Iodine Supplementation of *Leucaena leucocephala* Diet for Goats. I. Effects on Nutrient Utilization

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ABSTRACT : Twelve indigenous male goats, comprising of six intact and six castrated (2.5-3 years; 24.4±0.62 kg) were assigned evenly into two dietary treatments, viz. I_0 and I_{100} and were used to study the effect of supplementation of iodine on the nutrient utilization when their diet contained *Leucaena* leaf meal. They were offered a conventional concentrate mixture along with *Leucaena leucocephala* leaf meal, the latter to meet 50% of their crude protein (CP) requirements, and supplemented with either no iodine (I_0) or 0.1 mg of iodine (I_{100})/day/animal as potassium iodide for a period of 105 days. Wheat straw given *ad libitum* was the sole source of roughage. A metabolism trial of 8 days duration was conducted after 90 days of experimental feeding. It was observed that the overall dry matter (DM) intake during experimental period was higher ($p<0.05$) in I_{100} group as compared to I_0 group (508.6 vs. 443.7g d^{-1}). The intake of CP, digestible crude protein (DCP) and metabolisable energy (ME), although non-significant, tended to be higher in the iodine supplemented group, I_{100}. Digestibility of dry matter, organic matter (OM), CP, ether extract and crude fiber (CF) did not differ ($p>0.05$) between the treatments. However, nitrogen retention was higher ($p<0.01$) in I_{100} than I_0 with the values being 2.63 and 1.70 g d^{-1}, respectively. No difference ($p>0.05$) was evident in the retention of calcium and phosphorus between the two groups. The castrated animal exhibited lower DM intake concurrent with higher digestibility of DM and crude fibre ($p<0.05$), and organic matter and total carbohydrates ($p<0.01$) when compared to intact ones. It was concluded that supplementation of iodine to *leucaena* based ration may help in improving the DM intake and nitrogen utilization by goats. *(Asian-Aust. J. Anim. Sci. 2001. Vol. 14, No. 6 : 785-790)*

Key Words : *Leucaena*, Iodine, Nutrient Utilization, Goats

INTRODUCTION

The perennial shortage of feeds and fodders, especially of high protein forages, is one of the contributing factors for low productivity of livestock in tropical and subtropical countries including India. In order to bridge the gap between demand and supply of high protein forages, *Leucaena leucocephala* has been extensively propagated for eco-regenaration in India, Malaysia, Philippines, Sri Lanka and other tropical countries (Ranjhan, 1998) because of its high content of protein, minerals and β-carotene (Akbar and Gupta, 1985). Feeding of *leucaena*, either as a sole diet or as a supplement to basal ration produces adverse effects attributable to its non-protein plant amino acid mimosine and its immediate degradation product 3-hydroxy-4-(1H)-pyridone (DHP).

To overcome *leucaena* toxicity, a number of detoxification methods have been tried viz. heat treatment (D'Mello et al., 1983; Kadam et al., 1987), ferrous sulphate treatment, ensiling (Hongo et al., 1986), pelleting (Srivastava and Sharma, 1998), wilting and leaching (Padmavathi and Shobha, 1987), and feeding of DHP degrading microbes (Jones and Megarrity, 1983) etc. Most of the detoxification methods have one or more flaws viz., failure of effective detoxification, reduction in nutritive value, costlier to be adopted by marginal and small farmers or need for elaborate infrastuctural facility to practice. The flaws with various methods have compelled researchers to explore for easily adaptable methods, which can be useful at small farmer level in developing countries. Both mimosine and DHP are proven goitrogens (Hegarty et al., 1976, 1979; Gupta and Atreja, 1998) producing enlarged thyroid gland, reduced thyroid hormones and related adverse effects. Therefore, it is reasonable to hypothesize that provision of extra iodine to *leucaena* diets would overcome the thyroid affections. Iodine supplementation has been tried to alleviate the toxic effects of other goitrogenic feeds like mustard cake, cabbage, canola and soybean meal successfully. Addition of iodine to *leucaena* containing diet has also been tried for alleviating its adverse effects (Holmes, 1976; Jones et al., 1978). More recently a study in our laboratory has shown that supplementation of 40 μg of iodine to a *leucaena* diet has resulted in better nutrient utilisation in adult male goats (Pattanaik et al., 2000). Hence, the present study was designed to assess the effects of still higher dose of iodine supplementation (i. e., 0.1 mg) on intake and nutrient utilization of adult male goats fed *leucaena* leaf meal.

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MATERIALS AND METHODS

Animals and management

The study was carried out in Animal Nutrition Division of Indian Veterinary Research Institute, Izatnagar between November, 1998 and February, 1999 representing the peak winter season of the year. Twelve healthy adult male goats (2.5-3 years; 24.4± 0.62 kg BW) comprising six each of castrated and intact animals were randomly divided into two groups, viz. control (I_0) and experimental (I_{100}). Each group consisted of three castrated and three intact animals. The goats were housed in a well-ventilated cement-floored barn having individual feeding facilities. All the animals were dewormed by albendazole (5 mg/kg BW) before the onset of experiment and kept under strict hygiene and uniform management throughout the experiment.

Feeds and feeding

All the goats were fed as per NRC (1981) requirements individually with a conventional concentrate mixture [maize 50%; deoiled groundunt meal 25%; wheat bran 22%; dicalcium phosphate 1%; calcium carbonate 1% and salt 1%] and *Leucaena leucocephala* leaf meal (LLM) so that the latter meet 50% of net CP requirement. The chemical analyses of feeds are presented in table 1. Weighed quantities of concentrate mixture and LLM were offered daily at 09:00 h after removal of residues, if any. Wheat (*Triticum aestivum*) straw was offered *ad libitum* as basal roughage to all goats at 14:00 h after ensuring complete consumption of concentrates. Animals of treatment group only were given supplemental iodine (as potassium iodide solution) mixed with concentrate at 0.1 mg/day/animal. Clean and fresh drinking water was offered twice a day to all animals individually. Body weight was recorded at fortnightly intervals before feeding and watering for two consecutive days during 105 days of experimental feeding. Goats were left in an open paddock (18 m×9 m) for 3-4 h daily for their physical exercise.

Table 1. Chemical composition (percent) of dietary ingredients on dry matter basis

Attributes	Concentrate mixture*	*Leucaena leucocephala* leaf meal	Wheat straw
Organic matter	91.64	81.36	94.02
Crude protein	19.68	25.14	3.66
Ether extract	2.82	2.01	0.77
Total carbohydrate	69.14	54.21	89.59
Crude fiber	8.56	11.84	39.57
Nitrogen free extract	60.58	42.37	50.02
Total ash	8.36	18.64	5.98
Calcium	1.84	2.91	0.49
Phosphorus	1.10	0.63	0.36
Mimosine	-	1.45	-
Iodine (mg/kg DM)	0.13	0.86	0.12

* Contained maize: 50%, deoiled groundnut meal: 25%, wheat bran: 22% and 1% each of calcium carbonate, dicalcium phosphate and common salt (air dry basis)

Metabolism trial

A metabolism trial of 8 days duration, involving quantitative collection of feeds, residues, faeces and urine was conducted at the end of 90 days of experimental feeding in order to assess the digestibility, balance of nutrients and plane of nutrition. The goats were acclimatized in the metabolism cages for 3 days before commencing the collections. Faeces voided and urine excreted during 24 h periods were quantified. The dried representative samples of feeds, residues and faeces of each animal over the entire collection period were bulked, sampled and ground to pass through 1.5 mm sieve and stored in air tight polyethylene bags until further analysis. Representative aliquots of urine from individual animals were immediately preserved for nitrogen, calcium and phosphorus determination.

Analytical methods

Samples of feed, residues and faeces were analysed for proximate constituents and urine for nitrogen according to AOAC (1995). Calcium and phosphorus content of feeds, residues, faeces and urine were determined as per Talapatra et al. (1940). The mimosine content of *Leucaena leucocephala* leaf meal was estimated by the method of Megarrity (1978). Iodine content of concentrate mixture, LLM and wheat straw was determined as described by Bedi (1999). ME value of diets was estimated as detailed elsewhere (Pattanaik et al., 2000).

Statistical analysis

Data were statistically analysed to observe the effect of iodine supplementation, castration and their interaction using 2×2 factorial design (Snedecor and Cochran, 1989). Significance between means was ascertained using Duncan's new multiple range test.

RESULTS AND DISCUSSION

Chemical composition

The chemical composition of different feeds is given in table 1. The CP content of LLM was comparable to values reported by Haque et al. (1997). The mimosine content of LLM (1.45% on DMB) was similar to the findings of D'Mello and Fraser (1981). However it was lower than that reported by Gupta and Atreja (1998), Srivastava and Sharma (1998).

Mimosine content is known to vary among different varieties of *leucaena* (Gupta et al., 1986). The iodine content of the LLM appeared to exceed the range of 0.46 to 0.81 mg/kg DM, reported by Bedi (1999).

Voluntary dry matter intake

The net daily iodine intake of the control and experimental animals were 0.115 and 0.233 mg/d, which were equivalent to 0.228 and 0.407 mg/kg DM of the respective diets. The fortnightly average of daily DM intake is presented in figure 1. During the experimental period, the average voluntary intake of DM was significantly ($p<0.05$) higher in I_{100} than I_0 group (508.6±25.59 vs. 443.7±34.71g/d). Previous reports by Jones et al. (1978) and Pattanaik et al. (2000) have recorded increased DM consumption in steers and goats, respectively, due to feeding of *leucaena* with supplemental iodine. The reduced DM intake in *leucaena* fed animals often correlated with levels of circulating thyroid hormones (Holmes, 1981; Jones and Winter, 1982; Jones and Hegerty, 1984). Supplementation of extra iodine in the present study resulted in enhanced level of serum thyroxine (Rajendran et al., 2001) which explain the improvement in DM intake. Likewise, the intact animals exhibited greater ($p<0.05$) DM intake compared to the castrates (535.8 vs. 416.5 g/d) in accordance with their higher requirements. Similar was the observation of Adeloye (1992) while comparing the nutritional performance of intact and castrated goats.

Digestibility of nutrients

Digestibility of various nutrients are presented in table 2. Digestibility of DM, OM, CF, EE and total carbohydrates did not differ significantly ($p>0.05$) between I_0 and I_{100} groups. Pattanaik et al. (2000) have also observed no improvement in digestibility of DM by adult goats, when their diet containing *leucaena* was supplemented with iodine. The

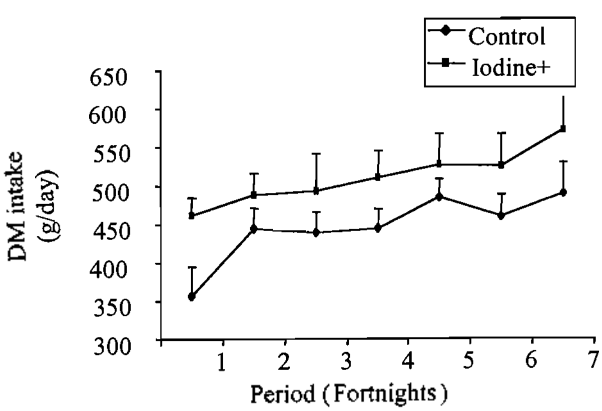

Figure 1. Mean daily dry matter intake by goats

digestibility of CP in group I_{100} and I_0 was similar contrary to the significantly higher value obtained by Pattanaik et al. (2000) due to iodine supplementation of *leucaena* diet. The comparison between castrated and intact animals revealed lower digestibility of DM and crude fibre ($p<0.05$), and organic matter and total carbohydrates ($p<0.01$) for intact animals. This could mainly be correlated to the observed higher DM intake in intact animals, as there exists a negative correlation between DM intake and digestibility (Crampton, 1957; Van Soest, 1965). Unlike the present observations, Adeloye (1992) found no significant difference in the digestibility of nutrients between intact and castrated goats. This is, in fact, reflective of the general observation that castration brings about a higher efficiency of conversion of feed/nutrients to the body tissues. The present findings are also similar to the reports of Adeloye (1992), who attributed the higher

Table 2. Mean digestibility±SE (percent) of various nutrients by goats

	Control (I_0)	I-supplemented (I_{100})	Intact vs. Castrated
Dry matter			
Intact	46.9±2.08	49.4±1.74	48.1±1.34^{p}*
Castrated	55.0±0.98	52.7±2.38	53.8±1.27^{q}
I_0 vs. I_{100}	50.9±2.09	51.0±1.51	-
Organic matter			
Intact	51.9±0.72	52.9±1.67	52.4±0.84^{p}*
Castrated	57.7±0.39	56.8±1.86	57.2±0.87^{q}
I_0 vs. I_{100}	54.8±1.34	54.8±1.42	-
Crude protein			
Intact	38.8±0.87	44.2±3.12	41.5±1.88
Castrated	47.2±2.02	47.5±4.33	47.4±1.24
I_0 vs. I_{100}	43.0±2.11	45.9±2.50	-
Ether extract			
Intact	42.2±0.52	48.1±3.75	45.2±2.15
Castrated	49.3±1.41	49.2±4.29	49.2±2.02
I_0 vs. I_{100}	45.7±1.71	48.7±2.56	-
Crude fibre			
Intact	51.5±2.02	54.9±1.31	53.2±1.32^{q}*
Castrated	58.5±1.93	58.9±2.20	58.7±1.31^{p}
I_0 vs. I_{100}	55.0±2.01	56.9±1.44	-
Nitrogen free extract			
Intact	55.1±1.03	53.8±1.65	54.5±0.91
Castrated	59.4±0.46	58.7±2.55	59.0±1.17
I_0 vs. I_{100}	57.2±1.10	56.3±1.73	-
Total carbohydrate			
Intact	53.8±0.63	54.3±1.50	54.0±0.74^{q}**
Castrated	59.1±0.58	58.9±1.21	59.0±0.60^{p}
I_0 vs. I_{100}	56.4±1.25	56.6±1.34	-

^{p,q} Means bearing different superscripts in a column within a particular criterion differ significantly.
* $p<0.05$; ** $p<0.01$

nutrient digestibility in castrated goats to the effect of castration.

Live weight changes and plane of nutrition

There was no difference ($p>0.05$) observed with respect to body weight changes by goats under the two groups (data not given). The daily intake of various nutrients viz. DM, CP, DCP and ME did not vary significantly ($p>0.05$) between the I_0 and I_{100} groups (table 3). However, the observed intakes are higher than those reported for *leucaena* fed goats earlier (Dutta et al., 1999). The intake of DM and CP by animals of both the groups were in accordance with recommended intakes (NRC, 1981; Kearl, 1982). In comparison between the intact and castrated groups, the former exhibited significantly higher intake of DM ($p<0.01$) which was also reflected in the higher intake of CP ($p<0.05$) by the intact animals.

Nitrogen retention

The intake, output and retention of nitrogen are presented in table 4. Both intake and retention of nitrogen were higher ($p<0.01$) in I_{100} than I_0 group, although faecal and urinary output were comparable in both the groups. Higher nitrogen intake with an apparently higher ME intake (table 3) could explain the higher nitrogen retention in I_{100} group. The results were comparable with earlier reports of Pattanaik et al. (2000) in adult goats, who observed a significant improvement in nitrogen utilization due to iodine supplementation of *leucaena* diets. The improved nitrogen retention could be due to higher levels of thyroid hormones in the iodine supplemented animals which, in turn, might have facilitated the action of somatotropin at cellular level (McDonald et al., 1980) thereby bringing about more efficient utilisation of nitrogen. Similar nitrogen retention by castrated and intact animals in spite of higher ($p<0.05$) intake by the latter could be attributed to lower digestibility of CP in the intact animals because of higher ($p<0.01$) faecal excretion of nitrogen.

Calcium and phosphorus retention

The intake and output of calcium (table 4) were higher ($p<0.01$) in I_{100} as compared to I_0 groups reflecting essentially the DM intake pattern. The retention, however, was similar in both the groups contrary to the observation of Pattanaik et al. (2000) who reported enhanced calcium retention in iodine supplemented goats fed LLM. The intake, outgo and retention of phosphorus (table 4) were similar in both

Table 3. Effect of iodine supplementation on the mean (±SE) plane of nutrition of goats

	Control (I_0)	I-supplemented (I_{100})	Intact vs. Castrated
DM intake(g kg $W^{-0.75}$)			
Intact	54.1±2.83	57.6±1.82	55.9±1.70^{p**}
Castrated	42.2±4.07	45.1±4.00	43.7±2.63^{q}
I_0 vs. I_{100}	48.2±3.46	51.4±3.42	-
CP intake (g kg $W^{-0.75}$)			
Intact	5.7±0.43	5.7±0.13	5.7±0.20^{p*}
Castrated	4.1±0.44	5.2±0.12	4.6±0.33^{q}
I_0 vs. I_{100}	4.9±0.46	5.4±0.13	-
DCP intake (g kg $W^{-0.75}$)			
Intact	2.2±0.19	2.5±0.14	2.4±0.12
Castrated	1.8±0.24	2.5±0.29	2.1±0.23
I_0 vs. I_{100}	2.0±0.17	2.5±0.14	-
ME intake (kcal kg $W^{-0.75}$)			
Intact	94.5±5.58	100.3±2.51	97.4±3.03
Castrated	80.5±7.98	83.4±5.27	81.9±4.33
I_0 vs. I_{100}	87.5±5.37	91.9±4.87	-

[p,q] Means bearing different superscripts in a column within a particular criterion differ significantly.

* $p<0.05$; ** $p<0.01$

Table 4. Effect of iodine supplementation on the mean (±SE) nitrogen balance of goats

	Control (I_0)	I-supplemented (I_{100})	Intact vs. Castrated
Intake (g d^{-1})			
Intact	9.4±0.20	10.3±0.28	9.8±0.25^{p*}
Castrated	6.9±0.98	9.1±0.44	8.0±0.68^{q}
I_0 vs. I_{100}	8.2±0.71^{b*}	9.7±0.36^{a}	-
Output (g d^{-1})			
Faecal			
Intact	5.7±0.59	5.7±0.18	5.7±0.09^{p**}
Castrated	3.7±0.65	4.7±0.29	4.2±0.39^{q}
I_0 vs. I_{100}	4.7±0.54	5.2±0.27	-
Urinary			
Intact	1.9±0.26	1.9±0.32	1.9±0.18
Castrated	1.6±0.08	1.8±0.41	1.7±0.19
I_0 vs. I_{100}	1.7±0.14	1.8±0.23	-
Retention (g d^{-1})			
Intact	1.7±0.13	2.7±0.21	2.2±0.24
Castrated	1.6±0.41	1.6±0.21	2.1±0.29
I_0 vs. I_{100}	1.7±0.19^{b**}	2.6±0.14^{a}	-
As % N intake			
Intact	21.4±3.63	26.2±1.61	23.8±2.07
Castrated	22.9±2.40	28.3±2.05	25.6±1.86
I_0 vs. I_{100}	22.2±1.98	27.2±1.26	-
As % N absorbed			
Intact	48.8±4.92	59.4±3.86	54.1±3.68
Castrated	52.8±5.00	60.1±5.17	56.4±3.60
I_0 vs. I_{100}	50.8±3.27	59.8±2.89	-

[a,b,p,q] Means bearing different superscripts in a row or column within a particular criterion differ significantly.

* $p<0.05$; ** $p<0.01$

I_0 and I_{100} groups indicating no beneficial effect of iodine supplementation and further confirms earlier observations (Pattanaik et al., 2000). Likewise, inspite of higher (p<0.01) intake by intact animals, retention of both calcium and phosphorus were similar to that by the castrated ones because of enhanced (p<0.01) faecal and total excretions. In contrast to the positive calcium and phosphorus balance observed in the present study, Senani and Joshi (1995) reported negative phosphorus balance in kids fed *leucaena* diets. However, in the latter case *leucaena* was supplied as the sole protein source, which might have altered the Ca : P ratio. But in the present study *leucaena* was incorporated so as to supply only 50% of the CP requirements and more over care was also taken to ensure an appropriate Ca : P ratio.

Table 5. Effect of iodine supplementation on the mean (±SE) calcium and phosphorus balance of goats

	Control (I_0)	I-supplemented (I_{100})	Intact vs. Castrated
Calcium retention			
Intake (g d^{-1})			
Intact	5.8±0.24	6.6±0.20	6.2±0.23^{p}*
Castrated	4.4±0.68	5.6±0.23	5.0±0.42^{q}
I_0 vs. I_{100}	5.1±0.46^{b}*	6.1±0.27^{a}	-
Output[1] (g d^{-1})			
Intact	4.3±0.10	4.8±0.33	4.5±0.20^{p}**
Castrated	3.0±0.44	4.0±0.21	3.5±0.32^{q}
I_0 vs. I_{100}	3.6±0.40^{b}*	4.4±0.25^{a}	-
Retention (g d^{-1})			
Intact	1.5±0.28	1.8±0.32	1.7±0.20
Castrated	1.4±0.24	1.6±0.17	1.5±0.14
I_0 vs. I_{100}	1.5±0.17	1.7±0.17	-
As % intake			
Intact	25.9±3.81	27.5±4.80	26.70±2.77
Castrated	31.6±0.71	28.1±2.83	29.90±1.52
I_0 vs. I_{100}	28.8±2.16	27.8±2.50	-
Phosphorus retention			
Intake (g d^{-1})			
Intact	3.0±0.16	3.4±0.08	3.2±0.12^{p}**
Castrated	2.5±0.26	2.8±0.14	2.6±0.15^{q}
I_0 vs. I_{100}	2.8±0.19	3.1±0.16	-
Output[1] (g d^{-1})			
Intact	1.7±0.07	1.7±0.20	1.7±0.09^{p}*
Castrated	1.2±0.12	1.5±0.07	1.4±0.09^{q}
I_0 vs. I_{100}	1.5±0.12	1.6±0.10	-
Retention (g d^{-1})			
Intact	1.3±0.20	1.7±0.12	1.5±0.14
Castrated	1.2±0.15	1.3±0.07	1.2±0.07
I_0 vs. I_{100}	1.3±0.11	1.5±0.12	-
As % intake			
Intact	42.6±5.37	49.6±4.59	46.4±3.37
Castrated	49.4±1.64	45.0±0.75	47.2±1:27
I_0 vs. I_{100}	45.8±2.73	47.6±2.34	-

[a,b/p,q] Means bearing different superscripts in a row or column within a particular criterion differ significantly * p<0.05; ** p<0.01.

[1] Represents the total output through faeces and urine.

From the results it is apparent that supplementation of iodine to *leucaena* based rations, may be used as a possible strategy to ameliorate the reported negative effects as evident from the improved DM intake and nitrogen utilization. However, further long-term trials are warranted to consolidate the present findings.

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