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Nutrient utilization, balances of Ca, P and N in lactating crossbred cows fed berseem fodder based total mixed ration containing different levels of energy and protein

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ABSTRACT

A metabolism trial was conducted on 12 crossbred cows (Karan Fries) assess the nutritive value of berseem based total mixed ration (having different levels of energy and protein) in terms of DCP, TDN and balances of Ca, P and N in lactating animals. They were randomly distributed into 3 groups of 4 each. The animals were offered berseem based TMR with energy and protein levels (%) as 55, 10 (group 1); 60, 12 (group 2) and 65, 14 (group 3) respectively. The feeding was done *ad lib*. The results indicated significantly higher digestibility of CP in group 3 as compared to groups 1 and 2. The digestibility of CF was significantly higher ($P<0.05$) in groups 1 and 3 as compared to group 2. The animals of group 3 also showed significantly higher digestibility of NFE as compared to group 1. The digestibility coefficients of various proximate principles and NDF ranged from 59.7 to 78.6% indicating by and large a highly digestible nature of various nutrients of TMR. There was no significant difference with respect to TDN among the 3 groups. In spite of assumed levels of 55, 60 and 65% in the 3 groups, the actual levels obtained ranged from 60.72 to 63.71%. The nutritive ratio ranged from 4.53 to 8.00 in 3 groups, being highest in group 1 and lowest in group 3. N-retained (g/100 kg BW) was significantly higher ($P<0.01$) in group 3 followed by group 2 and lowest in group 1. Ca and P retained (g/100kg BW) was significantly higher ($P<0.01$) in group 3 as compared to groups 1 and 2. The higher retention of Ca in the animals of group 3 may be due to the higher content of Ca in the TMR of these animals, higher DMI and the less losses through faeces. Milk yield was significantly higher ($P<0.05$) in groups 2 and 3 as compared to group 1. In milk composition TS, SNF and NPN were significantly higher ($P<0.05$) in group 1 as compared to groups 2 and 3, whereas the protein content in the milk was significantly higher ($P<0.01$) in group 3 as compared to groups 1 and 2. The higher retention of Ca in the animals of group 3 may be due to the higher content of Ca in the TMR of these animals, higher DMI and the less losses through faeces. Milk yield was significantly higher ($P<0.05$) in groups 2 and 3 as compared to group 1. In milk composition TS, SNF and NPN were significantly higher ($P<0.05$) in group 1 as compared to groups 2 and 3, whereas the protein content in the milk was significantly higher ($P<0.01$) in group 3 as compared to groups 1 and 2.

Key words: Animal nutrition, Berseem, Cows, Energy, Nutrient utilization, Protein, Total mixed ration

Total mixed ration (TMR) is used synonymously with complete feed, total blended ration and is a quantitative mixture of all dietary ingredients, blended thoroughly to prevent separation and sorting, formulated to specific nutrient content and offered *ad lib*. The formation of TMR and its quality is determined and affected by number of factors like nutrient density, particle size, source of roughage etc. The supply of green forage fluctuates according to season and conservation of forage is a must for regular supply of green forage throughout the year. Berseem (*Trifolium alexandrinum*) is a green leguminous fodder grown in winter in India, particularly in northern milk tract of Punjab, Haryana and Uttar Pradesh. In the present study, berseem was used as the roughage source in total mixed ration to evaluate its nutritive value in terms of digestible crude protein, total digestible nutrients and balances of Ca, P and nitrogen in lactating crossbred cows.

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MATERIALS AND METHODS

Crossbreds Karan Fries lactating cows (12) of similar milk yield and stage of lactation were randomly distributed into 3 groups of 4 each. Animals of each group were offered berseem based TMRs containing different levels of energy (TDN) and protein (CP) as 55, 10 (group 1); 60, 12 (group 2) and 65, 14 (group 3) respectively (NRC 1989). The average milk yield

in the beginning of experiment was 8.08±0.82, 9.00±0.84 and 8.82±0.89 in the 3 respective groups.

Management, preparation of TMRs and feeding of animals

Animals were maintained throughout the trial in a well ventilated shed and tied up individually where they can lie or move around freely. Each animal was separated from adjacent animal by specially designed iron rails at 1.5 m height and kept in floor space of 1.8 m×1.2 m. Separate large mangers were provided for each animal for feeding. Each animal was brushed and washed before milking at 5.30 AM, 12.00 noon and 6.00 PM daily.

Fresh green berseem fodder was chaffed daily in the morning to the size of 1 cm approximately. The chaffed fodder was then thoroughly mixed with the already mixed other constituents of the TMR. The composition of TMR offered to animals in each group is shown in Table 1. Each day 3 TMRs were prepared as per the requirement of the experiment in terms of energy and protein. Then each animal was offered TMR *ad lib.* Water was offered free choice. After, about 40 days of feeding a metabolism trial of 7-day was conducted to assess the nutritive value of berseem fodder based TMRs in terms of DCP, TDN balances of Ca, P and N in the lactating crossbred cows.

Table 1. Composition of TMRs in different groups

Ingredients	Parts		
	Group 1	Group 2	Group 3
Berseem fodder	25.0	34.0	40.0
Wheat straw	46.5	27.5	13.5
Wheat bran	21.0	20.0	16.0
Maize grain	2.0	12.0	21.0
Mustard oil-cake	4.0	5.0	8.0
Mineral mixture	1.0	1.0	1.0
Common salt	0.5	0.5	0.5
Total	100.00	100.00	100.00
*TDN%	55.05	60.26	65.24
**CP%	10.02	12.13	14.04

*Assumed values; **,analysed values.

Collection of milk samples

Milk samples were collected 3 times a day at milking time and pooled daily. Each time, 100 ml of milk sample was collected after uniform mixing of total milk in the bucket. Milk samples were stored in a refrigerator at 5°C using 3-4 drops of formalin per 100 ml milk as a preservative. A representative amount of aliquot was used for analysis of total solids, protein, NPN and fat content.

Collection of faeces and urine

Manual collection of faeces was done round the clock for 24 hr and after weighing, the faeces of each animal was thoroughly mixed and representative sample was retained for analysis daily. Similarly, urine of each animal was collected for 24 hr and representative sample kept for analysis.

Milk yield

Daily recording of milk yield of each animal was done. Milk yield was recorded 3 times in a day i.e., at 5.30 AM, 12.00 noon and 6.00 PM.

Milk composition

Milk samples were collected fortnightly for the analysis of milk for its composition. Each time 100 ml of milk sample was collected in a plastic bottle after uniform mixing of total milk of each animal in plastic bucket. Representative amount from each sample was used for determination of total solids, protein, non-protein nitrogen (NPN), fat and SNF contents in milk.

Analysis of feed, faeces, urine and milk

Samples of TMR offered and faeces collected were analysed for DM, CP, EE, CF, total ash (AOAC 1995) and NDF, ADF (Goering and VanSoest 1970). Samples of urine of each animal were also analysed for nitrogen (AOAC 1995). Representative samples of feed (TMR), faeces, urine and milk were analysed for Ca (Humphries 1956) and P (Ward and Johnstone 1962). Digestibility of DM, OM and various nutrients was calculated by subtracting the amount of DM, OM or the nutrients eliminated through faeces from the amount consumed.

Milk analysis

Total solids in milk were determined by following Gravimetric Method (ISI 1961). Milk sample (10 ml) was pipetted into a pre-weighed clean dry silica crucible separately and then weighed again. Crucible containing milk was then placed in boiling water-bath. After 30 min, crucible was removed from water bath and kept in the hot air oven at 90°–100°C, until constant weighing. Difference in the 2 weights gave the total solid content of the milk. The protein in the milk sample was determined as per AOAC (1995). The protein content in milk was obtained by multiplying N-content with the factor 6.38. For the determination of NPN content in the milk, the protein in the sample was precipitated using trichloroacetic acid and the filterate containing NPN was determined using micro-kjeldalh method of N-determination (AOAC 1995) Percentage of milk fat was estimated by using Gerber's method and the SNF in milk sample was calculated by subtracting milk fat percentage from total solids in the milk.

Statistical analysis

The data for different parameters collected during metabolism trial were subjected to statistical analysis (Snedecor and Cochran 1980).

RESULTS AND DISCUSSION

The chemical composition of various rations is shown in Table 2. The dry-matter intake and digestibility coefficients (%) of various nutrients (DM, OM, CP, EE, NFE, NDF and ADF) and nutritive value of TMRs in dairy cows fed TMRs in 3 groups having different levels of TDN and CP are shown in Table 3. There was no significant difference in the digestibility coefficients of DM, OM, EE, NDF and ADF. The digestibility of CP was significantly higher ($P<0.05$) in group 3 as compared to groups 1 and 2. The digestibility of CF was significantly higher ($P<0.05$) in groups 1 and 3 as compared to group 2. However, the higher digestibility of CF was not reflected by the digestibility figures of either NDF or ADF. The animals of group 3 also showed significantly higher ($P<0.05$) digestibility of NFE as compared to group 1. Studies on lactating crossbred cows with partial replacement of protein of concentrate mixture with berseem hay showed no significant difference in the digestibility of nutrients except EE (Pachauri *et al.* 1994). Chauhan and Chopra (1984) also observed similar findings, when the concentrate mixture was replaced by 33–36% berseem on the basis of digestible OM. Singh *et al.* (1998) compared the berseem based complete blocks with the conventional feeding system in buffalo calves. The digestibility coefficients of proximate principles, except CF did not vary between the 2 groups. The CF digestibility was higher ($P<0.05$) in conventional systems, whereas cost per kg gain was substantially lower in berseem based block. The digestibility coefficients of various proximate principles and NDF ranged from 59.7% to 78.6% indicating, by and large, a highly digestible nature of nutrients of various TMRs used in this study. Digestibility coefficients of EE ranged from 69.9% to 72.7% indicating a fairly high digestibility because of total mixed nature of ration while in forages generally the digestibility coefficient of EE is moderate to low because of the presence of indigestible and less digestible contents of the EE, such as pigments, sterols etc. This also contributed to an elevation of TDN value in lower TDN (assumed 55%) group.

Table 2.Chemical composition (%DM basis) of various TMRs in different groups

Attributes	Groups		
	1	2	3
OM	83.84	82.58	81.79
CP	10.32	12.46	14.67
EE	2.65	3.10	3.62
CF	22.08	18.05	15.21
NDF	54.65	48.46	42.99
ADF	38.00	32.70	28.57
NFE	48.79	48.97	48.29
Total ash	16.16	17.42	18.21

Table 3. Dry matter intake and digestibility coefficients (%) of various nutrients and nutritive value of the TMRs in dairy cows

Attributes	Groups		
	1	2	3
Body weight (kg)	424.5±45.87	453.4±35.19	445.0±45.62
DMI/100 kg body wt. (kg)	3.31	3.74	4.00
Digestibility coefficients (%)			
DM	66.76±2.29	66.93±0.72	72.17±1.23
OM	70.31±1.91	70.35±0.73	75.47±1.04
CP*	65.45^{a}±2.27	69.22^{a}±0.92	78.55^{b}±1.42
EE	69.85±1.23	71.77±0.78	72.72±1.42
CF*	72.06^{a}±1.07	64.13^{b}±0.83	69.07^{a}±0.78
NFE*	69.44^{a}±1.79	72.84^{ab}±1.03	76.76^{b}±1.21
NDF	63.66±2.55	59.73±0.83	64.43±0.69
ADF	56.37±2.25	53.07±1.81	58.02±1.17
Nutritive value			
DCP** (%)	6.76^{a}±0.24	8.63^{b}±0.11	11.52^{c}±0.21
TDN (%)	60.72±1.23	60.88±0.62	63.71±1.16
Nutritive ratio*	8.00^{a}±0.19	6.06^{b}±0.10	4.53^{c}±0.06

Values with different superscripts within a row differ significantly. *($P<0.05$) **($P<0.01$).

Digestible crude protein (DCP) in the TMRs increased with the increase in their CP content. It was because of increase in the digestibility of CP with the increase in the content of CP in the ration of different groups. There was no significant difference with respect to total digestible nutrients (TDN) among the 3 groups. In spite of assumed levels of 55, 60 and 65% in the 3 groups, the actual levels obtained ranged from 60.72 to 63.71%. The nutritive ratio ranged from 4.53 to 8.00 in 3 groups, being highest in group 1 and lowest in group 3, and it was expected because nutritive ratio declines with progressive increase in the CP levels of feed and progressive increase in the digestibility of protein.

N balance

The N intake (Table 4) was highest in group 3 followed by groups 2 and 1. This was expected because of higher concentration of protein in the ration of groups 3 and 2 as compared to group 1 and also the higher DMI in the groups 3 and 2. Losses through faeces was highest in groups 2 (medium protein level ration). However, losses through urine were higher in groups 2 and 3, as compared to group 1. Animals fed TMRs with higher levels of protein (groups 2 and 3) excreted higher amount of nitrogen in milk, highest being in group 3. N retained (g/100 kg BW) was significantly higher ($P<0.01$) in group 3, followed by group 2 and lowest in group 1.

Ca balance

The intake of Ca was highest in group 3, followed by groups 2 and 1 (Table 4). It was expected due to higher DMI by the animals of these groups and also the higher Ca content in the TMR of group 3. The outgo through the faeces was

Table 4. N, Ca and P balance in dairy cows fed berseem fodder based TMRs

N balance (g/day)	Groups		
	1	2	3
N intake	223.50±10.42	334.72±24.45	409.26±22.73
N outgo			
In faeces	77.39±6.42	103.28±8.63	87.77±8.03
In urine	60.81±6.68	71.88±3.33	78.30±6.83
In milk	41.15±3.67	54.78±2.60	72.21±1.50
N balance**	44.15^{a}±6.61	104.80^{b}±13.26	175.98^{c}±21.9
N retained** (g/100 kg bw)	10.94^{a}±2.34	22.90^{b}±1.90	39.57^{c}±49
Ca balance (g/day)			
Ca intake	176.09±8.21	235.78±17.20	252.52±14.02
In faeces	138.85±6.25	185.30±22.12	119.24±7.18
In urine	5.00±0.94	5.61±1.78	8.80±0.46
In milk	11.61±1.04	15.40±1.92	27.25±4.49
Ca outgo			
Ca balance**	20.63^{a}±6.97	29.18^{a}±4.80	97.23^{b}±3.52
Ca retained** (g/100kg bw)	4.78^{a}±1.22	6.81^{a}±1.68	22.22^{b}±3.52
P balance (g/day)			
P intake	96.17±4.48	123.42±10.46	148.03±8.22
P outgo			
In faeces	29.05±1.60	40.94±3.14	36.42±2.24
In urine	6.02±1.06	6.62±1.86	8.57±1.00
In milk	11.51±1.82	17.06±4.63	10.90±0.63
P balance	49.60±5.24	58.80±7.15	92.15±6.49
P retained** (g/100kg bw)	12.04^{a}±1.65	13.03^{a}±1.48	21.12^{b}±1.47

Values with different superscripts within a row differ significantly. *(P<0.05) **(P<0.01).

highest in group 2 and excretion through urine and milk was highest in the animals of group 3. Ca retained (g/100 kg BW) was significantly higher (P<0.01) in group 3 as compared to groups 1 and 2. The highest retention of Ca in the animals of group 3 may be due to the higher content of Ca in the TMR of these animals, higher DMI and the less losses through the faeces. Calcium availability decreases as Ca intake increases (Braithwaite 1979). When an animal's calcium intake exceeds its requirement, absorption declines regardless of calcium availability. Hansard *et al.* (1954, 1957) demonstrated that as cattle increased in age, true absorption of Ca decreased from 98% in milk fed calves to 22% in aged animals. The average availability of calcium in diets fed to lactating dairy cows (Ward *et al.* 1972, Klooster 1976, Hibbs and Conard 1983) ranged between 35 to 38%. In the present study, the animals of group 3 gained comparatively more body weight (+48.3 kg) in total lactation trial of 75 days as compared to other 2 groups, especially group 1 (+23.50). It may be possible that higher retention of Ca (g/100 kg bw) by the animals of this group would have contributed to the deposition in bones. This was in spite of higher excretion of Ca in milk by the animals of this group.

Table 5. Average milk yield (kg) and average compostion of milk (%) in dairy cows fed berseem fodder based TMRs in three groups having differengt levels of TDN and CP

Attributes	Groups		
	1	2	3
Milk yield (kg)	7.66^{a}±0.68	11.46^{b}±1.00	11.08^{b}±1.03
Fat	3.96±0.30	3.98±0.32	3.75±0.13
TS	14.09^{a}±0.46	13.4^{b}±0.22	13.37^{b}±0.42
SNF	10.13^{a}±0.47	9.44^{b}±0.10	9.62^{b}±0.44
Protein	3.48^{a}±0.07	3.30^{a}±0.14	4.09^{b}±0.02
NPN (mg%)	32.03^{a}±1.25	26.60^{b}±2.20	28.86^{b}±0.45

Values with different superscripts in the row between groups differ significantly, P<0.05.

P balance

The P balance (g/day) in 3 groups having different levels of TDN and CP is presented in Table 6. The P intake was highest in the animals of group 3 followed by groups 2 and 1. This may be due to higher P content in the TMR of group 3 and group 2 and also the higher DMI by the animals of these groups as compared to that of group 1. P outgo through faeces was also higher in the groups 2 and 3, whereas in urine the differences were not significant. P excretion through milk was higher in group 2 compared to groups 1 and 3 because of comparatively higher milk production in this group. P balance or P retained (g/100 kg bw) was significantly higher (P<0.01) in group 3 as compared to groups 1 and 2.

Most endogenous phosphorus is excreted through the faeces and varies with the amount of phosphorus consumed (ARC 1980). Variable endogenous faeces excretion is an important homeostatic control route for phosphorus. Urinary losses of phosphorus by cattle are generally low.

The amount of phosphorus absorbed by the animal depends on the source of the phosphorus, the amount of intake, the calcium-to-phosphorus ratio, intestinal pH, the age of the animal and dietary levels of calcium, iron, aluminium, manganese, potassium, magnesium and fat (Irving 1964). Teh *et al.* (1982) reported that increasing dietary phosphorus from 0.24 to 0.31% increased intake, live weight gain, plasma inorganic phosphorus and the breaking strength of tibia and ribs, Wise *et al.* (1958) recommended that 0.30% phosphorus be considered the minimum safe dietary allowance. In the present study, the percentage of phosphorus in the TMRs ranged from 0.71% to 0.85%. Considering the availability of 55% (NRC 1978), all the animals were getting the adequate amount of phosphorus. The phosphorus content of milk varies with its fat content, which is due to differences among breeds. Phosphorus needs as a percentage of the diet increases with the level of milk production, a relationship that occurs because of the animal's increased energy needs for higher production.

Milk yield and milk composition

There was significant difference in the milk yield between the different groups. It was significantly higher ($P<0.05$) in group 2 and 3 as compared to group 1 (Table 7). This may be due to the higher energy and protein concentration in the ration of animals group 2 and 3. The total solids (%), SNF (%) and NPN (mg %) were significantly higher ($P<0.05$) in group 1 as compared to groups 2 and 3, whereas the protein content in the milk was significantly higher ($P<0.01$) in group 3 as compared to groups 1 and 2. This indicated the influence of CP level of TMR on the protein content in milk. Because of the low yield in the group 1, there was significantly higher SNF content, but lower content of protein shows that protein availability was less (low protein ration). A higher NPN content in group 1 indicates slight wastage of protein; however, comparatively lower NPN content in the groups 2 and 3 indicates better utilization of protein which is reflected by higher protein content in the milk of group 3. Studies in lactating crossbred cows with partial replacement of protein of concentrate mixture with berseem hay showed no significant difference in the milk yield in different groups (Pachauri *et al.* 1994). Similar results were also reported by Chauhan and Chopra (1994), when these workers replaced concentrate mixture by 33–66% berseem on the basis of digestible OM.

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