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RESEARCH ARTICLE

Effect of varying levels of fibre and starch in calf starters containing finely ground maize grain on the performance of pre-ruminant calves

M Thirupathi[1], G Alexander[1](✉), D Nagalakshmi[1] and Suresh Rathod[2]

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Abstract: The nutrient composition and particle size of calf starter play a major role in shaping appropriate rumen development and starter intake and average daily gain in pre-ruminant dairy calves. Hence, a feeding trial was conducted to assess the effect of feeding calf starters containing finely ground maize grain with varying levels of fibre and starch on the performance of pre-ruminant dairy calves fed no roughage. Three iso-nitrogenous calf starters containing different levels of finely ground maize grain and soybean hulls (maize:soybean hulls 40:10; 30:20; 20:30) were evaluated through a feeding trial using 18 Holstein Friesian crossbred female calves (average body weight 34.19 ± 0.94 kg). The calves were divided into three groups of 6 calves each in a completely randomized design. Milk was offered to calves twice daily from the fourth day of age up to 63 day of age as per the step up/step down milk feeding schedule. In addition, calves in each group were offered respective calf starters individually *ad libitum* from 3 to 63 day of age. Daily starter intake and fortnightly body weight of calves were recorded during the trial. The calves were monitored for rumination from the third day of age until rumination was noticed. Blood samples were collected from calves on 63 day of age for estimation of various biochemical constituents. The level of starch and fibre in calf starters containing finely ground maize grain (57.72% of particles with a size of 1.18 mm above) had no influence on overall calf starter dry matter intake (401.89 to 424.68 g/d), average daily gain (0.660 to 0.700 kg/d), feed conversion efficiency, feed cost/kg gain, initiation of rumination and blood biochemical constituents in pre-ruminant dairy calves. Maximum pre-weaning average daily gain (700 g/d) can be achieved in Holstein Friesian crossbred female calves through feeding milk by step up/step down method and calf starter containing finely ground maize grain and soybean hulls in the ratio of 20:30 without offering any roughage.

Keywords: Calf starter, Fibre, Maize grain, Performance, Pre-ruminant calves, Starch

[1]Department of Animal Nutrition, College of Veterinary Science, P.V. Narsimha Rao Telangana Veterinary University, Hyderabad-500 030, Telangana, India

[2]Department of Livestock Farm Complex, College of Veterinary Science, P.V. Narsimha Rao Telangana Veterinary University, Hyderabad-500 030, Telangana, India

G Alexander (✉)
Department of Animal Nutrition, College of Veterinary Science, Mamnoor, Warangal-506 166, Telangana
Email:dralexvet@rediffmail.com

Introduction

Pre-weaning average daily gain (ADG) in calves is considered as the most important factor that affects first lactation performance in cows (Soberon et al. 2012). Supply of adequate nutrients from both liquid and solid feeds and maintaining ADG above 0.5 kg/day can increase first lactation performance of cows (Gelsinger et al. 2016).

The growth of pre-ruminant dairy calves depends on both milk and solid feed intake. Most of the necessary nutrients to pre-ruminant calves is initially supplied from milk. The nutrients requirements increase tremendously with advancing age in the fast-growing pre-ruminant calves. Therefore, in addition to milk, solid feed intake also equally important to the pre-ruminant calves to get adequate nutrients (Gelsinger et al. 2016).

Early rumen development of pre-ruminant calves is important to maximize solid feed intake and the ADG. The overall rumen development depends on the development of rumen epithelium, rumen muscularization and rumen volume. Fermentation of solid feed in the rumen produces volatile fatty acids. Among the volatile fatty acids produced, butyrate and propionate mainly stimulate development of rumen epithelium. Greater rumen epithelial development is achieved through feeding of concentrates (Heinrichs, 2005). Cereal grains rich in starch are main components of concentrates that are fermented to volatile fatty acids which stimulate rumen epithelium development. Cereal grains are frequently ground to reduce particle size and then incorporated into calf starters. Grain particle size and processing affect the fermentation rate of starch in the rumen (Suarez-Mena et al. 2016a). However, the optimum particle size distribution of grain for incorporation into calf starters may also be affected by level of inclusion of grain and other dietary factors.

Studies revealed that fibre content and source of fibre in calf starter may affect the starter intake and performance of pre-weaning calves either positively or negatively (Porter et al. 2007; Hill et al. 2008b) possibly through influencing rumen muscularization and capacity. It was also established that calves can be reared without roughage during pre-weaning period (Göncü et al. 2010). Soybean hulls have been used as non-forage fibre source in calf starters (Hill et al. 2008a). Therefore, this study was aimed to evaluate effect of varying levels of fibre and starch in calf starters through changing the levels of finely ground maize grain (FGMG) and soybean hulls on performance of pre-ruminant calves fed no roughage.

Materials and methods

A feeding trial was conducted using pre-ruminant dairy calves at Haveli Dairy Farm, Mulugu, Siddipet, Telangana. Laboratory analysis of collected samples was done at Department of Animal Nutrition, College of Veterinary Science, P.V. Narsimha Rao Telangana Veterinary University, Rajendranagar, Hyderabad.

Particle size distribution of maize grain

The mean particle size distribution (%) of FGMG was determined according to the procedure described by Lammers et al. (1996). A specific quantity of ground maize sample was taken on the upper screen of 7 screens of British Standard System (B.S.S) (410/1969) 7, 10, 14, 25, 36, 52 and 72 and allowed to rotate on Rotop sieve shaker (Secor India Standard Test Sieves, Scientific Engineering Corporation, Delhi).

Experimental diets and distribution of calves

Three iso-nitrogenous calf starters containing 19% crude protein (CP) with varying levels of fibre and starch were prepared by keeping FGMG and soybean hulls content in the ratio of 40:10 (F_1), 30:20 (F_2) and 20:30 (F_3), respectively with minor adjustment on the content of other ingredients (Table 1). Eighteen Holstein Friesian (HF) crossbred female calves (average body weight, 34.19 ± 0.94) were randomly assigned to three treatment groups of 6 calves each in a completely randomized design. The calves were reared for 61 days from 3 to 63 day of age to evaluate the above mentioned experimental rations.

Housing, feeding and management

The calves were separated from the dam immediately after birth and 2 litres of colostrum was fed through bottle as soon as possible. About two hours after birth, the calves were shifted to well ventilated calf shed having elevated individual pens covered with rubber mattresses as bedding. Another 2 l of colostrum was bottle fed on first day of birth. The calves were fed with colostrum @ 4 l per day up to 3 days of birth in two feedings. Milk (treated with 125 mg of tetracycline hydrochloride/l) was offered in separate buckets to calves twice daily from fourth day of birth onwards up to 63 day of age at 6.00 am and 6.00 pm following step up/step down feeding schedule. Milk feeding was increased weekly from 4 l/d during first week to 7 l/d at fourth week. Then, the milk offered was gradually decreased from 7 l/d during sixth week to 4 l/d at ninth week.

In addition to milk feeding, the calves in each group were offered respective calf starters individually *ad libitum* from 3 to 63 day of age at 8.00 am. Clean drinking water was always available to each calf in separate bucket. The amount of calf starter offered and residues if any were recorded daily to arrive at calf starter intake. Daily representative samples of calf starter offered and residues if any (next day) were collected in separate polythene bags for estimation of dry matter (DM).

The body weight of calves was recorded initially on 3 day of age and thereafter at fortnightly intervals (18, 33, 48 and 63 day of age) in the morning before offering water, milk and starter using electronic digital balance. Fortnightly and overall DM intake, ADG and feed conversion efficiency and cost economics were calculated as per the standard procedures.

Initiation of rumination

All calves under experiment were observed for rumination from 3 day of age and the day of initiation of rumination from birth was recorded for each calf.

Collection of blood

Blood samples were collected from the individual calves on 63 day of age aseptically from the jugular vein of calves into clean sterilized glass tubes and kept in slanted position at room temperature for separation of serum. The collected serum samples were centrifuged at 3000 rpm for 5 minutes and the supernatant serum was transferred to 5 ml Eppendorf tubes and stored at -20°C for estimation of various biochemical constituents.

Chemical analysis

The DM, total ash (TA), CP, ether extract (EE) and crude fibre (CF) content of calf starters were determined as per the procedures described in AOAC (2012). Nitrogen free extract (NFE) was obtained by subtracting the sum of CP, EE, CF and TA percentage on DM basis from 100. Organic matter (OM) was obtained by deducting the per cent TA on DM basis from 100.

Neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and cellulose content of calf starters were determined as per the method described by Van Soest et al. (1991).

The NDF was estimated by refluxing the sample with neutral detergent solution containing 50 µl of heat stable α-amylase (A3306 dietary fiber kit, Sigma Chemical Co., St. Louis, MO). The hemicellulose was calculated by deducting per cent ADF from per cent NDF. Starch in the calf starters was estimated by following the method of Clegg (1956).

Analysis of blood biochemical constituents

Glucose in serum was estimated based on enzymatic method (Trinder, 1969) using a commercial kit (Coral Clinical Systems, Goa). Total protein in serum was determined by biuret method using a commercial kit (Coral Clinical Systems, Goa) as per the method of Reinhold (1953). Bromocresol green (BCG) method (Doumas et al. 1971) was used to estimate the albumin content of serum using a commercial kit supplied by Coral Clinical Systems, Goa. Globulin concentration in the serum was calculated by subtracting the albumin from total protein. Abumin:globulin was calculated by dividing serum albumin with globulin. The blood urea nitrogen (BUN) in serum was determined by enzymatic method (Bretaudiere et al. 1976) using the kit supplied by Accurex Biomedical Private Limited, Boisar, Maharastra. Precision Xtra (Abbott Precision Xtra Ketone Test Strip, New York, USA) calf-side test was used for determination of BHBA in freshly collected whole blood from ear vein of calves on 63 day of age.

Statistical analysis

The results obtained from the feeding trial were subjected to statistical analysis through software (Version 15.0; SPSS) by applying the one-way analysis of variance through the generalized linear model. The treatment means were ranked using Duncan's multiple range test with a significance at $P < 0.05$ (Duncan, 1955).

Results and discussion

Particle size distribution of finely ground maize grain and the chemical composition of calf starters

The FGMG had 57.72% particles with a size of 1.18 mm and above (Figure 1) suggesting that the ground maize had moderate amount of fine particles. The calf starters used in the feeding trial were formulated to be isonitrogenous and hence contained similar levels of CP (19.30 to 19.33%; Table 2). All the proximate principles and cell wall constituents except CP differed among calf starters (Table 2) because of variations in the content of maize and soybean hulls in the calf starters. As the level of soybean hulls increased and maize content decreased, the NDF increased and starch decreased proportionately in the calf starters. The NDF content of calf starters varied from 18.33 to 29.89% (Table 2) which was higher than the NRC (2001) recommended value (NDF, 12.8%). In most of the earlier studies, the NDF content of calf starters was maintained below 20% (Hill et al. 2008a; Hill et al. 2008b; Bateman et al. 2009; Omidi-Mirzaei et al. 2015; Maktabi et al. 2016; Daneshvar et al. 2017). However, in some of the previous studies, the calf starters contained more than 20% NDF (Hill et al. 2009; Göncü et al. 2010; Rezapour et al. 2016). The starch content of calf starters in previous studies ranged from 25 to 42.3% (Suarez et al. 2007; Hill et al. 2008a; Hill et al. 2008b; Suarez-Mena

Table 1 Ingredient composition (%) of calf starters used for the feeding trial

Ingredients (kg/100kg)	F_1	F_2	F_3
Maize grain	40.0	30.0	20.0
Wheat bran	12.0	12.7	13.4
Molasses (cane)	8.0	8.0	8.0
Protected soybean meal	12.5	12.5	12.5
Soybean meal	12.4	11.85	11.3
Soybean hulls	10.0	20.0	30.0
Sodium bicarbonate	0.7	0.7	0.7
Dicalcium phosphate	0.43	0.5	0.55
Protected fat (Calcium soap)	1.0	1.0	1.0
Yeast (*Saccharomyces cerevisiae*)	0.3	0.3	0.3
Trace mineral and vitamin mixture*	0.3	0.3	0.3
Limestone powder	1.57	1.35	1.15
Toxin binder	0.5	0.5	0.5
Salt	0.3	0.3	0.3
Total	100	100	100

*Values per kg: Cu 6.750 g; Mn 18 g; Zn 33.750 g; Co 0.540g; Se 0.200g; Vitamin A 0.500 MIU; Vitamin D_3 0.500 MIU; Vitamin E 22.50 g and Biotin 0.500 g.

F_1: Finely ground maize grain and soybean hulls in the ratio of 40:10

F_2: Finely ground maize grain and soybean hulls in the ratio of 30:20

F_3: Finely ground maize grain and soybean hulls in the ratio of 20:30

et al. 2016b). In the present study, the starch content of calf starters varied from 18.71 to 32.37% (Table 2).

Milk intake

Even though, the amount of milk (l/d) fed was similar in the first and fourth fortnights, the fortnightly average milk intake of calves expressed as per cent of body weight was low at fourth fortnight (Table 3) because of increase in body weight of calves from the first week to ninth week. However, there was no significant difference in milk intake among calves fed different calf starters at different fortnights during the experimental period. The milk offered to calves by following step up/step down method was relatively higher in this study if compared to the conventional method (@ 10% of body weight). As the calf starter intake is limited during the first 4 weeks of age (Table 4), *ad libitum* to close to *ad libitum* milk feeding is beneficial to the calf in terms of resistance to disease, lifetime performance and calf welfare (Lorenz, 2021).

Dry matter intake

Even though the level of fibre and starch varied among calf starters, the fortnightly and overall average DM intake (Table 4; 401.89 to 424.68 g/d) was comparable among calves fed different calf starters. Similarly, starter intake did not differ significantly in pre-ruminant Holstein calves fed high-fibre (29.03%) or low-fibre (16.90%) diets (Porter et al. 2007). Further, high levels of soybean hulls with varying levels of fibre and starch in the pelleted starter containing large amount of fine particles (more than 93% of particles had particles <1.180 mm) did not influence on starter intake during the pre-weaning period in calves (Hill et al. 2008a). However, the starter DM intake in calves in the present study was relatively less as compared to those observed in earlier studies (Hill et al. 2008a; Göncü et al. 2010; Omidi-Mirzaei et al. 2015) which might be due to relatively higher milk intake.

Fig. 1 Finely ground maize grain

Table 2 Chemical composition (% DM) of calf starters containing finely ground maize grain

Constituent (%)	F_1	F_2	F_3
Dry matter	91.83	92.32	92.32
Organic matter	91.71	91.21	91.17
Total ash	8.29	8.79	8.83
Crude protein	19.33	19.30	19.33
Ether extract	3.72	3.66	3.55
Crude fibre	7.36	11.39	14.69
Nitrogen free extract	61.30	56.86	53.60
Starch	32.37	25.39	18.71
Neutral detergent fibre	18.33	23.64	29.89
Acid detergent fibre	10.25	14.53	18.76
Hemicellulose	8.08	9.11	11.13
Cellulose	8.52	11.92	16.23
Lignin	1.17	1.31	1.55
Calcium	1.35	1.31	1.25
Phosphorus	0.79	0.68	0.69

Each value is the average of duplicate analysis
F_1: Finely ground maize grain and soybean hulls in the ratio of 40:10
F_2: Finely ground maize grain and soybean hulls in the ratio of 30:20
F_3: Finely ground maize grain and soybean hulls in the ratio of 20:30

Fortnightly body weight changes and average daily gain

Step up/step down milk feeding and *ad libitum* calf starter feeding from 3 day of age ensure more bioavailable nutrient supply from milk and necessary solid feed supply for rumen development during the initial period. With increasing calf starter intake in response to rumen development, the nutrient supply from milk is decreased by reducing the milk offered gradually until weaning.

The varying levels of fibre and starch in the calf starters did not significantly (P>0.05) affect the fortnightly body weight changes and ADG in calves throughout the experimental period (Tables 5 and 6). The overall ADG (kg/d; Table 6) was 0.69, 0.66 and 0.70 in calves fed calf starters F_1, F_2 and F_3 respectively. However, in the second fortnight, the average starter DM intake and ADG were 75.84 and 64.8 g and 50 and 90 g higher in F_2 and F_3 calves (Tables 4 and 6), respectively than F_1 calves. It appears that the high level of inclusion of FGMG (40%) in calf starter F_1 could have increased volatile fatty acids production, lowered rumen pH and adversely affected the health of rumen papillae thereby reducing DM intake and ADG. During fourth fortnight, the calves under F_1, on an average consumed 149.69 and 61.04 g more calf starter DM and recorded 50 and 60 g more ADG than calves fed F_2 and F_3 calf starters, respectively which suggested that the inclusion of high level of maize grain (40%) in calf starters may be beneficial at 8 to 9 weeks of age.

Table 3 Fortnightly average milk intake (% body weight) in pre-ruminant dairy calves fed different calf starters containing finely ground maize grain

Fortnight	F_1	F_2	F_3	SEM	P value
1	13.67±0.52	13.65±0.71	13.59±0.73	0.358	0.996
2	15.54±0.59	15.52±0.76	15.05±0.71	0.381	0.855
3	12.14±0.50	12.16±0.58	11.75±0.54	0.301	0.841
4	6.74±0.26	6.85±0.32	6.64±0.28	0.159	0.883

Table 4 Effect of varying levels of fibre and starch in calf starters containing finely ground maize grain on fortnightly and overall average dry matter intake (g/d) in pre-ruminant dairy calves

Fortnight	F_1	F_2	F_3	SEM	P value
1	39.67±12.65	77.00±22.66	39.49±5.53	9.35	0.172
2	150.96±36.63	226.80±48.28	215.76±43.37	24.71	0.425
3	431.50±97.46	381.04±87.96	419.31±78.75	48.22	0.916
4	1063.88±100.01	914.19±153.64	1002.84±116.40	69.61	0.703
Overall	424.68±57.31	401.89±76.80	423.38±56.20	34.88	0.961

Table 5 Effect of varying levels of fibre and starch in calf starters containing finely ground maize grain on fortnightly body weight (kg) changes in pre-ruminant dairy calves

Fortnight	F_1	F_2	F_3	SEM	P value
Initial weight	33.95±1.53	34.65±1.68	33.97±1.94	0.94	0.949
1	39.75±1.64	39.55±2.10	40.62±2.01	1.05	0.918
2	48.50±2.37	49.08±2.22	50.77±2.58	1.32	0.789
3	61.25±2.96	60.75±3.19	62.85±3.18	1.70	0.884
4	76.32±2.80	75.00±3.31	77.05±3.39	1.74	0.899

Table 6 Effect of varying levels of fibre and starch in calf starters containing finely ground maize grain on fortnightly and overall average daily gain (kg/d) in pre-ruminant dairy calves

Fortnight	F_1	F_2	F_3	SEM	P value
1	0.39±0.05	0.33±0.05	0.44±0.05	0.032	0.340
2	0.58±0.07	0.63±0.04	0.67±0.09	0.041	0.695
3	0.85±0.08	0.77±0.07	0.80±0.05	0.040	0.783
4	1.00±0.04	0.95±0.05	0.94±0.06	0.029	0.697
Overall	0.69±0.39	0.66±0.03	0.70±0.04	0.021	0.694

The increased level of fibre in the calf starter through non-forage fibre sources did not influence ADG significantly in most of the previous studies (Porter et al. 2007; Hill et al. 2008a; Hill et al. 2008b) which is in accordance with observations of present study. Maktabi et al. (2016) recorded 582 g/d ADG in pre-ruminant male calves fed starter with no fibre source (NDF, 14.1%), while the ADG (g/d) was 657 and 605 in calves fed starter containing 10% (NDF 17.1%) and 20% (19.9%) beet pulp as non-forage fibre source. However, the pre-weaning ADG in the calves of the present investigation was comparatively higher than the earlier studies (Porter et al. 2007; Hill et al. 2008a; Hill et al. 2008b; Göncü et al. 2010; Daneshvar et al. 2017) which could be attributed to higher milk intake of calves in the present study due to step up/ step down method of milk feeding and longer pre-weaning period.

Feed conversion efficiency

The calves, in general, exhibited better feed conversion efficiency (calculated considering starter intake and ADG) during the initial period of the study as compared to the final period (Table 7) which could be attributed to a higher intake of milk during the first few weeks of life. Increased calf starter intake with advancing age might have contributed for poor efficiency towards the end of the pre-weaning period. The higher feed conversion efficiency ($P<0.05$) observed in F_2 calves than F_1 and F_3 calves in the first fortnight might be due to inefficient utilization of milk. However, relatively lower feed efficiency (9.8%) observed in F_2 calves during the fourth fortnight could be attributed to relatively lower calf starter DM intake. The overall feed conversion efficiency in F_1, F_2 and F_3 claves was 0.61, 0.60 and 0.59, respectively and was not influenced by varying levels of fibre and starch in the calf starters.

More or less similar feed efficiency was observed in some of the earlier experiments with pre-ruminant calves (Hill et al. 2009; Omidi-Mirzaei et al. 2015; Maktabi et al. 2016) and the feed efficiency was not influenced due to varying levels of fibre in calf starters in pre-ruminant calves (Maktabi et al. 2016). However, extremely high (Göncü et al. 2010) or low (Fokkink et al. 2011; Daneshvar et al. 2017) feed efficiency was observed in other studies involving pre-ruminant calves. The difference in feed efficiency between studies could be attributed to variations in milk/milk replacer feeding, weaning age, type of calf starter, breed and environment.

Table 7 Effect of varying levels of fibre and starch in calf starters containing finely ground maize grain on fortnightly and overall feed conversion efficiency in pre-ruminant dairy calves

Fortnight	F_1	F_2	F_3	SEM	P value
1	0.10±0.03[b]	0.24±0.04[a]	0.09±0.02[b]	0.023	0.009
2	0.28±0.07	0.35±0.06	0.32±0.04	0.034	0.698
3	0.50±0.08	0.47±0.85	0.51±0.06	0.042	0.950
4	1.12±0.09	1.01±0.14	1.12±0.11	0.066	0.746
Overall	0.61±0.06	0.60±0.08	0.59±0.04	0.037	0.975

Table 8 Cost economics of feeding calf starters with varying levels of fibre and starch containing finely ground maize grain in pre-ruminant dairy calves

Parameter	F_1	F_2	F_3	SEM	P value
Feed intake/day (kg)	0.456±0.06	0.420±0.08	0.448±0.06	0.037	0.927
Cost of feed/kg (Rs.)	22.71	22.80	22.87	-	-
Cost of feed/day (Rs.)	10.38±1.42	9.58±1.87	10.25±1.40	0.863	0.929
Cost of feed/kg gain (Rs.)	14.84±1.75	14.07±2.10	14.25±1.13	0.931	0.946

Table 9 Effect of varying levels of fibre and starch in calf starters containing finely ground maize grain on blood biochemical profile in pre-ruminant dairy calves

Constituent	F_1	F_2	F_3	SEM	P value
Glucose (mg/dl)	92.01±1.80	89.47±1.38	87.48±1.30	0.933	0.139
Total protein (g/dl)	7.16±0.09	7.18±0.06	7.22±0.09	0.046	0.881
Albumin(g/dl)	3.95±0.07	3.99±0.02	3.98±0.04	0.029	0.874
Globulin(g/dl)	3.21±0.12	3.20±0.07	3.24±0.10	0.056	0.949
Albumin:globulin	1.24±0.06	1.25±0.03	1.23±0.04	0.276	0.972
Blood urea nitrogen (mg/dl)	13.92±0.58	13.40±0.32	13.43±0.19	0.226	0.602
β- hydroxy butyrate (mmol/l)	0.38±0.02	0.37±0.03	0.30±0.03	0.016	0.09

Cost economics

There was no much variation in cost of the ground maize grain and soybean hulls which varied among calf starters. Hence, the cost of the calf starters was more or less similar among treatments (Table 8). The feed cost per kg gain was 59 paise less in calves fed calf starter F_3 as compared to those calves fed calf starter F_1 which could be attributed to relatively better body weight gain and feed conversion efficiency. The primary objective of pre-weaning calf nutrition is to achieve maximum ADG. Even though, the lowest cost per kg gain was recorded in calves fed calf starter F_2, the body weight gain in this group was relatively lower and therefore, the advantage on feed cost/kg gain may not be favourably considered.

Initiation of rumination

Initiation of rumination in pre-ruminant calves indicates the beginning of rumen development. The average days required for initiation of rumination in the present study were 17.17±1.72, 17.33±1.02 and 18.67±1.25 in F1, F2 and F3 groups of calves and the differences among the treatments were not significant. The varying fibre levels (NDF, 18.33 to 29.89%) in the calf starters did not affect initiation of rumination in pre-ruminant calves. Similarly, Porter et al. (2007) also reported that fibre levels (NDF, 16.90 vs 29.06%) in calf starters did not affect initiation of rumination in pre-ruminant Holstein calves.

Blood biochemical profile

Calf starters containing varying levels of fibre and starch fed to calves did not significantly (P>0.05) influence serum glucose, total protein, albumin, globulin, albumin: globulin and BUN and blood BHBA levels (Table 9) suggesting that the level of starch or NDF in calf starters may not influence blood biochemical constituents.

The BUN in the blood of pre-weaned calves is indicative of initiation of urea recycling and absorption during rumen development (Hayashi et al. 2006). The BUN levels observed in the calves of the present study at 63 day of age indicated the possibility of a higher level of ammonia in the rumen due to degradation of starter proteins.

The blood BHBA (mmol/l) in calves fed calf starters F_1, F_2 and F_3 at 63 day of age was 0.38, 037 and 0.30, respectively and was not significantly different among treatments. However, BHBA concentration was 21% higher in calves fed calf starter (F1) containing 40% maize than calves fed calf starters containing 20% maize. Increase in blood BHBA was observed earlier with increasing grain intake in calves (Quigley et al. 1991).

Conclusion

Varying levels of starch and fibre in calf starters containing FGMG (57.72% of particles with a size of 1.18 mm above) had no influence on overall starter DM intake, ADG, feed conversion efficiency, initiation of rumination, faecal score and blood biochemical constituents in pre-weaning dairy calves. Feeding milk by step up/step down method and calf starter containing finely ground maize grain and soybean hulls in the ratio of 20:30 without offering any roughage can be recommended to achieve maximum pre-weaning average daily gain (700 g/d) in HF cross bred female calves.

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