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Black gram (*Vigna Mungo* L.) foliage supplementation to crossbred cows: effects on feed intake, nutrient digestibility and milk production

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Objective: An experiment was conducted to examine the effect of dietary supplementation of dried and ground foliage of black gram (*Vigna mungo* L.) on feed intake and utilization, and production performance of crossbred lactating cows.
Methods: Eighteen lactating crossbred (*Bos taurus*×*Bos indicus*) cows (body weight 330.93± 10.82 kg) at their second and mid lactation (milk yield 6.77±0.54 kg/d) were randomly divided into three groups of six each in a completely randomized block design. Three supplements were formulated by quantitatively replacing 0, 50, and 100 per cent of dietary wheat bran of concentrate mixture with dried and ground foliage of black gram. The designated supplement was fed to each group with basal diet of rice straw (*ad libitum*) to meet the requirements for maintenance and milk production. Daily feed intake and milk yield was recorded. A digestion trial was conducted to determine the total tract digestibility of various nutrients.
Results: The daily feed intake was increased ($p<0.05$) with the supplementation of black gram foliage. Although the digestibility of dry matter, organic matter, crude protein, and ether extract did not vary ($p>0.05$), the fibre digestibility was increased ($p<0.05$), which ultimately improved ($p<0.05$) the total digestible nutrients content of composite diet. Although, the average milk yield (kg/animal/d) and composition did not differ ($p>0.05$) among the groups, milk yield was increased by 10 per cent with total replacement of wheat bran in concentrate mixture with of black gram foliage. The economics of milk production calculated as feed cost per kg milk yield (INR 10.61 vs 7.98) was reduced by complete replacement of wheat bran with black gram foliage.
Conclusion: Black gram foliage could be used as complete replacement for wheat bran in concentrate mixture of dairy cows in formulating least cost ration for economic milk production in small holders' animal production.

Keywords: Black Gram Foliage, Intake, Nutrient Digestibility, Milk Yield, Cows

INTRODUCTION

Small holders' production rely on feeding of low-quality roughages, agricultural crop-residues and industrial by-products which contain high level of ligno-cellulosic materials and thus, less palatable, resulting lower feed intake. Rumen fermentation is largely affected by fermentable nitrogen and fibre along with some other associated factors [1,2]. One of the strategies to manipulate the rumen environment is supplementation, particularly when poor quality roughages are fed. The principal objective of supplementation is to increase the supply of nutrients, mainly energy and protein, such as to create favourable conditions in the rumen which result in enhanced fermentation of basal roughage and thus, improve animal performance [3,4]. Use of unconventional feed resources to develop least cost ration has been increasing for sustainable

livestock farming. Black gram (*Vigna mungo* L.) is a major important pulse cultivated not only in India, but also in other Asian countries and some parts of Africa [5]. A large quantity of pods and foliage are obtained as by-product during collection of seeds, which could be utilized as supplement to livestock [6,7]. This study, therefore, aimed to assess the effect of dietary supplementation of black gram foliage on feed intake, nutrient digestibility and production performance of crossbred cows fed rice straw based diet.

MATERIALS AND METHODS

The experiment was conducted at Malda district in West Bengal Province of India. Mixed farming involving crops and livestock integration and feeding of agricultural byproducts has been a way of life in this region. A huge quantity of black gram foliage has been available as byproduct during the harvesting of crop for feeding to ruminants.

Animals and diets

Eighteen lactating crossbred (*Bos taurus*×*Bos indicus*) cows (body weight [BW] 330.93±10.82 kg) at their second and mid lactation (milk yield 6.77±0.54 kg/d) were randomly allocated into three dietary treatments in a completely randomized block design. Prior to start of the experiment the cows were treated with broad-spectrum anthelmintic (Albendazole suspension [Smith Kline Phermaceuticals Limited, India] at 2 mL/10 kg BW). Three supplements were formulated replacing wheat bran by 0, 50, and 100 per cent with dried and ground foliage of black gram in concentrate mixture (Table 1). The supplements were designated as control (CON), 50% black gram foliage (BGF-50) and 100% black gram foliage (BGF-100) and fed to crossbred cows along with basal diet of rice straw (*ad libitum*) to meet the requirements [8] for maintenance and milk production. Black gram foliage was collected during the thrashing of matured pods for collection of seeds and incorporated in the respective supplements. The amount of supplements offered to individual cows was adjusted weekly as per the milk yield of each animal to meet the requirement.

Table 1. Ingredients and chemical composition of supplements, black gram foliage and wheat bran

Constituents	Supplements			Black gram foliage	Wheat bran
	CON	BGF-50	BGF-100		
Ingredients (kg)					
Maize grain	25.0	25.0	25.0	-	-
Mustard cake	30.0	30.0	30.0	-	-
Wheat bran	43.0	21.5	-	-	-
Black gram foliage	-	21.5	43.0	-	-
Mineral mixture	1.0	1.0	1.0	-	-
Common salt	1.0	1.0	1.0	-	-
Chemical composition (% DM)					
OM	95.8	94.1	92.3	87.2	91.6
CP	18.3	18.4	18.7	15.5	14.8
EE	5.2	5.1	5.0	2.9	3.2
Total Ash	4.2	5.9	7.7	12.8	8.4
NDF	28.4	29.7	31.8	41.6	37.2
ADF	10.6	14.1	18.3	27.1	11.5

DM, dry matter; OM, organic matter; CP, crude protein; EE, ether extract; NDF, neutral detergent fibre; ADF, acid detergent fibre.

Experimental procedure

The daily allowance of the supplements was offered in two equal meals in the morning (06:00 h) and in the afternoon (15:00 h) during the time of milking along with rice straw as total mixed ration. Residues remaining were weighed 24 h post-feeding to ascertained daily feed consumption. The feeding trial was carried out for 85 days duration including the first 15 days for adaptation and subsequent 70 days for data recording. Milking was done twice daily (6:00 h and 15:00 h) and daily milk yield of individual cows were recorded throughout the experiment. Milk samples (50 mL each) from each cow was drawn once a week for analysis of milk composition and stored at 4°C after adding 2 to 3 drops of potassium dichromate as a preservative, until further analysis.

A digestion trial of 6 days duration was conducted towards the end of experimental feeding. Samples of feed offered and refused were collected daily. The daily feed intake and faecal output from individual cows were recorded. A suitable subsample of faeces was collected and dried at 80°C±2°C for 24 h in a forced-draft oven for dry matter (DM) estimation. Pooled samples (6 days for each animal) were ground and stored for chemical analysis.

Chemical and statistical analyses

Samples of feeds, residues and faeces were milled to pass through a 1 mm sieve and analyzed for proximate principles following the methods of the AOAC [9] to determine DM by oven drying method (934.01), organic matter (OM) by muffle furnace incineration (967.05), crude protein (CP), by kjeldahl method (984.13), ether extract (EE) (920.39), ash (942.05). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were estimated by the methods of Van Soest et al [10]. Milk samples were warmed in water bath at 38°C and mixed for homogenous solution and analyzed for total solids, total ash, total protein and fat content [11].

The results obtained were subjected to analysis of variance using the general linear models procedures of the SPSS 11.0 software and treatment means were ranked using Duncan's multiple range tests according to Snedecor and Cochran [12].

RESULTS AND DISCUSSION

Black gram foliage contained comparable crude protein with wheat bran which made the experimental supplements iso-ni-

trogenous (Table 1). However, higher fibre content of the supplements could be attributable to more cell wall constituents present in BGF, which usually present in the leaf meal [13-15]. The chemical composition of feed ingredients and supplements offered to lactating crossbrewd cows were within the normal range and comparable to values reported for Indian feeds and fodder [16].

Daily intake (g/kg $W^{0.75}$) of rice straw as well as total dry matter (Table 2) was increased significantly ($p<0.05$) with the supplementation of BGF, irrespective of levels. The DM intake of lactating cows ranges from 81 to 121 g/kg $W^{0.75}$ [8,17]. In the present study, the cows had DM intake of 118 to 136 g/kg $W^{0.75}$, which clearly indicates that the supplements were palatable. The increased total DM intake due to greater straw intake in BGF supplemented cows could be attributable to positive associative effects of BGF in utilization of rice straw by modulating rumen fermentation [18], which also significantly ($p<0.05$) increased fibre digestibility. Our study also gets support from the observation of Islam et al [19] that supplementation of legume forage increased the DM intake.

Although, the digestibility coefficient of DM, OM, CP, and EE were similar ($p>0.05$), the NDF and ADF digestibility was significantly ($p<0.05$) increased in BGF-100 supplemented cows. The nutrient density (%) of composite diets and intake of total digestible nutrients (TDN) (g/kg $W^{0.75}$) were significantly ($p<0.05$) higher in cows fed BGF-100 supplement with comparable values between control and BGF-50 supplemented cows. The present results represent that all the experimental animals had enough nutrients (digestible crude protein and TDN) to meet the requirements for maintenance and milk production [8]. However, a trend in higher TDN content of diet in BGF-50 group animals with significant ($p<0.05$) increase in BGF-100 indicates better plane of nutrition of cows fed BGF supplemented diet. The associative effects between the feeds can modify the metabolic processes in the rumen, so that the response of an animal to a combination of feeds can differ from the balanced median values of its components considered individually. This kind of response can be synergistic or antagonistic with a possible impact in nutrient utilization by the animals. The possible associative effect of BGF supplementation on acceleration of the fibre digestion of rice straw and nutrient density of composite diet could be related to fulfilment of nutritional adequacy of fermentation due to supplementation of limiting amino acids and minerals through BGF, resulting stimulation of the fibrolytic activity and also to the possible presence of growth promoting factors [20,21].

Table 2. Feed Intake, nutrient digestibility and plane of nutrition of crossbred cows supplemented with black gram foliage

Attributes	Treatments[1]			SEM	p value
	CON	BGF-50	BGF-100		
Body weight					
Kg	323.3	337.6	331.9	12.8	0.713
Metabolic size ($W^{0.75}$)	76.2	78.8	77.8	1.73	0.851
Intake (g/ kg $W^{0.75}$)					
Concentrate	46.7	47.7	48.8	1.34	0.752
Rice straw	72.1[a]	85.2b	87.2[b]	4.14	0.023
Total DM	118.8[a]	132.9[b]	136.0[b]	4.69	0.019
Nutrient digestibility (%)					
DM	61.3	61.8	62.4	1.92	0.910
OM	64.8	67.6	68.9	1.76	0.861
CP	65.6	66.1	67.3	1.76	0.920
EE	64.3	65.8	66.8	1.64	0.953
NDF	53.3[a]	54.6[ab]	56.1[b]	1.92	0.042
ADF	40.6[a]	44.1[ab]	46.2[b]	2.93	0.038
Nutrient density (%)					
DCP	6.7	7.0	7.2	0.13	0.923
TDN	59.6[a]	62.7[ab]	64.3[b]	1.87	0.017
Nutrient Intake (g/kg $W^{0.75}$)					
DCP	8.2	8.3	8.3	0.47	0.901
TDN[2]	65.9[a]	72.4[ab]	73.6[b]	3.69	0.016

SEM, standard error of the mean; DM, dry matter; OM, organic matter; CP, crude protein; EE, ether extract; NDF, neutral detergent fibre; ADF, acid detergent fibre; DCP, digestible crude protein; TDN, total digestible nutrients; DOM, digestible organic matter.
[1] CON, cows supplemented with control concentrate mixture (maize grain, 25%; mustard cake, 30%; wheat bran 43%; mineral mixture and common salt, 1% each); BGF-50, cows fed concentrate mixture containing 50% black gram foliage replacing wheat bran; BGF-100, cows fed concentrate mixture containing 100% black gram foliage replacing wheat bran.
[2] TDN calculated from DOM (1 kg DOM = 1.05 kg TDN; NRC, 1981).
[a,b] Mean bearing different superscript within a row differ significantly ($p<0.05$).

Although, the average milk yield (kg/d) and composition did not differ ($p>0.05$) among the groups, milk yield was increased by 10 per cent in BGF-100 group animals with total replacement of wheat bran by BFG in concentrate mixture (Table 3), suggesting efficient utilization of feed nutrients in these animals. Continuous supply of energy and nitrogen for rumen microbes improved rumen fermentation for better utilization of fibrous feeds and could have provided additional volatile fatty acids for better milk production [19,22]. The cost of wheat bran and black gram foliage containing concentrates were (INR/quintal) 1,677, 1,441, and 1,204, respectively. The cost-benefit analysis of effect of wheat bran revealed that the cost of concentrate for lactating cows could be reduced by INR 473/quintal, if wheat bran is fully replaced by black gram foliage. The feeding cost per kg milk production was reduced (INR 10.61 vs 7.98) in cows fed BGF-100 diet as compared to control.

Present study suggests that the locally available agro-industrial byproducts viz. Black gram foliage could be incorporated in formulating least cost ration for economic milk production in small holders' dairy production without any adverse effect on feed intake, nutrient utilization and production performance of crossbred cows.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Table 3. Effect of dietary supplementation of black gram foliage on milk yield, milk composition and economics in dairy cows

Attributes	Treatments[1]			SEM	p value
	CON	BGF-50	BGF-100		
Milk yield					
kg/d	6.4	6.9	7.0	0.8	0.751
4% FCM (kg/d)	6.2	6.8	6.9	0.5	0.824
Milk composition (%)					
Fat	3.89	3.92	3.90	0.1	0.983
Protein	3.62	3.64	3.69	0.02	0.991
Total Ash	0.76	0.75	0.77	0.01	0.990
SNF	8.82	8.94	9.02	0.06	0.894
Total solids	12.74	12.91	12.94	0.07	0.945
Yield (g/d)					
Fat	249.10	270.35	274.94	17.32	0.675
Protein	232.43	252.12	257.90	9.52	0.753
Economics of feeding[2] (INR/d)					
Cost of supplement	59.68	54.16	45.71	-	-
Cost of rice straw	8.24	10.07	10.18	-	-
Total feed cost	67.92	64.23	55.89	-	-
Feed cost/kg milk yield	10.61	9.31	7.98	-	-

SEM, standard error of the mean; FCM, fat corrected milk; SNF, solid not fat; INR, Indian Rupees.

[1] CON, cows supplemented with control concentrate mixture (maize grain, 25%; mustard cake, 30%; wheat bran 43%; mineral mixture and common salt, 1% each); BGF-50, cows fed concentrate mixture containing 50% black gram foliage replacing wheat bran; BGF-100, cows fed concentrate mixture containing 100% black gram foliage replacing wheat bran.

[2] The unit cost (INR/quintal) of supplements were 1,677, 1,441, and 1,204 for CON, BGF-50, and BGF-100, respectively. The cost (INR/quintal) of rice straw and black gram foliage were 150 and 300, respectively.

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