The Effect of Processing Method of Dolichos Bean (*Lablab purpureus L. Sweet*) on the Digestibility and Performance of Growing-finishing Pigs

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Abstract

A 4 x 4 Latin square experiment was carried out using 4 bancows to investigate the effect of processing method on the digestibility of nutrients of dolichos beans and nitrogen retention in pigs. Four diets were formulated to contain the control diet with 0.09 soybean meal or 0.33 of the control diet and 0.67 of each of either raw, boiled or roasted dolichos bean meal in diets I, II, III and IV, respectively. In onother experiment, four diets were formulated such that 0.18 of raw (Diet 2), boiled (Diet 3) or roasted (Diet 4) dolichos bean meals replaced the 0.09 soybean meal contained in the control (Diet 1). These diets were ded to 12 female and 12 castrated male pigs in a 4 x 2 factorial arrangement. Feed intake, growth performance and slaughter characteristics were evaluated. Mean values of crude protein digestability and nitrogen retention in the raw dolichos meal (50.6% and 18g/d) were relatively lower than in the processed meals ($p \leq 0.05$). The corresponding values for boiled dolichos meal were higher ($p < 0.05$) than those of roasted meal (73.6% versus 65.2% and 12.8g/d versus 8.7g/d). Animals fed on the raw dolichos diet (Diet 2) had significantly lower growth rates and poorer feed conversion ratio. The two parameters were improved on the animals fed on heat-treated dolichos diets. It was concluded that thermo-processing, particularly boiling greatly improved nutrient availability and overall utilisation of dolichos bean meal for pigs.

Keywords: Dolichos bean, processing, pigs, digestibility, growth

Introduction

Dolichos bean (*Lablab purpureus L. Sweet*) is a grain legume crop closely related to members of the genera *Phaseolus*, *Vigna* and *Stozolobium* (Muldoon, 1985). Dried dolichos beans are invariably not commonly used as human food. This is due to poor cooking characteristics, low protein quality associated with low profile of sulphur containing amino acids and high levels of antinutritional factors (Muldoon, 1985; Pawar and Ingle, 1987). Dolichos beans, however, may alternatively be used as protein source for pigs after being treated.

Cooking, germination, fermentation, infrared cooking, microwave processing and dielectric heating have been advocated as methods capable of destroying most of the antinutritional factors present in legume seeds.

There is a general consensus that trypsin inhibitors and haemagglutinins are

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reduced to harmless levels by boiling and other heat treatments (Grant *et al.*, 1982). For inactivation of proteinaceous antinutritional factors (ANF) hydrothermal processing seems to be more effective than dry heat applications (van der Poel, 1990), since the integral structure of the protein is affected in the presence of moisture, thus initiating proteolysis. Working with piglets, van der Poel *et al.* (1991) reported that steam heating of beans improved ileal digestibility of dry matter, nitrogen and lysine.

There is scarce information on the possible changes in susceptibility of dolichos bean protein to proteolysis after different heat processing methods. This study was planned to evaluate the effect of boiling and roasting dolichos beans on nutrient digestibility and growth performance of growing pigs.

Materials and Methods

Experiment 1: A 4x4 Latin square experiment involving four types of diets fed to four castrated pigs, in a change over design was employed. Diet 1 was the control, formulated as shown in Table 1. The other diets were composed of proportionately 0.67 of either raw (Diet II), boiled (Diet III) or roasted (Diet IV) dolichos bean meal, the other portion (0.33) being Diet 1. Dolichos beans consisting of different colours (white, brown and black) were purchased from Morogoro Region Co-operative Union. Raw dolichos meal was obtained by milling the raw seeds. Boiled dolichos meal was obtained by initially soaking the raw dolichos bean seeds in cold water for a period of 20 hours. There after the water was drained and the seeds were heated in boiling water for 30 minutes, sun dried and milled. Roasted dolichos bean meal was obtained by dry roasting the seeds in metal pans over wood fire for 15 minutes at a temperature of 100°C and then milled.

Hominy meal (a by-product of dehulled dry milling maize consisting of the bran coating, endosperm and maize germ) was obtained from local mills and air dried before mixing with the other ingredients. De-fatted cotton seed cake was procured from the Morogoro Multipurpose Oil Extraction Plant (MOPROCO). Soybeans were purchased from Morogoro Regional Co-operative Union. The seeds were prepared using procedure adopted for boiled dolichos bean.

Four castrated male pigs with mean initial weight 23 kg were placed in individual metabolic cages and the four diets were offered to each in rotation. The experimental protocol comprised of five-day preliminary and seven-day collection periods. Daily feed allowance was set at 600 g per pig and was offered twice a day, at 0900 and 1500h. Drinking water was available throughout. Total faeces and urine were collected daily, weighed and recorded. All faeces were bulked and stored at -4°C. The urine was collected under 20 ml preservative medium (25 ml of 98% H_2SO_4 and 74.9 g $CuSO_4$ into a litre of distilled water). Ten percent of the urine was bulked and stored at -4°C. At the end of each collection period samples of the diets, faeces and urine were taken for chemical analysis.

Experiment 2: Twelve castrated male and 12 female pigs, of Landrace x Large White crosses, with average initial weight of 30 kg were randomly assigned to four diets in a 4 x 2 factorial experiment. Diet 1 was the same as the control diet in Experiment 1. Diets 2, 3 and 4 were formulated to contain 0.18 of raw, boiled and roasted dolichos bean meals, respectively (Table

Table 1: Composition of the experimental diets used in the growth study

	Dietary treatment			
Component	1	2	3	4
Physical composition (%)				
Hominy meal	82.8	72.0	72.0	72.0
Cotton seed cake	5.0	6.7	6.7	6.7
Soybean meal	9.0	0.0	0.0	0.0
Dolichos bean meal:				
Raw	0.0	18.0	0.0	0.0
Boiled	0.0	0.0	18.0	0.0
Roasted	0.0	0.0	0.0	18.0
Fish meal	0.9	1.1	1.1	1.1
Min.-vit. Premix	2.0	2.0	2.0	2.0
Lysine	0.2	0.1	0.1	0.1
Methionine	0.1	0.1	0.1	0.1
Calculted nutrient composition (%)				
Crude protein	15.69	15.5	15.50	15.50
Crude fibre	4.70	5.10	5.10	5.10
Lysine	0.75	0.75	0.75	0.75
Methionine	0.42	0.42	0.42	0.42

1). The diets were balanced to be iso-nitrogenous (15.5% CP) and iso-calorific (12.6 MJ ME/kg).

The animals were housed individually and fed according to a scale 2.5 x MEm, where MEm was 719 kJ ME/kg $W^{0.63}$ (ARC, 1981). The daily allowance was offered twice daily, at 0900h and 1500h. Daily feed intake and weekly body weights were recorded for a period of 14 weeks, after which the animals were slaughtered. After slaughter the body was dehaired and eviscerated. Hot carcass weight was taken as the weight of the carcass excluding the head, hocks and visceral organs, except kidney and flare fats. Since the animals were slaughtered at different live weights, all carcass records were corrected to 90 kg slaughter weight using covariance analysis.

Proximate analysis of the feed ingredients, diets and faeces was performed following the standard procedures of AOAC (1990). Urine was analysed for nitrogen content only. Phosphorus contents were determined using the Hitachi Model Colour Spectrophotometer. Calcium was determined using the Ion Electrode (Ion 83 Ionmeter) from Denmark.

Results

Experiment 1: Heat processing slightly reduced CP content of the dolichos meal (Table 2). Crude protein and ether extract contents were higher and CF was

Table 2: Chemical composition of the feed ingredients and experimental diets used in the digestibility study and growth study

	Components (% DM)								
	DM	OM	CP	CF	NFE	EE	Ash	Ca	P
Feed ingredient									
Raw dolichos	94.0	88.8	30.5	12.6	48.5	3.2	5.2	1.2	0.3
Boiled dolichos	94.1	89.3	28.7	12.3	52.8	1.4	4.8	1.4	0.4
Roasted dolichos	94.4	89.2	28.6	12.4	52.5	1.3	5.2	0.7	0.3
Boiled soybean	95.5	89.3	41.5	5.9	36.5	9.9	6.2	1.7	0.6
Defatted cotton seed cake	94.1	87.4	35.1	23.7	31.7	2.8	6.7	1.0	0.3
Fish meal	94.1	78.2	65.8	0.0	8.8	9.5	15.9	4.0	2.7
Hominy meal	93.3	86.3	13.6	8.4	62.0	9.0	7.0	1.7	1.1
Diets used in Digestibility experiment									
I	93.5	86.4	19.5	8.7	54.9	9.9	7.0	3.3	1.3
II	92.3	87.2	25.0	11.7	53.6	4.6	5.1	1.3	0.5
III	92.0	86.9	25.6	12.3	51.7	5.3	5.1	1.6	0.5
IV	92.5	86.7	25.7	11.7	52.3	4.5	5.8	1.9	0.6
Diets used in growth study									
1	93.5	86.4	19.5	8.7	54.8	9.9	7.0	3.3	1.3
2	93.5	86.7	19.7	12.0	52.3	9.2	6.8	1.9	1.1
3	93.3	86.9	19.3	12.2	52.9	9.2	6.4	2.3	2.3
4	93.0	86.1	19.7	12.2	52.1	9.1	6.9	2.2	0.9

lower in soybean than dolichos beans. Replacement of 0.67 of Diet 1 by equal amounts of raw, boiled and roasted dolichos meals in diets II, III and IV respectively increased crude protein and crude fibre contents of the diets, relative to the control diet. The digestion coefficients for all the fractions were significantly ($P < 0.05$) higher for the control diet (Diet 1) compared with dolichos meals (Table 3). Dry matter and organic matter digestibility values of raw dolichos meal were lower ($P < 0.05$) than values for boiled and roasted meals. The mean difference between boiled and roasted dolichos meals was however not significant. Crude protein digestibility was highest for boiled dolichos meal, followed by roasted meal and lowest in the raw dolichos meal ($P < 0.01$).

Although the animals were fed restrictedly (600 g/d), those on raw dolichos bean meal diets did not finish their allowance (intake was about 50%). Nitrogen intake by this group was significantly lower than their counterparts ($P < 0.001$). Pigs fed on boiled dolichos meal (Diet III) retained more nitrogen compared with those on the other diets (Table 4). There was no significant difference on nitrogen retention between animals

Table 3: The effect of processing on the apparent digestibility coefficients (%) of Diet 1 and the different forms of dolichos bean meal

	Diet 1	Dolichos meal [1]				
		Raw	Boiled	Roasted	SED	Sign
DMD	71.43^{ab}	54.51^{b}	66.87^{ab}	66.76^{ab}	4.34	*
OMD	81.77^{a}	61.16^{c}	70.43^{b}	71.81^{b}	0.75	***
CPD	77.07^{a}	50.63^{d}	73.63^{b}	65.22^{c}	1.94	***
CFD	48.78^{a}	29.64^{c}	44.78^{b}	47.12^{b}	1.02	***
EED	82.77^{a}	57.71^{c}	74.69^{b}	76.09^{b}	1.01	***
NFE	88.41^{a}	69.97^{c}	77.52^{b}	78.86^{b}	1.13	***
DE (MJ/kg DM)	14.86^{a}	10.0^{d}	12.12^{b}	11.47^{c}	0.20	***

[1] In this and subsequent tables; a,b, c and d mean within rows bearing different superscript letters are significantly different ($p<0.005$). *, *** $p< 0.005$ and $p < 0.001$, respectively. [1]Values derived from digestibility of Diet 1.

TABLE 4: The effect of processing on the nitrogen utilisation by the animals fed on diets containing different forms of dolichos bean meal

	Experimental Diets				SED	Sign
Parameter (g/d)	I	II	III	IV		
Nitrogen intake	17.5b	11.9c	23.5a	22.9a	0.4	***
Faecal-Nitrogen	3.4c	3.3c	4.4b	5.1a	0.2	***
Urinary-Nitrogen	4.8b	6.7a	6.3ab	9.0a	0.3	***
Nitrogen retention	9.2b	1.8c	12.8a	8.7a	2.3	***
N-retained/N-intake (%)	52.9a	15.5c	54.3a	38.3b	6.3	***

fed the control diet (Diet 1) and those on the roasted dolichos meal (Diet IV). Pigs fed Diet II had significantly lower nitrogen retention (1.8 g/d) and efficiency of nitrogen utilisation (15.5%) than those on the other diets ($P<0.05$). On the other hand, the efficiency of nitrogen utilisation was poorer (38% versus 54%) in animals offered roasted compared with those offered boiled dolichos meal ($P<0.05$). The latter value was not significantly different from that of the control diet (53%).

Experiment 2: The chemical composition of the diets used in the growth study is also shown in Table 2. Except for crude fibre and calcium contents, the chemical components of the four diets were similar. Crude fibre content was higher and calcium was lower in the diets containing dolichos (diets 2, 3 and 4) than in the control diet.

Table 5 shows the effect of dietary treatments on the growth performance of the pigs. There was no significant difference or interaction between sex and diets in all the growth parameters studied. Animals offered the control diet (Diet 1) had significantly higher average daily gain than those given the diets with dolichos meal ($P<0.05$). Animals fed raw dolichos

Table 5: Effect of dietary treatments on the growth performance of the pigs

Parameter	Dietary Treatment				
	1	2	3	4	SED
No. of animals	6	6	6	6	
Initial weight (kg)	35.5	30.4	28.8	33.8	2.2NS
Final weight (kg)	71.4^{a}	36.2^{c}	55.4^{b}	57.9^{b}	3.6***
Daily gain (kg/d)	0.41^{a}	0.06^{c}	0.29^{b}	0.30^{b}	0.02***
Feed intake (kg/d)	2.0^{b}	1.1^{c}	1.5^{b}	1.7^{ab}	0.1***
Feed/gain	4.9^{a}	18.3^{b}	5.2^{a}	6.6^{a}	8.9*

meal (Diet 2) had the poorest average body weight gain compared with those on the processed dolichos beans (diets 3 and 4). Average body weight gain was not significantly different between animals fed boiled (Diet 3) and roasted (Diet 4) dolichos beans.

Although the pigs were fed restrictedly, pigs on raw dolichos meal (Diet 2) did not finish their ration offered, thus feed intake was lower ($P < 0.001$) in this group (Table 5). Feed intake of pigs fed roasted dolichos meal (Diet 4) was not significantly different from those fed boiled dolichos meal (Diet 3) and those on the control (Diet1). Feed: gain ratio was higher ($P < 0.05$) in the animals fed raw dolichos meal (Diet 2) compared with those on the other diets. The differences between animals on the other diets were not significant.

Carcass parameters were not significantly affected by dietary treatments, except for the significantly lower kidney fat and higher jowl, heart and thyroid gland weights of animals fed Diet 2 ($P < 0.05$) than those on the other treatments (Table 6).

Discussion

The mean crude protein value of dolichos meal obtained in the present study agreed with the 30% CP reported by Gohl (1981). The slightly lower values of CP observed on the processed dolichos meals compared with the raw meal could be due to losses of some nitrogenous compounds during processing.

The relatively lower DM digestibility of raw dolichos meal than the processed meals is attributed partly to the effect of antinutritional factors (ANF) present in the raw bean (Lambourne and Wood, 1985). Although the ANF were not measured in the present study, Jaffe and Vegalette (1968) reported the level of trypsin inhibitor in dolichos seeds to be 4.38 units/gm, being the highest among the legume seeds. The low protein bio-availability in raw legume seeds has been associated with high content of storage proteins, which are resistant to proteolysis and the presence of fibre, tannin and phenolic compounds (Singh and Eggum, 1984). Improvement in the digestibility of crude protein with heat treatment observed in the present study is in agreement with other studies (Singh and Eggum, 1984 and van der Poel, 1990). Bacon (1988) explained the mechanism by which toxic prop-

Table 6: The mean effects of sex and treatment on carcass characteristics of pigs (corrected to 90 kg slaughter weight)

Component	Dietary treatment				
	1	2	3	4	SED
Carcass component					
Carcas weight (kg)	64.4	63.8	65.4	65.6	0.6
Dressing percentage	71.7	70.8	72.6	72.9	0.8
Carcass length (cm)	96.0	96.2	95.6	94.3	3.2
Backfat thickness (cm)	38.9	38.1	41.1	38.8	1.6
Loin eye area (cm^2)	33.5	30.9	33.9	32.8	0.3
Ham weight (kg)	8.5	8.5	8.5	8.5	0.2
Loin weight (kg)	7.0	6.9	7.3	6.7	0.2
Jowl weight (kg)	1.4b	1.8a	1.6ab	1.5ab	0.1**
Kidney fat weight (kg)	1.3a	0.6b	1.1a	1.0a	0.1*
Non-carcass Components (kg)					
Head	5.4	5.8	5.4	5.55	0.2
Heart	0.38bc	0.55a	0.44b	0.44b	0.03*
Spleen	0.10ab	0.09ab	0.10ab	0.11a	0.004*
Kidney	0.09	0.09	0.08	0.087	0.004
Thyroid	0.01b	0.02a	0.01b	0.01b	0.002*
Liver	1.1	0.8	1.0	1.1	0.1

erties including ANF of legume proteins are destroyed by heat. Temperatures around boiling point cause irreversible disorganisation of the protein structures, particularly in the membrane, so that their tertiary structures are note regained after cooling. The effectiveness of boiling over roasting in CP digestibility agrees with the view that for inactivation of proteinaceous ANF hydrothermal processing appears to be more effective than dry heat application (van der Poel *et al.*, 1991).

The exceedingly high faecal nitrogen excretion from animals fed on raw dolichos diet (Diet II) in the present study may partly be attributed to the relatively lower digestibility of raw dolichos protein. This is probably accentuated by the action of trypsin inhibitor present in raw dolichos bean seeds as reported by Jaffe and Vegalette (1968) and Griffiths (1984). There was also a possibility of high levels of metabolic faecal nitrogen excretion due to presence of lectins, which are reported to be high in raw pulses (Pusztai et al., 1981 and Grant *et al.*, 1982). Lectins are known to cause increased cell permeability to plasma proteins and this may increase losses of plasma proteins into the gut (van der Poel and Huisman, 1988).

The poor growth performance of animals fed raw dolichos diet (Diet 2) may be attributed to lower protein utilisation manifested by relatively lower nitrogen bal-

ance. Griffiths (1984), Lambourne and Wood (1985), Muldoon (1985) and Pawar and Ingle (1987) demonstrated that loss in endogenous amino acids increases the deficiency in essential amino acids, thus explaining the reduction in growth performance of pigs fed raw pulses rich in antinutritional factors. These factors were associated with the observed decreased digestibility, feed intake and consequently retarded growth.

The positive influence of processing on feed intake, efficiency of feed utilisation and growth rate agrees with the results reported by van der Poel (1990). This might also be attributed to optimal processing conditions, although more work is needed to evaluate time and temperature of processing, which ensures better results. The significantly lower mean growth performance of animals fed the processed dolichos meal compared with those offered the control diet (Diet 1) might also be due to relatively better quality of soybean protein as compared to dolichos bean protein.

The relatively lower mean carcass weight and dressing percentage of animals fed on raw dolichos diet (Diet 2) relative to those on the other treatments is attributed to the significantly poor growth performance observed in this group. The significantly heavier heart and thyroid glands of the pigs fed Diet 2 than those on the other diets agrees with the results of Boisen (1983), who reported cases of hyperplasia of the pancreas and spleen in animals offered raw legume protein. The high weight of the thyroid gland might be due to poor iodine utilisation induced by combined effects of various antinutritional factors (ANF) as Liener and Kakade (1980) reported poor utilisation of trace mineral elements resulting from effects of ANF activity in raw legume protein. Busato *et al.* (1991) associated the enlargement of the thyroid gland, a condition known as goitre, to the effects of glucosinolates present in raw legume seeds.

Conclusion

It can be concluded that raw dolichos meal is unsuitable for growing-finishing pigs. Dolichos beans need to be heat processed before its inclusion in pig diets in order to improve its nutrient availability and overall utilisation. More work is however needed to evaluate the optimum time and temperature of processing and level of inclusion of heat processed dolichos seed in the pig diets.

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