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Performance of Crossbred Calves on Acid Processed or Copper and Iodine Supplemented High Glucosinolate Mustard Meal Incorporated Diets

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Abstract

The Performance of growing calves was assessed on hydrochloric acid (HCl) treated (16 ml HCl per kg meal raising the moisture content to nearly 40 percent, diffused for 72 hrs. followed by heating at 180°C for 2h, (T2), copper and iodine supplemented (500 mg each per kg meal as $CuSO_4$ and KI, respectively (T3) and untreated mustard (*Brassica juncea)* meal (T4) incorporated diets, completely replacing soybean meal of control diet (T1), in a 24 weeks growth trial, with 6 crossbred (Jersey x Sahiwal) calves in each treatment. The calves fed T2 diet gained more weight ($P<0.05$) as compared to those on T1 diet. The ADG was the highest in T2 (413g), followed by T3 (339g), T1 (328g) and T4 (194g). HCl treatment, copper and iodine supplementation improved DM intake and digestibility of nutrients. The DCP and ME intake per unit metabolic body size was similar ($P>0.05$) among soybean meal, HCl treated and copper and iodine supplemented groups, but was higher ($P<0.05$) as compared to untreated mustard meal diet. Body composition of calves in four groups was similar; the total body water, protein and fat content ranged, respectively, from 45.6 to 59.6, 12.6 to 16.8 and 18.6 to 35.8 per cent of the body weight. Mustard meal after HCl treatment can be utilized as suitable substitute for soybean meal in the diet of growing crossbred calves.

Key words : Mustard meal; Glucosinolate; Copper; Iodine; HCl treatment; Calves

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INTRODUCTION

Mustard (*Brassica juncea*) meal, a residue left after oil extraction of seeds, is rich in crude protein and well balanced with amino acids. Glucosinolates, the antinutritional factor present in the meal, reduce palatability and restrict its incorporation in livestock feeds. The degradation of glucosinolates into toxic compounds i.e., thiocyanate, isothiocyanate and nitrites produced either by myrosinase enzyme inherently present in the cellular compartment of the feed or by the enzyme produced by bacterial microflora (Nugon-Baudon *et al.,* 1990), suppress thyroid uptake of iodine and lower thyroid hormone levels (Barrett *et al.,* 1997). The different cultivars of mustard grown in India contain glucosinolates varying from 12 to 90 mg per g meal (Chauhan *et al.,* 1999). Out of various methods, acid treatment was found to reduce intact glucosinolates (Tripathi and Agrawal, 1998) upto 90% in mustard meal. Further more, feeding of rapeseed meal induce copper and iodine deficiencies in animals (Barry *et al., 1981;* Sharman *et al.*, 1981). Supplemental iodine had an inhibitory effect of thiocyanate on iodine secretion by the mammary gland (Miller *et al.,* 1969) and increased milk iodine content (Laarveld *et al.* 1981), while that of copper increased erythrocyte and leukocyte counts (Medvetskie, 1985) in cattle. Thus, an attempt was made to study the performance of cross-bred calves fed diets containing Hydrochloric acid (HCl) treated, copper and iodine supplemented and untreated mustard meal completely replacing soybean meal.

MATERIALS AND METHODS

Treatment of Mustard meal

Expeller processed mustard meal, containing 89.8% dry matter (DM), 28.3% crude protein (CP), 10.7% ether extract (EE) and 46.2 mg glucosinolates per g of oil extracted meal, was treated with 16 ml HCl per kg. at 40 per cent moisture, diffused for 72 h and dried at 180°C in hot air oven for 1 hr as per method of (Tripathi and Agrawal, 1998).

Animals and Housing

Twenty four male cross-bred (Jersey x Sahiwal) calves (230 ± 15.40 days and 86.6±2.7 kg BW) were randomly assigned to four dietary treatment (T1, T2, T3 and T4) on the basis of age and body weights. The animals were housed in individual pens.

Table 1. Ingredients (% air dry basis) and chemical composition (% in DM) of concentrate mixtures and roughage

Feed ingredients	Concentrate mixtures				Roughage	
	CM I	CM II	CM III	CM IV	A	B
Ingredients						
Soybean meal	26.50	-	-	-		
Mustard meal HCl treated	-	49.50	-	-		
Mustard meal UT	-	-	49.50	49.50		
Deoiled rice bran	35.00	24.00	24.00	24.00		
Wheat	35.50	23.50	23.50	23.50		
Salt	1.0	1.0	1.0	1.0		
Mineral mixture*	2.00	2.00	2.00	2.00		
Chemical composition						
CP	22.25	22.31	22.33	20.13	14.75	7.88
OM	90.02	89.02	88.60	89.12	88.35	86.92
EE	1.50	1.50	1.38	1.00	1.60	1.50
NDF	45.6	42.6	43.0	48.0	60.95	72.5
ADF	16.4	17.7	17.4	16.5	38.85	49.6
ADL	2.4	3.6	2.7	2.9	5.70	7.3
AIS	2.15	2.63	2.60	2.38	4.98	8.55
Calcium	2.40	2.35	2.50	2.40	1.65	1.70
Phosphorous	0.90	0.91	0.92	0.98	0.16	0.19
Copper (ppm)	49.4	114.3	240.5	112.0	ND	100.7
Iron (ppm)	795.0	934.0	700.0	742.0	ND	3374.0
Glucosinolate (mg/g)	0.0	2.2	25.0	25.5	ND	ND

*Contained : (g/kg) calcium 320, phosphorus 62, manganese 2.7, zinc 2.6 and (ppm) iron 1000, fluorine 900, iodine 100, copper 100.

[A]Oats hay (Trial I) ; [B] Mixture of green jowar, maize and oats in equal proportions (Trial II).

UT; untreated; ND. Not determined.

Feeds and Feeding

Four concentrate mixtures were fed to four groups of experimental calves. Concentrate mixture (CM-I) contained soybean meal (SBM) and served as control, while CM II, III and IV contained mustard meal, HCl treated, untreated mustard meal and supplemented with $CuSO_4$ and KI, each @ 500 mg per kg and untreated mustard meal, respectively (Table 1). The respective concentrate mixtures were fed to meet the total protein requirement (ICAR, 1998) of calves and allowances were adjusted as per increment in the body weights throughout 24 weeks feeding. The Oats hay (Trial I) or a mixture of green (Trial II) Jowar (*Andropogon Sorghum)*, Maize (*Zea mays*) and Oats (*Avena sativa*) in equal proportions was fed as basal roughage *ad libitum* to meet rest of the energy requirements. Free choice of water was available to the animals twice a day in the morning and evening. The animals were dewormed in the beginning of the experiment with albendazole @ 10 mg/kg body weight. The calves were weighed for three consecutive days at each fortnight before offering feed and water, the mean of which was used to assess the total and average daily gain.

Digestibility trials

Two digestibility trials each of seven days duration, at 45 days and 175 days of experimental feeding were carried out in individual pens by conventional total collection method. During the trial samples of concentrate mixture, feed offered, orts and faeces were collected. The mean of initial and final body weight during trial were used for the calculation of intake. Samples of feed, faeces and orts were dried in hot air oven, pooled and ground samples were utlilized for chemical analysis. A part of preserved fresh faeces was used for nitrogen estimation.

Chemical analysis

Samples of feed, orts and faeces were analysed for proximate principles (AOAC, 1990) and cell wall fractions (Goering and Van Soest, 1970). The gross energy (GE) content was determined by chromic oxide indicator method (Hill *et al.,* 1960). The metabolizable energy (ME) of ruminant feeds was calculated using the following equation (Kirchgessner, 1995) :

$$ME = 0.0312 \times DXL + 0.0136 \times DXF + 0.0147 (DOM-DXF) + 0.00234 \times XP$$

where, ME = ME of feed (MJ/kg), DXL = Digestible total lipids (g/kg), DXF = Digestible total fibre (g/kg), DOM = Digestible organic matter (g/kg), XP = N {6.25 (g/kg)}

Total glucosinolate content of mustard meal and concentrate mixtures was determined using thymol method (Tholen *et al.,* 1989). Calcium was estimated by titrimetric method (AOAC, 1965) and phosphorus by colorimetric method (Donald *et al.,* 1956). Copper and iron levels in feeds were determined using atomic absorption spectrophotometer (Perkin-Elmer, USA).

Body composition

The body composition of experimental calves was determined at the end of growth trial using antipyrine dilution technique as suggested by Brodie *et al.* (1949) and modified by Wellington *et al.* (1956). The total body water was calculated (Soberman, 1950) from antipyrine level in plasma. The empty body weight was determined using the procedure of Bensadoum *et al.,* (1963), whereas body fat and body protein by Reid *et al.* (1963). The body mineral content was determined by subtracting the water and organic matter content of the body.

Statistical analysis

Data of intake and digestibility were subjected to analysis of variance (Snedecor and Cochran, 1968). Data on growth were analysed using mathematical model (Harvey, 1975).

$$Yijk = (u + Ti + Aj + w_k + eij_k)$$

Where, u = General mean, Ti = Effect of i^{th} treatment, Aj = Effect of j^{th} age, W_k = Effect of $_k^{th}$ initial body weight, eij_k = Random error

RESULTS AND DISCUSSION

The HCl treatment substantially reduced glucosinolate content of mustard meal (4.5 mg/g) as compared to 46.2 mg in raw meal. The glucosinolate content of CM II, CM III and CM IV was 2.2, 25.0 and 25.5 mg/g meal, respectively. The HCl treatment destroyed glucosinolate (Tripathi and Agrawal, 1998), so, it was lower in CM II.

Nutrient digestibility

The digestibility of nutrients was similar (P>0.05) in all the four groups in trial I, whereas, it was significantly (P>0.05) different in trial II (Table 2). The digestibility of OM, CP and GE was similar in T1, T2 and T3 and was higher to that of T4, whereas the digestibility of DM was highest in T2 as compared to that on other diets, which was similar (P>0.05). However, the NDF digestibility was depressed on T4 diet than the comparable digestibility on other diets. But ADF was digested similarly by calves on all diets. The glucosinolate present in the mustard meal exhibited deleterious effects on the digestive abilities of the calves and the lower digestibility coefficients were in T4 during trial II. Further, it is envisaged that glucosinolates require some time for the manifestation of their deleterious effects on animal performance. Hence, the digestibility of the nutrients on untreated mustard meal affected adversely. These are in agreement with the results of Tripathi *et al.* (1995). The digestive processes as a result of microbial and fungal activities in the rumen got disturbed due to antifungal properties of glucosinolates (Manici *et al.*, 997; Verkerk *et al,* 1997) But HCl treatment, copper and iodine supplementation were found to reduce such deleterious effects and thereby, improved nutrient digestibility.

Table 2. Nutrient digestibility in calves during metabolism trial

Attributes	Treatments				SEM
	T1	T2	T3	T4	
Trial I					
DM	63.14	61.80	63.23	62.48	1.61
OM	65.11	63.75	65.04	64.36	1.16
CP	65.32	66.91	67.65	67.61	1.34
NDF	61.25	58.61	59.30	57.79	1.36
ADF	50.66	45.61	51.03	49.79	2.01
GE	63.47	62.14	63.72	62.34	1.62
Trial II					
DM*	56.8^{b}	60.9^{a}	56.8^{b}	49.7^{b}	2.47
OM*	59.9^{a}	61.5^{a}	59.6^{a}	52.5^{b}	1.80
CP*	60.0^{a}	62.2^{a}	63.3^{a}	47.5^{b}	3.87
NDF*	57.9^{ac}	59.5^{ac}	56.1^{bc}	49.7^{b}	2.32
ADF	43.9	46.2	40.7	34.6	2.98
GE*	56.2^{a}	57.8^{a}	56.0^{a}	48.5^{b}	2.26

^{abc}Means with different superscripts in a row differ significantly* : P <0.05

Table 3. Effect of treatments on plane of nutrition in calves

Attributes	Treatments				SEM
	T1	T2	T3	T4	
Dry matter intake (DMI)					
Trial I					
Roughage*	3.60[a]	3.19[b]	2.86[b]	2.96[b]	0.33
Concentrate	1.19	1.18	1.18	1.17	0.04
DMI (kg/100 kg BW)**	4.06[a]	3.93[b]	3.67[b]	3.88[b]	0.09
DMI (g/kg $w^{0.75}$)*	133.6[a]	127.7[b]	121.3[b]	122.4[b]	4.86
Trial II					
Roughage	3.66	3.95	3.41	2.92	0.33
Concentrate	1.22	1.41	1.24	1.11	0.91
DMI (kg/100 kg BW)	3.39	3.41	3.39	3.18	0.11
DMI (g/kg $W^{0.75}$)	116.1	120.4	115.7	105.4	0.51
Digestible crude protein intake					
g/day*	354.32[a]	368.96[a]	326.99[a]	220.46[b]	34.79
g/kg $W^{0.75}$*	8.48[a]	8.28[a]	8.08[a]	5.38[b]	0.62
Consumed % of requirement	118	115	108	73	–
Metabolizable energy intake					
Mcal/day*	9.39[a]	10.39[a]	8.79[ab]	7.16[b]	0.82
Mcal/kg $W^{0.75}$*	0.226[a]	0.234[a]	0.218[ba]	0.192[b]	0.01
Consumed % of requirement	100.00	103.00	97.67	86.27	–

[ab]Means with different superscripts in a row differ significantly* : P<0.05, ** : P<0.01

Plane of nutrition, growth and body composition

The daily intake of concentrate mixture was similar among the calves on all the diets during both the trials. However, the DMI per 100 kg body weight (P<0.01) and per unit metabolic body size was higher (P<0.05) on control diet than the comparable intake on test diets during trial I and it was due to variation in DMI through roughage (Table 3). The DCP and ME intake per unit metabolic body size were lower (P <0.05) on untreated mustard meal incorporated diets, but the intake of these constituents were similar on all other diets. The intake of DCP and ME was as per requirements of ICAR (1998) on

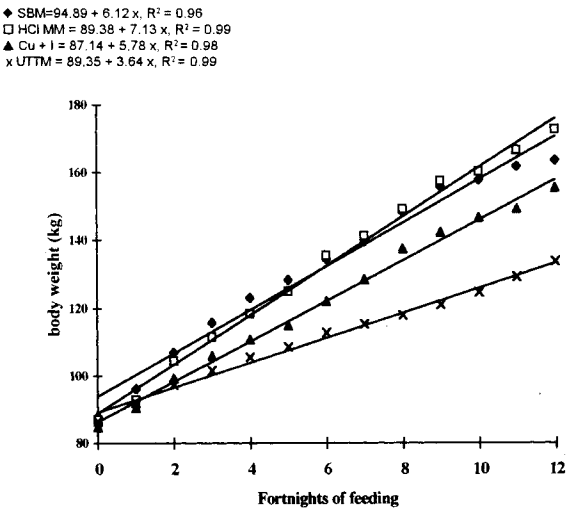

Fig 1. Body weight changes of calves on various dietary treatments

all the diets, except on T4, which was lower by 27 and 24 per cent for DCP and ME, respectively.

The growth of calves on untreated mustard meal was depressed as compared to similar growth of calves on other diets. The average ADG was 328, 413, 339 and 194g in T1, T2, T3 and T4 groups, respectively. The growth of calves was constantly poor in T4 group

Table 4. Average daily gain and body composition (% of live weight)

Attributes	Treatments				SEM
	T1	T2	T3	T4	
Average daily gain					
ADG (g/day)*	328[a]	413[a]	339[a]	194[b]	41.5
Body composition					
Empty body weight	123.1	139.9	123.8	106.1	10.47
Water	55.4	45.6	53.2	59.6	3.35
Protein	15.7	12.8	15.0	16.8	0.98
Fat	22.6	35.8	26.0	18.6	12.62
Mineral matter	6.1	58.0	5.9	5.0	1.48

[ab]Means with different superscripts in a row differ significantly, *:P<0.05

inspite of an increase in feeding period (Fig 1). The body composition of calves was found to be similar among all the groups (table 4). The poor growth response on untreated mustard meal (T4) was probably due to the cumulative effect of lower DCP and ME intake, and the presence of glucosinolate in the diet. The lower average daily gain was also reported (Kossaibatti and Bryant, 1994; Tripathi *et al.,* 1998) on untreated rapeseed/mustard meal as compared to SBM or GNC diets. Glucosinolates and/or its metabolites impairs liver function, induce iodine deficiency (Panter and James, 1990; Barrett *et al.,* 1997) and create hindrance in DNA synthesis (Nugon-Boudon and Rabot, 1994; Verkerk, 1997), thereby impaired growth. The HCl treatment (T2), Cu and I supplementation (T3) reduced such deleterious effect of glucosinolate and resulted in a better growth. Further, the supplementation of copper during active growth phase acts as a growth promoter and iodine supplementation normalises the availability of iodine for the thyroid. The heating during HCl treatment of meal not only decomposes the glucosinolate, it also reduces the degradability of protein and improve the efficiency of utilization of amino acids for growth (Mustafa *et al.,* 1999).

CONCLUSION

Incorporation of mustard meal as a protein source in the diet of growing calves though didn't affect intake and body composition, but the glucosinolates present in the feed exerts deleterious effect on digestibility and growth. The glucosinolate require some time for the manifestation of its deleterious effect on digestibility and growth. The HCl treatment as well as Cu and I supplementation mitigated the adverse effect of glucosinolates and improved nutrient digestibility and growth performance. The mustard meal after HCl treatment was found to be a suitable substitute of the SBM in the diets of growing calves.

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