Effect of Level of *Leucaena leucocephala* in the Diets of Jamunapari Goats on Carbon Nitrogen and Energy Balances

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ABSTRACT : Fifteen intact male Jamunapari goats, average body weight 22.0 ± 1.18 kg were divided into three groups of 5 animals in each to investigate the effects of feeding leucaena on energy retention and distribution of retained energy. Leucaena leaves and twigs provided 0%, 25% and 50% of CP in the rations of animals in L_1 (control), L_2 and L_3 groups, respectively. Energy balances were determined in an open circuit respiration chamber from gaseous exchange and nitrogen carbon balances. Energy retentions calculated from gaseous exchange data were 181.6, 190.0 and 172.8 kJ/kg $W^{0.75}$/d and from carbon-nitrogen balances were 178.2, 199.5 and 171.1 kJ/kg $W^{0.75}$/d in L_1, L_2 and L_3 groups, respectively. No significant difference was observed among the groups in both the methods. The retention of nitrogen and energy in the form of protein was similar in different treatment groups. Similarly, no significant effect was observed on energy retention in the form of fat and total energy retention due to incorporation of leucaena in the diets.

(**Key Words:** *Leucaena leucocephala*, Carbon-Nitrogen Balance, Goat, Energy Balance)

INTRODUCTION

Leucaena leucocephala is a protein rich tropical legume indigenous to Mexico but now widely distributed in the high rainfall region of central America, Africa, Asia and Northern Australia. It is widely grown in tropics as a fodder plant for livestock. Mimosine, a non-protein amino acid present in leucaena leaves and twigs and its break down product 3-hydroxy-4 (1H)-pyridone (DHP) have a structural similarity with tyrosine. It has been suggested that at molecular level mimosine may act as tyrosine antagonist and inhibit thyroxine utilizing enzymes (Crounse et al., 1962). The deficiency of thyroid hormones is considered to be one of the major factors for obesity, although it has been observed that total fat content of the body was decreased with a marked thyroid deficiency (Dickson, 1982). The relationship of the thyroid to fat deposition is of great interest to livestock producers for a means of improving meat quality. Very few studies have been conducted on the effect of energy utilization feeding leucaena which is known to have definite effects on thyroid hormones.

As such the objective of this study was to observe the effects of feeding various levels of leucaena on energy retention and distribution of energy in the form of protein and fat in Jamunapari goats.

MATERIALS AND METHODS

Fifteen intact male goats of Jamunapari breed weighing 22 ± 1.18 kg were divided into 3 groups of 5 animals in each in a completely randomized design. The animals in the control group (L_1) was supplied with a conventional ration consisting or a concentrate mixture (crushed maize grain 50%, solvent extracted groundnut cake 30% and wheat bran 20%) and *Avena sativa* (oat) hay to provide nutrients as per the recommendations of the NRC (1981). The concentrate was fortified with 1% common salt and 2% mineral mixture consisting of moisture max. 5%, calcium mix. 28%, phosphorus mix. 12%, iodine (as KI) 0.026 to 0.130%, copper 0.077 to 0.130%, fluorine max. 0.04%. Molasses was addded to meet energy requirements. Animals in L_2 and L_3 groups received similar rations except that leucaena leaves and twigs provided 25 and 50% CP of the total ration replacing 50% or 100% of the groundnut cake and wheat bran, respectively to have isonitrogenous diets.

So the L_2 group was offered with the concentrate mixture II consisting of crushed maize grain 67%, groundnut cake 20% and wheat bran 13%. The L_3 group was offered with the concentrate consisting of only crushed maize grain. Feeding trials continued for 165

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Received September 20, 1996; Accepted April 25, 1997

days during which chamber studies were conducted after 90 days of feedings. Animals were shifted to open circuit respiration chamber one by one. Animals were adjusted for 2-3 days before taking the readings. Air samples from respiration chamber were analysed for oxygen by a dual channel Paramagnetic Oxygen Analyser (Servomex Taylor, model OAT 184), for carbon dioxide by a modified Sonden Apparatus with a 100 ml burette and methane by Infrared gas Analyser (Analytical Development Co. Ltd., Hoddesdon, England, Model 300). Hastings mass flow meter (Teledyne Hastings – Raydist, VA, USA) was used to record the flow rate and total volume of air coming out of respiration chamber. Atmospheric pressure was recorded electronically (Appleby and Ireland, Serial No. 252730). Dry and wet bulb temperature of air leaving the chamber was recorded (Decibel Instruments, Chandigarh, India, Serial no. 23/83). Heat production was calculated as per Brouwer's (1965) equation.

$$H = 16.175\ O_2 + 5.021\ CO_2 - 2.167\ CH_4 - 5.987\ N$$

were H is heat production (kJ day $^{-1}$). O_2 is volume of oxygen consumed (l day $^{-1}$), CO_2 is volume of carbon dioxide produced (l day $^{-1}$), CH_4 is volume of methane produced (l day $^{-1}$) and N is amount of nitrogen excreted in urine (g day $^{-1}$).

The gross energy content of feed, faeces and urine was determined by a Gallenkamp automatic adiabatic bomb calorimeter. The carbon content of feed, faeces and urine was estimated by adopting sodalime absorption method given by van ES (1961). The carbon content of carbon dioxided and methane produced was calculated from the volumes obtained in respiration calorimetry using the factor recommended by Brouwer (1965), 0.5360 g litre $^{-1}$ both for carbon dioxide and methane. The loss of energy (kJ) through methane was calculated by multiplying the volume of methane (l) by the factor 39.54.

The quantity of protien deposited was calculated by multiplying the nitrogen balance by 6.25 as body protein assumed to contain 16% nitrogen. The carbon content of body protein and fat was considered to be 52.0% and 76.7%, respectively (Brouwer, 1965). Thus, the quantity of carbon stored as protein was computed. The remaining carbon was considered to be stored as fat since the quantity of carbohydrate deposited in animal body is negligible. Fat storage was calculated by dividing the carbon balance less that stored as protein, by 0.767. The energy present in protein and fat stored was than calculated by using average calorific values 22.26 and 39.20 kJ g $^{-1}$ for protein and fat, respectively (Blaxter and Graham, 1955).

Data were subjected to analysis of variance for a randomised design. The values obtained for energy retention from gaseous exchange data using Brouwer's equation and from the values of carbon and nitrogen balance were subjected to paired 't' test for their comparison (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

The gross energy content of feeds have been presented in table 1. Higher gross energy content in leucaena leaves and twigs might be due to presence of higher level of organic matter and ether extract content. Lower level of organic matter content in molasses might have been resulted in to lower level of gross energy and carbon content (table 1).

The dry matter intake was 47.5, 53.5 and 55.8 g/kg $^{0.75}$/d in L_1, L_2 and L_3 groups, respectively. There was no significant difference in dry matter intake among different groups. No significant increase in dry matter intake was also observed when groundnut cake was replaced by 100% from the concentrate mixture (Gupta et al., 1987) and CP upto 50% from the total ration (Kishan et al., 1986) by leucaena in goat. The ratio of roughage and concentrate in the diet was 0.30 : 1, 0.62 : 1 and 1.05 : 1 in L_1, L_2 and L_3 groups, respectively. The digestibility of dry matter was

Table 1. The organic matter, crude protein, carbon and gross energy content of feeds (% on dry matter basis)

Particulars	Organic matter	Crude protein (N × 6.25)	Carbon	Gross energy (MJ/kg)
Concentrate mixture I	9.89	21.75	39.70	18.242
Concentrate mixture II	91.61	18.73	39.86	18.267
Maize grain, crushed	91.05	11.84	38.29	18.263
Molasses	88.54	8.25	36.36	14.041
Oat hay	91.89	11.03	38.80	17.075
Leucaena leaves & twigs	92.69	29.37	41.29	19.673

74.3, 69.8 and 67.1 percent in L_1, L_2 and L_3 groups, respectively. There was no significant difference among different groups on dry matter digestibility. Incorporation of leucaena in the diet had no significant ($p > 0.05$) effect on the digestibility of crude protein (table 2).

The gross energy intake and its losses through faeces, urine and methane are presented in table 3. The gross energy intake per kg metabolic body size per day was 805.8, 917.1 and 974.0 kJ in L_1, L_2 and L_3 groups, respectively. The gross energy intake in L_2 and L_3 groups

Table 2. The dry matter intake, apparent digestibility, metabolizability and energy content of the experimental diets during chamber study

Particulars	L_1	L_2	L_3	Pooled SE[1]
Number of animals	4	5	4	–
Dry matter intake (g/d)				
Concentrate mixture I	310.1	–	–	–
Concentrate mixture II	–	268.5	–	–
Maize grain, crushed	–	–	201.1	–
Molasses	137.6	186.2	158.5	–
Oat hay	133.0	154.1	171.4	–
Leucaena	–	125.8	207.8	–
Total intake[2]	580.8	734.7	738.9	30.15
Total intake[2] (g/kg $W^{0.75}$/d)	47.5	53.5	55.8	1.35
Digestibility (%)				
Dry matter[2]	74.3	69.8	67.1	0.86
Crude protein[2]	56.5	60.3	60.0	2.93
DE/GE[2] (%)	73.6^b	66.3^a	65.5^a	0.94
DE[2] (MJ/kg DM)	12.51^b	11.38^a	11.42^a	0.17
ME/GE[2] (%)	65.1^b	58.2^a	57.0^a	0.97
ME[2] (MJ/Kg DM)	11.17^b	9.96^a	9.96^a	0.17

L_1 - 0% leucaena CP in the diet; L_2 - 25% leucaena CP in the diet; L_3 - 50% leucaena CP in the diet.
[1] Pooled standard error.
[2] Statistically analysed.
[a,b] Values in row bearing different superscripts differ ($p < 0.05$).

Table 3. Partition of energy in Jamunapari goats fed different levels of leucaena during chamber study (kJ/kg $W^{0.75}$/d)

Particulars	L_1	L_2	L_3	Pooled SE[1]
Metabolic body size (kg)	12.2	13.7	13.2	–
Gross energy intake	805.8^a	917.1^b	974.0^b	23.18
Energy in faeces	212.5^A	307.9^B	337.2^B	11.13
Digestible energy intake	593.3	609.2	636.8	17.11
Energy in urine	24.7	27.2	31.4	2.30
Energy in methane	43.9	46.9	50.6	1.46
Metabolizable energy intake	524.7	535.1	554.8	9.50
Heat production	343.5	345.2	382.0	8.41
Energy retained	181.6	190.0	172.8	12.17

[1] Pooled standard error.
[a,b] Values in row bearing different superscripts differ ($p < 0.05$).
[A,B] Values in row bearing different superscripts differ ($p < 0.01$).

($p < 0.05$) higher than L_1. There was no significant difference between L_2 and L_3 groups. Higher level of gross energy intake in L_2 and L_3 groups might be due to the higher level of gross energy content in leucaena leaves and twigs than other ingredients in the rations. Loss of energy through faeces was significantly ($p < 0.01$) higher in L_2 and L_3 groups than L_1 group. It indicates a lower level of digestible energy content in leucaena leaves and twigs as the dry matter digestibility in all the three diets were similar (table 2). Though the gross energy intake in leucaena fed groups were significantly ($p < 0.05$) higher there was no significant difference in metabolizable energy intake in all the three groups (table 3) as the metabolizability as well as digestibility of the gross energy of diets were lower in leucaena fed groups (table 2). Mtenga and Shoo (1990) reported that metabolizable energy content of leucaena leaves and twigs varied from 8 to 9.1 MJ kg^{-1} dry matter.

Inclusion of various levels of leucaena in diets did not show any significantly difference in carbon intake as well as in carbon balances among the treatment groups (table 4). Brouwer (1965) recommended calculation of energy retention from carbon and nitrogen retention by the equation $R = 51.83\ C - 19.40\ N$, where R is energy retention in kJ; C is carbon retention in g; and N is nitrogen retention in g. The pooled average value for energy retention for all the treatment groups was 2,503.4 ± 173.48 kJ obtained by Brouwer's (1965) equation and the observed value was 2,416.0 ± 169.77 kJ. There was no significant difference between these two values. The intake of nitrogen was 14.95, 19.13 and 18.69 g in L_1, L_2 and L_3 groups, respectively. There was no significant difference among the three groups in nitrogen intake.

Table 4. The carbon, nitrogen and energy balances in Jamunapari goats fed different levels of leucaena

Particulars	L_1	L_2	L_3	Pooled SE[1]
		Carbon Balance (g/d)		
Carbon intake	224.8	286.5	287.0	17.10
Carbon losses				
Faeces	63.2[a]	98.8[b]	101.3[b]	5.46
Urine	1.9	1.9	1.0	0.22
Carbon dioxide	107.3	119.7	128.0	5.24
Methane	7.1	8.7	8.6	0.45
Carbon balance	+45.2	+57.4	+48.1	3.34
Carbon balance (g/kg $W^{0.75}$/d)	+3.70	+4.19	+3.66	0.24
		Nitrogen Balance (g/d)		
Nitrogen intake	14.95	19.13	18.69	0.71
Faecal nitrogen	6.67	8.16	7.41	0.67
Urinary nitrogen	3.61	3.73	3.19	0.33
Nitrogen balance	+4.67[a]	+7.24[b]	+8.08[b]	0.48
Nitrogen balance (g/kg $W^{0.75}$/d)	+0.40	+0.57	+0.61	0.03
		Energy Balance (g/d)		
Protein deposited (g/d)	29.2[a]	45.3[b]	50.5[b]	3.01
Fat deposited (g/d)	39.2	44.2	28.5	4.21
Energy stored as protein (kJ/d)	650.2[a]	1,007.5[b]	1,124.7[b]	67.03
- do - (kJ/kg $W^{0.75}$/d)	54.8	73.6	84.1	4.81
Energy stored as fat (kJ/d)	1,536.4	1,732.2	1,115.9	164.93
- do - (kJ/kg $W^{0.75}$/d)	123.4	125.9	87.0	11.8
Total energy retained (kJ/d)	2,186.1	2,739.7	2,240.9	167.32
- do - (kJ/kg $W^{0.75}$/d)	178.2	199.5	171.1	11.88
Total heat production (kJ/d)	4,264.8	4,572.3	5,101.6	193.09
- do - (kJ/kg $W^{0.75}$/d)	350.6	335.6	384.1	11.25

[1] Pooled standard error.
[a,b] Values in row bearing different superscripts differ ($p < 0.05$).

However, the balances of nitrogen in leucaena fed groups were significantly ($p < 0.05$) higher than control (L_1) group (table 4). This resulted in significantly ($p < 0.05$) lower level of energy storage in the form of protein in control (L_1) group. But there was no significant difference in energy balance in the form of protein per kg metabolic body size per day among different treatment groups. There was no significant difference among different groups in energy storage in the form of fat. In respiration calorimetry studies the observed values on energy retention from gaseous exchange data were 181.6, 190.0 and 172.8 kJ/kg $W^{0.75}$/d (table 3) and in carbon nitrogen balance studies the values were 178.7, 200.0 and 171.1 kJ/kg $W^{0.75}$/d (table 4) in L_1, L_2 and L_3 groups, respectively. No significant difference was observed among the treatment groups in both methods. The pooled average value of energy retention of all the treatment groups obtained from gaseous exchange data was lower than that obtained in carbon-nitrogen balance study. The average difference was 1.03% of the gross energy intake. van Es (1961) also reported a lower energy retention value when computed from gaseous exchange data than carbon nitrogen balance study and the average difference was 1.6% of gross energy intake.

CONCLUSION

Incorporation of leucaena leaves and twigs in the diets of Jamunapari goat providing upto 28% DM and 50% CP had no significant effect on nitrogen and energy retentions. Energy stored in the form of fat and protein were also similar.

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