Iranian Journal of Applied Animal Science

Nutrient Intake and Digestibility by West African Dwarf (WAD) Sheep Fed Graded Levels of Pigeon Pea Seed Meal

Research Article

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Received on: 20 Jan 2012
Revised on: 15 Apr 2012
Accepted on: 1 May 2012
Online Published on: Jun 2013

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Online version is available on: www.ijas.ir

ABSTRACT

A study was carried out to evaluate nutrient intake and digestibility by West African Dwarf (WAD) sheep fed graded levels of dietary pigeon pea seed meal (PSM). Four diets designated A, B, C and D were formulated to contain 0, 10, 20, and 30% levels of PSM, respectively. Four WAD rams aged between 15 and 17 months and weighing between 16 and 19 kg were used to conduct digestibility study in a 4 × 4 latin square design experiment. Data were collected on dry matter intake (DMI), nutrient intake and digestibility. Simple linear regression and correlation were used to assess relationships between some of the digestion components. There were no significant (P>0.05) differences in DMI among the treatment means. The nitrogen intake (g/d) was significantly (P<0.05) higher in the animal group fed PSM based diets rather than in the control group. Fecal nitrogen, though higher in the animals fed diets C and D, did not differ significantly (P>0.05). Urinary nitrogen was significantly (P<0.05) higher in the group fed PSM diets than in the control group. Apparent-nitrogen digestibility was also significantly (P<0.05) higher in the treatment groups fed PSM diets than in the control group. The metabolic faecal nitrogen (MFN) and the endogenous urinary nitrogen (EUN) increased by increasing levels of PSM. The biological value (BV) and digestible crude protein (DCP) also increased significantly (P<0.05) by increasing dietary levels of PSM. The results of this study indicated that dietary boiled pigeon pea seed meal enhanced digestibility and nutrient utilization by West African Dwarf sheep accompanying with the highest N-balance at 20% level of PSM.

KEY WORDS digestibility, meal, nutrient intake, pigeon pea, ram.

INTRODUCTION

The increase in world population especially in developing countries like Nigeria calls for urgent improvement in livestock production. Deficiency of animal proteins in human diets is one of serious nutritional problem that needs urgent intervention in Nigeria and other African countries. Sheep are among the most important livestock species in Nigeria with an estimated population of approximately 23 million heads (FAO, 2006). There is large market for sheep and goats in the Southern Nigeria; hence there is mass importation from the North of the country due to inadequate number of sheep and goat in the south (Okali and Lipton, 1984). Conventional protein and energy feedstuffs are expensive and their use in ruminant nutrition competes with monogastric animals and human nutrition. There is need to address this problem of scarce feed resources in ruminant nutrition, especially protein concentrates. This can be achieved by searching for alternative protein feedstuff that attracts less competition from monogastric animals and humans. Raw pigeon pea seed are rich in protein (18.5-31.1%) and carbohydrate (36.0-66.0%) depending on the variety, which includes biological value ranging from 61.6-69.8% (raw seed) and 62.4-76.6% (dhals) (Basit Ali Shah, 1991).

The high protein genotypes contain significantly higher (about 25%) sulphur-containing amino acids, namely methionine and cystine as well as a good source of dietary minerals such as calcium, phosphorus, magnesium, iron, sulphur and potassium (Singh *et al.* 1990).

According to the same authors (Singh *et al.* 1990) pigeon pea has also a good source of water-soluble vitamin, especially thiamine, riboflavin, niacin and cholines. However, pigeon pea seeds contain anti-nutritional factors like trypsin, chymotrypsin, polyphenolic compounds (Ani and Okeke, 2003) and hemagglutinin (Amaefule, 2002; Akinmutimi, 2004) and even tannins (Ene-Obong, 1985). These substances tend to form complexes with protein thereby hindering protein utilization by the animals (Ani and Okeke, 2003).

However, heat treatment has been found to improve and reduce the anti-nutritional factors in the seeds thereby improving nutrient utilization by poultry (Akinmutimi, 2004). Although pigeon pea seed meal, as an alternative and cost effective feedstuff, is used in monogastric animals feeding trials, there is still paucity of information on its use for sheep nutrition.

Also there is no information about other cost effect processing strategy that would overcome anti-nutritional factors found in pigeon pea seeds especially in ruminant nutrition. It is hypothesised that boiling could be an effective procedure for overcoming detrimental effects of these anti-nutritional factors. This study was therefore designed to evaluate the digestibility and nutrient utilization in West African Dwarf sheep fed graded levels of dietary boiled pigeon pea seed meal.

MATERIALS AND METHODS

Location

This study was carried out in the Sheep / Goat Unit of the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, Abia State of Nigeria, latitude 05˚ 28´ North and longitude 07˚ 31´ East, and altitude of 122 meters above sea level. It lies within the tropical rainforest zone characterized by average annual rainfall of 2,177 mm in 148-155 rain days. Average ambient temperature is 25.5 ˚C with minimum and maximum temperatures of 22 ˚C and 29 ˚C, respectively. Relative humidity ranged from 76 to 87% (NRCRI, 2004).

Procurement and processing of experimental material

The pigeon pea seed used in this study was purchased from open markets in Enugu, the Capital of Enugu State. The pigeon pea seeds were cleaned up by winnowing, and the clean seeds boiled for 30 minutes at about 100 ˚C as earlier reported by Kaankuka *et al.* (2000). Boiling the seeds was aimed at reducing heat labile anti-nutritional factors. The seeds were then dried on a concrete floor for 3 days before milling in a grinding machine to cracked sizes of 2-4 parts / seed.

Experimental diets

The processed pigeon pea seeds were used to formulate four diets, at 0, 10, 20 and 30% levels designated A, B, C and D, respectively. The ingredients and composition of the experimental diets are shown in Table 1.

Experimental animals, design and management

Four mature WAD rams weighing between 16.0 and 19.0 kg were used in the study. The rams were selected from the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike. The animals were first dewormed and also bathed with acaricide against external parasites, using Ferbendazole and Pfizona, respectively. They were subsequently housed in previously disinfected metabolism cages. Each animal was randomly allocated to one of the experimental diets (Table 1) in a 4 × 4 Latin square design. The experiment consisted of 4 phases each lasting 28 days during, which the first 21 days were preliminary period followed by 7 days of metabolism study. Each animal was rotated through the experimental diets such that at the end of the study, each animal had been fed on all of the diets. During the feeding, each animal received 1 kg of one of the experimental diets. Potable water was offered *ad libitum* to each animal daily. Daily voluntary feed intake was determined by weighing the quantity offered and the refusal. During metabolism trial, total feed offered, feed leftover, faecal and urinary outputs were measured prior to feeding in the morning. Feed, refusal and faecal samples were then sub-sampled (50 g) after through mixing. Part of the sub-sample was placed in draft oven at 100 ± 5 ˚C for 48 hr for DM determination. Another part of the sub-sample was dried at 60 ˚C for 48-72 hours for determination of proximate composition.

Total urine for each animal was collected daily during metabolism trial in a graduated transparent plastic container containing 15 mL of 25% H_2S0_4 to reduce volatilization of ammonia from the urine. The total volume of urine output per animal was measured and about 10% of it was sampled in plastic bottles and stored in deep freezer at -5 ˚C. At the end of each 7 day collection period, the feed, faeces and, urine samples collected were bulked for each animal and sub-samples taken for analysis.

Analytical procedure

Feed and faecal samples were analyzed for proximate composition (AOAC, 1990). Nitrogen (N) in urine samples was also determined according to AOAC (1990).

Table 1 The Composition and proximate constituents of experimental diets and pigeon pea seed meal

Ingredients (%)	A	B	C	D	PSM
Cassava peel	52.50	52.50	52.00	45.50	-
Pigeon pea	0.00	10.00	20.00	30.00	-
Maize offal	35.50	25.50	16.00	12.50	-
Palm kernel cake	10.50	10.50	10.50	10.50	-
Bone meal	1.00	1.00	1.00	1.00	-
Common salt	0.50	0.50	0.50	0.50	-
Total	100.00	100.00	100.00	100.00	-
Analysed chemical composition (% DM)					
DM (%)	87.00	87.10	86.70	86.60	93.16
CP	6.80	7.20	8.37	9.54	20.50
CF	9.27	9.93	11.96	10.13	6.52
EE	1.31	2.18	1.30	2.17	2.42
Ash	6.53	7.40	5.64	6.50	4.24
NFE	63.09	60.39	59.43	58.26	59.48
* ME (MJ/kg DM)	1.50	1.51	1.52	1.53	1.74

DM: dry matter; CP: crude protein; CF: crude fibre; EE: ether extracts; NFE: nitrogen free extract and ME: metabolizable energy.
PSM: pigeon pea seed meal.
* Calculated.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) applicable to a 4 × 4 Latin square experiment (Steel and Torrie, 1980). Differences between treatment means were determined by Duncan's multiple range test (SAS, 1996). Relationships between the faecal-N and N-intake, between absorbed-N and urinary-N, and between N-balance and absorbed-N were carried out to obtain metabolic faecal nitrogen (MFN), endogenous urinary nitrogen (EUN), and BV and DCP, respectively (SAS, 1996). The intercept on the ordinate axis gives the nitrogen excreted in faeces for the diets. When the nitrogen intake is hypothetically zero, the excreted nitrogen is the metabolic faecal nitrogen (MFN) (Akinsoyenu, 1974). The intercept on the Y-axis (urinary-N) with absorbed-N (X) gives the urinary nitrogen value at zero nitrogen absorption, which is the endogenous urinary nitrogen (EUN) (Akinsoyenu, 1974). The gradients of lines relating N-balance to N-absorbed are the indices of biological value (BV), while the N-absorbed at zero N-balance when multiplied by 6.25 gives the digestible crude protein (DCP) requirement for maintenance (Mba *et al.* 1975).

RESULTS AND DISCUSSION

The nutrient composition of the experimental diets is presented in Table 1. The dry matter intake (DMI), nutrient intake and digestibility by WAD sheep fed graded levels of dietary pigeon pea seed meal are presented in Table 2.

The DMI expressed as percentage body weight was higher ($P<0.05$) in the group fed the pigeon pea diets than those on the control diet. Nitrogen intake was significantly ($P<0.05$) higher for the PSM diets than the control diet. Nitrogen output in faeces and urine were increased with increased N-intake except for diet B.

The urinary nitrogen values were significantly ($P<0.05$) influenced by dietary pigeon pea seed meal. The N-balance (g/d) of sheep in all the treatment groups was similar ($P>0.05$) but numerically higher for diet C. Nitrogen absorption and digestibility by sheep from diets A to D increased according to its total intake. All the PSM diets recorded significantly ($P<0.05$) higher absorbed-N than the control. Faecal-N (g/kg DM) was positively correlated with N-intake (g/d) (Table3).

The coefficients of correlation(r) between faecal-N and N-intake showed the MFN values for each of the diets. The values of MFN ranged from 0.071 to 0.095 g/100 g DM, and increased with increasing nitrogen intake from diet A to D. The relationship between urinary-nitrogen (g/day/W $kg^{0.75}$) and absorbed nitrogen (g/d/W $kg^{0.75}$) in this study is presented in Table 4.

The absorbed-N and the urinary-N showed positive correlation for all the diets, A to D, and significantly differed at various levels of probability. Absorbed nitrogen of diets C and D were the highest (Table 2) as well as were highly correlated ($P<0.001$) with the urinary nitrogen. The intercept on the Y axis gave the urinary nitrogen value at zero nitrogen absorption, which was the endogenous urinary nitrogen (EUN) in g/d/W $kg^{0.75}$). The EUN values increased as the nitrogen intake increased progressively from animals fed diet A to those fed diet D.

Nitrogen balance (g/d/W $kg^{0.75}$) was linearly and positively correlated with absorbed nitrogen (g/d/W $kg^{0.75}$) as shown in Table 5.

The BV obtained for WAD sheep in this study ranged from 54-76. The calculated DCP (g/d/W $kg^{0.75}$) in this study were 0.51, 0.58, 0.81 and 0.84% for diets A, B, C and D, respectively, with a mean of 0.69 ± 0.17.

Dry matter and nutrient digestibility coefficients are presented in Table 6.

Table 2 Feed intakes and nitrogen balance in WAD sheep fed graded levels of dietary pigeon pea seed meal

Parameters	Diets				SEM
	A	B	C	D	
Mean wt.(kg)	17.75	17.63	18.00	17.88	0.18
Mean wt. (W $kg^{0.75}$)	8.65	8.60	8.74	8.69	0.06
DMI (g/d)	532.88	553.45	574.39	557.49	23.61
DMI (W $kg^{0.75}$)	61.73	64.64	65.93	64.23	2.47
DMI as % BW	3.01	3.16	3.21	3.13	0.12
CP intake (g/d)	36.24^{b}	39.85^{b}	48.12^{a}	53.19^{a}	1.74
Total N-intake (g/d)	5.80^{b}	6.38^{b}	7.70^{a}	8.51^{a}	0.28
N-intake (g/d/W $kg^{0.75}$)	0.67^{c}	0.74^{c}	0.89^{b}	0.98^{a}	0.03
Faecal-N (g/d)	2.51	2.15	2.62	2.74	0.23
Urinary-N (g/d)	0.69^{c}	1.14^{bc}	1.41^{b}	2.48^{a}	0.14
N-balance (g/d)	2.60	3.09	3.67	3.29	0.34
N-balance (g/d/W $kg^{0.75}$)	0.31	0.36	0.42	0.38	0.04
Absorbed-N (g/d)	3.29^{c}	4.23^{b}	5.08^{ab}	5.77^{a}	0.26
Absorbed-N (g/d/W $kg^{0.75}$)	0.38^{c}	0.49^{b}	0.58^{ab}	0.66^{a}	0.03
Apparent-N digestibility (%)	56.20^{b}	65.82^{a}	66.42^{a}	68.06^{a}	2.61

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means; DMI: dry matter intake and CP: crude protein.

Table 3 Regression analysis and correlation coefficient between faecal-N (g/kg/DM) (Y) and N-intake (g/d) (X) in WAD sheep fed graded levels of dietary pigeon pea seed meal

Diets	Regression equation	Correlation coefficient (r)	SE	Intercept on Y-axis	MFN g/100 g
A	Y= 0.713 + 0.084 X	0.588^{ns}	0.081	0.713	0.071
B	Y= 0.793 + 0.067 X	0.329^{ns}	0.390	0.793	0.079
C	Y= 0.930 + 0.052 X	0.323^{ns}	0.277	0.930	0.093
D	Y= 0.950 + 0.043 X	0.190^{ns}	0.296	0.950	0.095

NS: non significant; SE: standard error and MFN: metabolic faecal nitrogen.

Table 4 Regression analysis and correlation coefficient between urinary-N (g/d/W $kg^{0.75}$) (Y) and absorbed-N (g/d/W $kg^{0.75}$) (X) in WAD sheep fed graded levels of dietary pigeon pea seed meal

Diets	Regression equation	Correlation coefficient (r)	SE	Intercept on Y-axis	EUN/d/W $kg^{0.75}$ g/100 g
A	Y= 0.028 + 0.155 X	0.865^{**}	0.070	0.028	0.028
B	Y= 0.061 + 0.247 X	0.951^{***}	0.058	0.061	0.061
C	Y= 0.095 + 0.541 X	0.726^{**}	0.011	0.095	0.095
D	Y= 0.175 + 0.582 X	0.984***	0.042	0.175	0.175

** (P<0.01); *** (P<0.001); SE: standard error and EUN: endogenous urinary nitrogen.

Table 5 Regression analysis and correlation coefficients between N-balance (g/d/W $kg^{0.75}$) (Y) and absorbed-N (g/d/W $kg^{0.75}$) (X) in WAD sheep fed graded levels of dietary pigeon pea seed meal

Diets	Regression equation	Correlation coefficient (r)	SE	N-absorbed at zero N-balance	Biological value	DCP for maintenance g/d/W $g^{0.75}$
A	Y= 0.081 + 0.540 X	0.957^{***}	0.065	0.081	54	0.51
B	Y= 0.092 + 0.581 X	0.986^{***}	0.058	0.092	58	0.81
C	Y= 0.129 + 0.727 X	0.875^{**}	0.011	0.129	73	0.81
D	Y= 0.134 + 0.758 X	0.994^{***}	0.041	0.134	76	0.84

** (P<0.01); *** (P<0.001); SE: standard error and DCP: digestible crude protein.

Table 6 Apparent digestibility coefficients (%) of WAD sheep fed graded levels of dietary pigeon pea seed meal

Constituents	Diets				SEM
	A	B	C	D	
DM	60.40	68.73	65.13	70.94	3.61
CP	56.27	65.83	66.41	68.05	2.66
CF	57.33^{d}	62.01^{c}	67.05^{b}	70.11^{a}	0.70
EE	66.99^{c}	69.00^{bc}	74.86^{ab}	76.12^{a}	2.32
NFE	65.64	72.19	69.91	76.31	4.10
Energy	63.98^{b}	72.14^{ab}	69.23^{ab}	74.74^{a}	2.86

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
DM: dry matter; CP: crude protein; CF: crude fibre; EE: ether extracts; NFE: nitrogen free extract and SEM: standard error of the means.

Indeed, the ether extract digestibility values increased progressively from diet A to D. The values were 66.99, 69.00, 74.86 and 76.12 percent for diets A, B, C and D, respectively, which were significantly different ($P<0.05$) among the treatment groups. NFE digestibility was not different between treatment groups, although it increased by increasing dietary PSM. Energy digestibility increased as pigeon pea level increased in diets and was significantly ($P<0.05$) higher in diet D rather than diet A.

There were no differences in DMI among the treatment groups (Ahamefule, 2005). Increase in the N-intake is expected to be reflected in an increase in DMI (Ahamefule, 2005). However, in the present study it was not so, indicating there are other unknown factors which control intake. Ahamefule (2005) reported that higher nitrogen level in diets enhanced feed intake. All sheep were within the positive N-balance on different diet at the DMI of not less than 3% of body weight, which satisfy the recommended daily DMI for small ruminants in the tropics (Devendra and Mcleroy, 1987).

The N-intake values increased progressively as the level of PSM increased in the diet. Faecal nitrogen was not influenced by N-intake and was consistent with a study by Ahamefule (2005). Differences in urinary-N values observed among animals on different treatment diets might be due to variation in nitrogen intake. Animals fed diet a excreted less nitrogen in urine because they consumed less DM. Ibeawuchi *et al*. (1993) earlier reported that when animals consumed less nitrogen, they excreted less urinary-N. Higher urinary-N excretion by animals fed the PSM diets in comparison to control (0%) PSM might be due to its higher solubility in rumen as observed by Ranjah (1981). Higher urinary-N from diet C and D than diet A could be a result of high N-intake from PSM.

The positive N-balance (g/d) values obtained for all the treatment diets indicated that the maintenance requirements of the experimental animals were adequately met. The higher value of absorbed-N in the PSM diets, 43% increase when diet A (3.39 g/d) is compared with diet D (5.77 g/d) suggest high protein quality of PSM, and might be connected to the higher apparent-N digestibility observed in the PSM diets as reported elsewhere (Olaleru and Adegbola, 2001). The values of correlation coefficients (r) between faecal-N and N-intake did not differ significantly ($P>0.05$).

Lower MFN values in the present study as compared to a value of 0.24 g/d reported by Ellis, (1956) could be due to differences in breeds, nutrition, environmental conditions and seasons, when these two studies carried out. The higher EUN observed in animals fed PSM diets was consistent with the higher N-intake observed by Ibeawuchi *et al.* (1993). In addition the mean BV (65±10.25) agreed with the 65 reported for ruminants by Devendra and Mcleroy, (1987). The mean DCP (0.69±0.17 g/d/W $kg^{0.75}$) in our study compared favorably with the range 0.63-0.68 g/d/W $kg^{0.75}$ reported by Akinsoyinu (1974) for goats for maintenance. The importance of used diets in this study was the fact that they could provide adequate energy to enhance synchronization of nutrients for better utilization. Devendra and Burns (1983) had earlier reported that DMI was an important factor in the utilization of feed by ruminant livestock. The results of crude fiber digestibility in this study showed that crude protein content of diets was positively correlated with the crude protein digestibility (CPD) and crude fiber digestibility (CFD). This agreed with previous reports (Olaleru and Adegbola, 2001; Fasae *et al*. 2005), which found that CFD and CPD decreased with decreasing level of CP in diets.

CONCLUSION

Animals fed diet C (20% PSM) had higher N-balance and this level of PSM inclusion in sheep diets is recommended for concentrate formulation. However, further studies using different protein-energy ratio might be necessary.

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