0.06^{b}	0.38^{a}	0.10

Means in the same row followed by the same letter were not significantly different at p <0.05 by Duncan's Multiple Range Test. The data are means of four replications. OMD – Organic Matter Digestibility; SCFA – Short Chain Fatty Acid; ME – Metabolizable Energy; Y = volume of gas produced at time 't'; A = intercept (gas produced from the soluble fraction); B = gas production from the insoluble fraction; C = gas production rate constant for the insoluble fraction (b); T = incubation time.

However, the roasted beans recorded the highest ($p<0.05$) incubation time (T) of 19.50 compared with other treatments which had 14.25, 10.50 and 13.00 for autoclaved, boiled and raw beans, respectively. The gas production from the insoluble fraction (b) of the substrate (Mucuna bean) in boiled (24.50 mL) and autoclaved (25.50 mL) Mucuna treatments was similar ($p>0.05$) to that obtained in the raw (24.50 mL) Mucuna seeds. The gas production rate constant for the insoluble fraction (C) in the raw Mucuna seed (0.38) was significantly higher than other treatments (0.05, 0.06 and 0.07) for autoclaved, boiled and roasted beans, respectively).

Discussion

The value obtained for roasted beans was high because the beans were exposed to dry heat for a longer period of time, therefore, a higher percentage of the moisture in such beans were removed. The values of autoclaved, boiled and raw were similar probably due to the similar range of temperature they were exposed to. The crude protein (CP) value obtained for the autoclaved beans was low probably due to the higher temperature at which the processing was done. Mugendi *et al.* (2010) had reported that leaching of protein occurs especially at high temperature and pH and this accounted for the reduction observed in autoclaved beans. The CP were not similar probably due to the different temperatures and the increase in CP by boiling is consistent with the findings of Wanjekeche *et al.* (2003) and was higher than the minimum protein requirement of 10 – 12 % recommended by ARC (1985) for ruminants. The similarity in crude fibre across treatments portends that these different treatments did not significantly affect crude fibre content in the Mucuna beans. The ash values in this study were in contrast with those reported (Ukachukwu and Obioha, 1997), where the pair obtained a reduction in ash and fat contents by soaking and boiling Mucuna seeds in water.

The gas production assessment is used routinely since gas volume is related to both the extent and rate of substrate degradation (Blummel *et al.*, 1997). The low gas production observed for roasted seed could be adduced to insufficient carbohydrate or substrate to break down. The heat of roasting might have rendered the carbohydrate unavailable or burnt. Moreover, the proliferation of microbial content was low due to low CP content thereby affecting the rate of fermentation (Babayemi, 2007).

The low values of fermentative parameters (OMD, ME and SCFA) may be due to high temperature of processing and consequent leaching of nutrients as temperature increased. The differences observed could also be as a result of the duration of processing, processing method and the rumen environment. The OMD in roasted beans was significantly lower than other treatments. The implication is that ruminants will be able to digest Mucuna bean processed in other ways to meet up energy requirements than roasted bean. Furthermore, the use of roasted Mucuna bean as a feed for ruminants is not feasible due too the significantly low potential degradable protein fraction of roasted Mucuna. The heat treatment had rid the bean of all the beneficial nutrients resulting in a product not very different from typically starchy staples and as such having low digestibility. The significantly high incubation time (t) for roasted Mucuna bean when compared to other treatments meant that the low degradable fraction may be difficult to digest therefore, may be available in minute quantities insufficient for production and metabolic purposes. That the results may be attributable to the presence of anti nutrients, as such autoclaving and boiling were better methods of reducing the concentrations in Mucuna when compared to roasting (Laurena *et al.*, (1991); Siddhuraju *et al.*, (1996); Szabo and Tebbett, (2002). The roasted bean had a low digestibility value and not enough substrate for microbes to break down in order to release fatty acid. Therefore, this can be the reason for the low methane gas production. The similarity in effect among autoclaved, boiled and raw Mucuna bean is in agreement with the findings of Siddhuraju and Becker (2001).

Conclusion

Mucuna's high energy content and protein holds possibilities for use as a rich source of energy in the dry season for ruminants as evidenced in the proximate composition of the various treatments applied to Mucuna beans. Boiling and autoclaving beans proved to have improved the gas production and fermentative characteristics when compared with the roasted form.

References

AOAC (1990). Official Methods of Analysis (15th ed.) Association of Official Analytical Chemists, Washington, DC.

ARC Agricultural Research Council (1985). The nutrient requirements of farm animals. No. 2 Ruminants: Technical Review and Summaries. ARC, London, UK.

Ayala- Burgos, A. J., Herrera–Diaz, P. E., Cstillo-Caamal, J. B., Rosado– Rivas, C. M., Osornio–Munoz, L. and Castillo–Caamal, A. M. (2003). Rumen degradability and chemical composition of the velvet bean (*Mucuna spp.*) grain and husk. *Tropical and Subtropical Agroecosystems* 1: 71-74.

Babayemi, O. J. (2007). *In vitro* fermentation characteristics of and acceptability of West African dwarf goats of some dry season forages. *African Journal of Biotechnology* 6: 1260-1265.

Blummel, M., Steingass, H., and Becker, K. (1997). The relationship between *in vitro* gas production, *in vitro* microbial biomass yield and N. incorporation and its implications for the prediction of voluntary feed intake of roughages. *British Journal of Nutrition* 77:911-921.

Burgos, A., Matamoros, I. and Toro, E. (2002). Evaluation of velvet bean (*Mucuna pruriens*) meal and *Enterolobium ciclocarpum* fruit meal as replacement for soyabean meal in diets for dual purpose cows. In: Food and Feed from *Mucuna:* Current uses and the way forward. Proceedings of the Centro Internacional de Information sobre Cultivos de Cobertura (CIDICCO). April 26-29. Workshop, Tegucigalpa, Honduras, pp 228-236.

Carsky, R. J., Tarawali, S. A., Becker, M., Chikoye, D., Tian, G. and Sanginga, N. (1998). Mucuna–Herbacious cover legume with potential for multiple uses. *Resource and Crop Management Research Monograph* 25-54pp.

Castillo-Caamal, J. B., Jimenez-Osornio, J. J., Lopez-Perez, A., Aguilar-Cordero, W., and Castillo-Caamal, A. M. (2003). Feeding velvet bean to small ruminants of Mayan farmers in the Yucatan peninsula, Mexico. *Tropical and Subtropical Agrosystems* 1:113-117.

FAO (2011). Grassland index. A searchable catalogue of grass and forage legumes. Retrieved from: http://www.fao.org/ag/AGP/AGPC/doc/GBASE/Default. Retrieved 25 May 2017.

Getachew, G., Blummel, M., Makkar, H.P.S., and Becker, K. (1998). *In vitro* gas measuring technique for assessment of nutritional quality of feeds: A review. *Animal Feed Science and Technology* 72: 261-281.

Laurena, A., Rodriguez, F. M., Sabino., N. G., Zamora, A. F., and Mendoza, E. M. T. (1991). Amino acid composition, relative nutritive value and in vitro digestibility of several Philippine indigenous legumes. *Plant, Food and Human Nutrition* 41: 69-68.

Menke, K. H. and Steingass, H. (1988). Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. *Animal Research and Development* 28: 7 – 55.

Mugendi, J. B., Njagi, E. N. M., Kuria, E. N., Mwasaru, M. A., Mureithi, J. G. and Apostolides, Z. (2010). Effects of processing technique on the nutritional composition and anti-nutrient content of Mucuna bean (*Mucuna pruriens* L.). *African Journal of Food Science* 4(4): 156 – 166.

Ørskov, E. R. and McDonald, I. (1979). The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *Journal of Agricultural Science* 92: 49–503.

Osei – Bonsu, P., Buckles, D., Soza, F. R. and Asubin, J. Y. (1995). Traditional food uses of *Mucuna pruriens* and *Canavalia ensiformis* in Ghana. CIMMYT Internal Document. CIMMYT, Mexico, D. F. Sp.

Sandoval-Castro, C. A., Herrera, P., Capetillo, L. and Ayala, B. A. J. (2003). *In vitro* gas production and digestibility of Mucuna bean. *Tropical Subtropical Agrosystems*. 1: 77-79.

SAS. (1999). Statistical Analysis System. SAS Institute Inc., Raleigh, New Cary, USA.

Siddhuraju, P., Vijayakumari, K., and Janardhanan, K, (1996). Chemical composition and protein quality of the little – known legume, velvet bean (*Mucuna pruriens*). *Journal of Agriculture and Food Chemistry* 44: 2636-2641.

Siddhuraju, P. and Becker, K. (2001). Effect of various domestic processing methods on antinutrients acid *in vitro* protein and starch digestibility of two indigenous varieties of Indian pulse, *Mucuna pruriens* var. utilis. *Journal of Agriculture and Food Chemistry* 49, 3067.

Szabo, N. J. and Tebbett, I. R. (2002). The chemistry and toxicity of *Mucuna* species. In: B. M. Flores, M. Eilitta, R. Myhrman, L. B. Carew and R. J. Carsky (Eds), Food and Feed from *Mucuna:* Current uses and the way forward. Proceedings of the Centro Internacional de Information sobre Cultivos de Cobertura (CIDICCO) Workshop, Tegucigalpa, Honduras, pp 120 – 141.

Ukachukwu, S. N. and Obioha, F. C. (1997). Chemical composition of *Mucuna cochinchinensis* as alternative protein feedstuff. *Journal of Applied Chemistry*. 4: 34 – 38.

Versteeg, M. N., Amadji, F., Eteka, A., Gogan, A., Koudokpon, V. (1998). Farmer's adoptability of Mucuna fallowing and agro forestry technologies in the Coastal Savannah of Benin. *Agricultural Systems* 56: 3: 269-287.

Wanjekeche, E., Wakasa, V. and Mureithi, J. G. (2003). Effect of alkali, acid and germination on nutritional composition and antinutritional factors of *Mucuna* (*Mucuna pruriens*). In *Mucuna's* potential as a food and feed crop (Proceedings of an international workshop held September 23-26, 2002, in Mombasa, Kenya). *Tropical and Subtropical Agrosystems*. 1: 183-192.