Effect of Thermal Processing of Cereal Grain on the Performance of Crossbred Calves Fed Starters Containing Protein Sources of Varying Ruminal Degradability

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ABSTRACT : In order to investigate the effect of incorporation of thermally processed cereal (maize) grain and differently degradable protein sources in the calf starter, twenty four newly born crossbred (*Bos taurus* × *Bos indicus*) calves were assigned at random to six diets in a 3×2 factorial design involving three protein sources viz. groundnut meal (GN), cottonseed meal (CS) and meat and bone meal (MB), each along with two differently processed grain, namely ground raw (R) and pressure cooked (P) maize. The corresponding calf starters with green oats (*Avena sativa*) were given free-choice from 14 d onwards till the end of the 90 d experimental feeding. A restricted milk diet was fed till the age of weaning at 60 d. Total DM intake was not affected by cereal or protein sources. However, daily intake of DM (59.23 vs 66.45 g) and CP (12.38 vs 14.10 g) per kg $W^{0.75}$ was reduced ($p<0.05$) due to cereal processing. Better ($p<0.05$) feed and protein efficiencies after weaning and during entire period in calves fed processed maize resulted in a trend of higher ($p\leq0.092$) growth rate especially when GN was the source of protein. In comparison among protein sources, calves fed MB diets tended to grow faster ($p\leq0.098$) concurrent with a higher CP intake before weaning. It is thus evident that thermal processing of maize in the calf starter seems to improve calf performance. Moreover, results indicated that feeding of protein and starch sources of matching ruminal degradability may prove beneficial for early growth of crossbred calves. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 9 : 1239-1244*)

Key Words : Maize, Processing, Protein, Degradability, Performance, Cavles

INTRODUCTION

The vast and ever increasing livestock population in developing countries like India have compelled nutritionists to either explore newer feed resources or evolve feeding strategies to optimize nutrient availability from the existing feed stuffs. The latter approach through feeding higher undegradable dietary protein (UDP) failed to translate into higher productivity in many instances. The response to varying protein degradability could be altered by rate of starch breakdown in rumen (Herrera-Saldana and Huber, 1989) through either varying dietary starch sources or grain processing. Depending upon method of processing, source of grain and species of animal, the rumen and total tract utilization of starch enhances to a varying degree, it being greater with corn and sorghum than barley (Theurer, 1986). Provision of protein and starch of matching degradability would essentially facilitate synchronized supply of nitrogen and energy to ruminal microbes which Aldrich et al. (1993) suggested to be a logical strategy than diet formulation with higher UDP. Such hypothesis was tested extensively in adult ruminants but only to a limited extent in non-ruminating and just ruminating calves (Maiga et al., 1994; Olivares-Reyna et al., 1992; Abdelgadir et al., 1996a; Abdelgadir et al., 1996b).

In the backdrop of above considerations the present experiment was conducted to evaluate the performance of crossbred calves from birth to 90 d of age on calf starters containing thermally processed cereal grain along with protein sources of varying ruminal degradability.

MATERIALS AND METHODS

Animals and feeds

Twenty four newly born crossbred (*Bos taurus* × *Bos indicus*) calves, after 24 h colostrum feeding, were allocated to six dietary treatments in a 3×2 factorial design involving three protein sources and two differently processed maize grain. Accordingly, six calf starters were formulated containing three protein sources viz. groundnut meal (GN), cottonseed meal (CS), meat and bone meal (MB) having ruminal degradability of 76.9, 57.6 and 44.4 percent, respectively along with either raw (R) or thermally processed (P) maize. Thermal processing was done by pressure cooking coarsely ground maize with water (1:2.5, w/w) at a pressure of 15 psi for 10 min. The detailed ingredients of the iso-nitrogenous and iso-caloric calf starters are listed in table 1. Besides concentrates, the calves had an access to whole milk and green oats (*Avena sativa*).

Feeding and management

The calves were daily fed calculated quantity of

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Table 1. Physical composition of calf starters[a] and chemical composition of feeds and fodder

Attributes	Calf starters							
	R-GN	P-GN	R-CS	P-CS	R-MB	P-MB	Milk	Green oats
Ingredient composition (% air dry basis)								
Maize, raw	50	-	50	-	50	-	-	-
Maize, pressure cooked	-	50	-	50	-	50	-	-
Groundnut meal	35	35	25	25	19	19	-	-
Cottonseed meal	-	-	22	22	-	-	-	-
Meat and bone meal	-	-	-	-	10	10	-	-
Wheat bran	12	12	-	-	19	19	-	-
Mineral mixture[b]	2	2	2	2	1	1	-	-
Common salt	1	1	1	1	1	1	-	-
Chemical composition (% of DM)								
OM	90.99	92.31	91.19	93.24	91.78	93.02	93.36	86.88
CP	22.35	21.57	22.91	22.35	23.50	23.23	27.34	9.80
EE	3.04	2.38	4.22	3.22	4.84	3.75	35.16	2.92
TCHO	65.60	68.36	64.06	67.67	63.44	66.04	30.86	74.16
Ash	90.01	7.69	8.81	6.76	8.22	6.98	6.64	13.12
RDP	14.75	14.67	14.35	14.07	13.80	14.18	-	-
UDP	5.45	5.43	6.75	6.93	8.10	8.33	-	-

[a] Added with vitamin mix (vitablend AD_3) @ 20 g per 100 kg of compounded mixture; containing 50,000 IU of vitamin A and 5,000 IU of vitamin D_3 per gram.

[b] Contained, moisture (max) : 70 g/kg; Ca (min) : 280 g/kg; P (min) : 120 g/kg; Fe : 0.5-0.75 g/kg; I : 0.26-1.30 g/kg; Cu : 0.77-1.30 g/kg; Co : 0.13-0.26 g/kg and F (max) : 0.40 g/kg.

RDP : Rumen degradable protein; UDP : Undegradable dietary protein.

whole milk as per standard schedule upto the weaning age of 60 d in two divided doses once each in the morning and evening. The calves were housed in separate straw-bedded pens having facilities for individual feeding and watering. Besides the respective calf starters, green oats (*Avena sativa*) and clean drinking water were provided free choice from 14 d onwards.

Observations and chemical analysis

Feed intake was recorded by offering weighed quantities of feeds and weighing back the refusals daily after 24 h of consumption. The body weight of the calves were recorded at fortnightly intervals. The initial and final bodyweights, however, were averages of three recordings obtained by weighing the calves individually for three consecutive days. Feeds and refusals were analysed for dry matter, crude protein ($N \times 6.25$), ether extract and total ash according to AOAC (1990). The nutritive value in terms of digestible crude protein (DCP) and metabolizable energy (ME) of different diets were assessed elsewhere (Pattanaik, 1997).

Statistical analysis

Data were statistically analysed according to a 3×2 factorial design with interaction, using sources of protein and cereal processing as the main factors (Snedecor and Cochran, 1967). Differences between means were tested using Duncan's New Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical composition of experimental feeds along with milk and green oats are given in table 1.

Live weight gain

The diets did not influence the live weights attained at weaning as well as at the end of 90 d of experimental feeding, resulting in comparable ($p>0.05$) growth rates (ADG) among calves of all the groups (table 2). Although calves on meat and bone meal incorporated diets tended to exhibit higher ($p \leq 0.098$) ADG during the pre-weaning period, degradability of feed proteins on the whole appears to have little impact on growth of calves from birth to 3 months of age. It was probably because of masked effect of ad libitum supply of calf starters resulting in marginal difference in microbial protein supply and demand of the host as observed by Swartz et al. (1991) and Abe et al. (1985). The calves on processed maize tended to have better ADG ($p \leq 0.092$) in comparison to those on raw maize (353 vs 308 g/d) as was shown by Ramirez et al. (1985) and Vladimirov et al. (1991). This could mainly be attributed to gelatinization of cereal (maize) starch as a result of pressure cooking. Gelatinization is known to enhance the ability of

Table 2. Live weight changes and average daily gain of experimental calves

Protein:	GN		CS		MB		
Maize:	Raw	Processed	Raw	Processed	Raw	Processed	SEM[a]
Live weight changes, kg							
Initial weight	26.4	27.8	26.5	27.8	30.0	26.5	2.37
Weight at weaning	41.8	48.0	41.4	45.1	51.1	46.1	2.81
Final weight	51.1	62.1	52.9	56.8	62.0	58.5	3.51
Net gain, kg							
Start to weaning	15.4	20.3	14.9	17.4	21.1	19.6	1.85
Weaning to end	9.4	14.1	11.4	11.6	10.9	12.4	1.73
Entire period	24.8	34.4	26.3	29.0	32.0	32.0	2.49
Average daily gain, g							
Start to weaning	256.3	337.5	248.0	289.8	352.0	327.0	30.91
Weaning to end	312.5	470.8	379.3	387.3	362.5	421.8	57.69
Entire period	275.0	382.0	293.0	322.3	355.8	355.6	27.67

[a] Standard error of means.

GN=Groundnut meal; CS=Cottonseed meal; MB=Meat and bone meal.

starches to absorb large quantities of water leading to improved digestibility (Smith, 1976). The positive impact of incorporation of processed maize on ADG, however, showed a diminishing trend as the undegradability of protein increased. Accordingly, the improved ADG on P-GN diet over R-GN diet (382 vs 275 g/d) could be attributed to synchronized availability of protein and starch from rapidly rumen degradable groundnut meal and processed maize, respectively in the former case. This could be substantiated from the observed greater total volatile fatty acids and microbial nitrogen in the rumen of the R-GN than P-GN fed calves (Pattanaik et al., 1999). Likewise, better performance was observed in growing lambs (Matras et al., 1991) and early weaned calves (Abdelgadir, 1996b) on starch and protein sources of similar rumen degradation rates.

The fortnightly average daily live weight gain during the entire study period showed no significant variation due to dietary treatments (figure 1). However, calves fed thermally processed maize showed significantly ($p<0.05$) higher growth during second and sixth fortnights in comparison to those on raw maize.

Feed intake

The intake of total DM as well as that from milk, calf starters and green oats were not affected by cereal processing or degradable protein sources (table 3). The diet did not impart any influence on the fortnightly average daily DMI either (figure 2). MB diets, however, induced greater ($p<0.05$) intake during the fourth fortnight in comparison to GN or CS diets. The daily DM and CP intake per kg $W^{0.75}$ were alike ($p>0.05$) across the protein sources similar to the observations of Swartz et al. (1991) who also noticed no effect of protein degradability on DM and CP intake by Holstein calves during 1 to 12 weeks of age. However, calves fed MB diets tended to consume more CP as compared to those on GN or CS based ones (3.49 vs 2.93 and 3.20 g/d) which correlated well with the trend of better ADG on the said diets (table 2). However, both the DM and CP intakes per unit metabolic body size (kg $W^{0.75}$) were significantly ($p<0.05$) reduced (59.23 vs 66.45 and 12.38 vs 14.10 g for DM and CP, respectively) on thermally processed maize diets during the post-weaning period with a similar, although non-significant trend, over the entire period. This was in agreement with Maiga et al. (1994) who noticed higher intake associated with carbohydrate of lesser ruminal degradability. Further, reduced DM intake due to feeding of processed maize was also observed by Grubic (1988). No significant difference, however, was evident with respect to intake of DCP and ME by calves of different groups during the post-weaning period.

Feed conversion

The dietary variations did not show any significant effect on efficiency of DM and CP utilization during all the periods of measurement (table 4). Maiga et al. (1994) also noticed similar feed efficiency in calves from birth to 12 weeks of age when their diets contained protein and carbohydrate sources of varying ruminal degradability. Provision of thermally processed maize, in place of raw maize in the diet, however, improved the efficiency of DM and protein utilization; it is being more conspicuous with GN than CS or MB diets, probably because of synchronised supply of rumen degradable protein and starch.

When compared between cereal sources; calves fed processed maize exhibited significantly higher ($p<0.05$) feed and protein efficiencies during post-weaning as

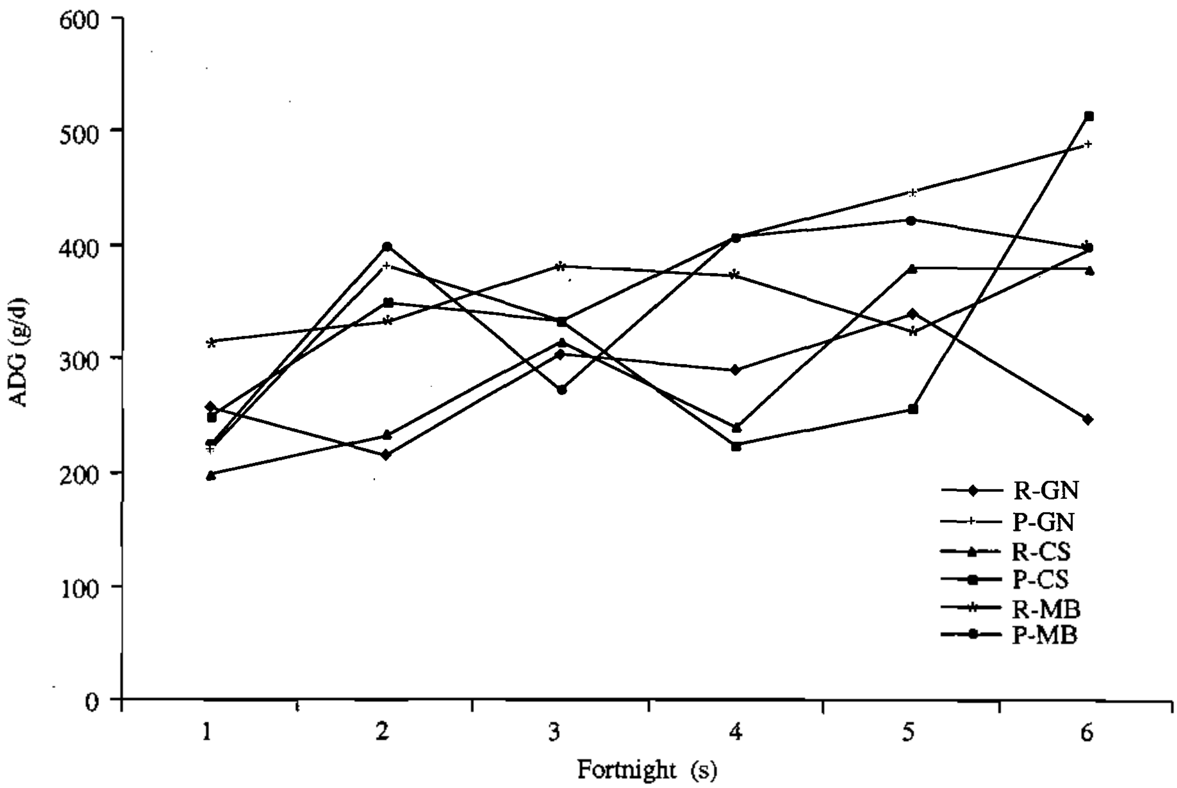

Figure 1. Average daily gain (g/d) of calves fed experimental diets (fortnightly averages)

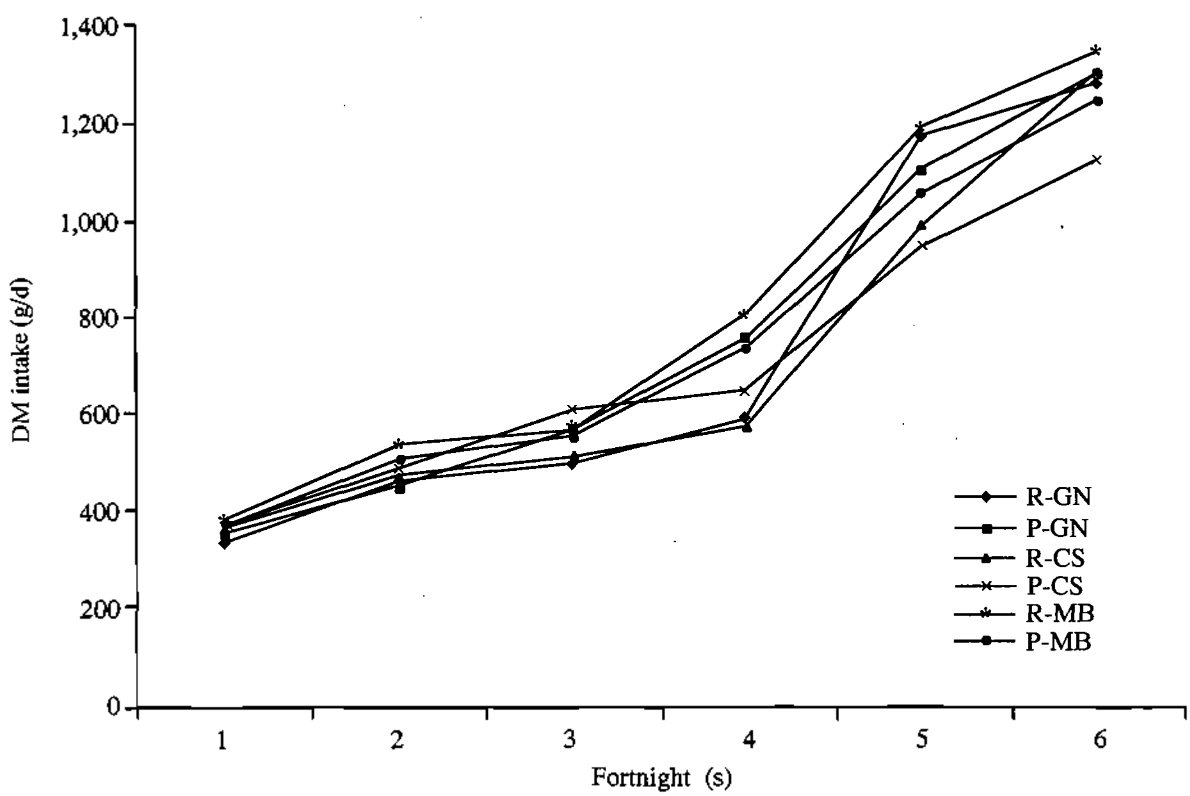

Figure 2. Average daily DM intake (g/d) of calves fed on experimental diets (fortnightly averages)

Table 3. Intake of feed (DM) and crude protein by experimental calves

Protein:	GN		CS		MB		
Maize:	Raw	Processed	Raw	Processed	Raw	Processed	SEM[a]
DM intake, kg, entire period							
Milk	19.20	19.55	18.98	19.92	21.84	19.33	1.27
Calf starter	39.03	40.05	37.36	37.18	41.90	41.86	2.80
Green oats	8.07	9.55	8.21	6.87	9.84	6.65	0.93
Total	66.30	69.15	64.55	63.98	73.57	67.84	3.42
DM intake, g/kg $W^{0.75}$/d							
Before weaning	33.9	35.1	34.9	36.0	36.5	36.7	1.34
After weaning[#]	70.5	61.1	65.7	55.9	63.2	60.7	3.53
Entire period	47.6	44.3	45.5	42.9	46.8	45.4	1.77
CP intake, g/kg $W^{0.75}$/d							
Before weaning	2.8	3.1	3.0	3.4	3.3	3.7	0.24
After weaning[#]	14.7	12.2	14.0	11.6	13.7	13.3	0.83
Entire period	7.3	6.6	7.1	6.5	7.30	7.4	0.38
DCP intake, g/kg $W^{0.75}$/d							
After weaning	9.5	8.7	9.9	8.5	9.4	10.0	0.53
ME intake, MJ/kg $W^{0.75}$/d							
After weaning	0.86	0.79	0.85	0.73	0.79	0.86	0.05

[a] Standard error of means.
[#] Significant (p<0.05) effect of cereal sources.
GN=Groundnut meal; CS=Cottonseed meal; MB=Meat and bone meal.

Table 4. Dry matter and crude protein conversion efficiency of experimental calves

Protein:	GN		CS		MB		
Maize:	Raw	Processed	Raw	Processed	Raw	Processed	SEM[a]
Dry matter, kg/kg gain							
Before weaning	2.16	1.62	2.11	1.83	1.65	1.67	0.30
After weaning*	4.62	2.67	3.12	2.59	3.79	2.96	0.49
Entire period*	2.71	2.02	2.52	2.30	2.31	2.14	0.20
Crude protein, g/kg gain							
Before weaning	169	142	183	177	148	168	23.26
After weaning*	960	532	663	612	820	652	103.69
Entire period*	416	299	392	346	362	349	33.83
Digestible crude protein, g/kg gain							
After weaning	624	382	477	448	565	489	70.45
Metabolizable energy, MJ/kg gain							
After weaning	56.07	34.60	40.96	39.33	47.57	42.17	6.19

[a] Standard error of means.
* Significant (p<0.05) effect of cereal sources.
GN=Groundnut meal; CS=Cottonseed meal; MB=Meat and bone meal.

well as entire period, in spite of lower intake, implying improved utilization of starch because of thermal processing. Likewise, the efficiency of DCP and ME utilization also tended to be higher in processed maize fed animals during the post-weaning period. Similar better feed efficiency in young calves fed processed maize was noticed by Grubic (1988). This could have been due to probable passage of larger quantities of undigested starch from raw maize into the lower intestine which subsequently might have undergone fermentation leading to wasteful production of microbial nitrogen; thereby resulting in reduced protein utilization. Thermal processing, on the other hand, invariably results in improved total tract digestibility by increasing the rate of starch degradation in the rumen (Anzola et al., 1988; Malcolm and Kiesling, 1993), besides enhanced digestibility of starch at the intestine level because of increased susceptibility to enzymatic degradation (Owens et al., 1986; Rooney and Pflugfelder, 1986). This is especially so with maize which is most resistant to microbial attack in the rumen (Campling, 1991). The source of protein, however, imparted no influence ($p>0.05$) on efficiencies of utilization of DM and CP similar to the observations of Swartz et al. (1991) and Heinrichs and Garman (1992) in young calves during first 12 weeks of life.

Conclusively, thermal processing of cereal maize appeared to improve calf performance during the pre-ruminant phase of life. Further, feeding for synchronized supply of rapidly degradable protein and starch in the rumen may prove beneficial for better performance of early weaned crossbred calves.

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