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Effect of strategic supplementation on growth performance and economics of Barbari goat kid production on rangelands

U B CHAUDHARY[1], M K TRIPATHI[2], PRABHAT TRIPATHI[3] and RAVINDRA KUMAR[4]

Central Institute for Research on Goats, Makhdoom, Uttar Pradesh 281 122 India

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ABSTRACT

The effect of supplementary feeding of concentrate feeds was assessed on performance, and economics of kids with grazing based production system. Male Barbari kids (30) were divided randomly in 5 equal groups. Kids were allowed 8 h daily grazing and offered arhar straw (*Cajenus cajan*) *ad lib.* after grazing for 128 days. Kids of control group did not provide any concentrate supplement, while other kid groups received either concentrate pellet feed (CPF), barley grains (BG), wheat bran plus mineral mixture and salt (WBMS) or barley grain plus mineral mixture and salt (BGMS) at 1% of live weight after grazing. The final live weights were the highest in CPF (27.6 kg) supplemented kids, whereas other groups of kids had the lower final live weights. Total live weight gains were higher in CPF (12.33 kg), BG (10.20 kg) and BGMS (10.03 kg) supplemented kids in comparison of control (7.18 kg) and WBMS (9.05 kg) group of kids. Average daily gain (ADG) ranged between 51.6 and 88.7 g, which is higher in the kids of CPF group. The CPF supplementation improved growth of kids by 73%, followed by BG (42%) than that occurred in control kids. Total volatile fatty acids and NH_3–N were similar among the groups, whereas concentrate supplemented kids had the higher protozoa population in rumen fluid. Hematology and plasma minerals were also not different among kids groups. Although the supplementary feeding have increased the cost of feeding from ₹ 227 to 401 on each kid, however net return on each kid over the control were ₹ 467, 712, 755 and 1,287, respectively, in WBMS, BGMB, BG and CPF group of kids. Study concluded that supplementary feeding of 1.0% concentrate provided higher economic returns over the kids managed on grazing alone, and the feeding of concentrate pellet provided maximum net returns.

Key words: Economics, Kids, Production, Rangelands, Strategic supplementation

Goat production system in India has been largely on grass based with small quantities of concentrate supplements. These supplements are provided to the animals during their growing or productive physiological stages, while other animals maintained on grazing alone. Animals of traditional feeding systems are categorized as semi intensive (some supplement) or extensive system (grazing alone) systems of feeding management. The animals on pasture grazing alone rarely approach their genetic potential for milk, meat and wool production (Black 1990) particularly in the tropical climate where the quality and quantity of the pasture is very low. High animal grazing pressure and poor management situations of the community pastures have degraded the grazing resources and reduced carrying capacity of the pastures to a 2–3 ACU (Animal Carrying Unit) of Indian grazing lands. Above ground vegetations of the rangelands have also deteriorated at faster rates due to tree cutting and/or over lopping. Therefore, appropriate supplementary feeding of goats required in harnessing optimum productivity of milk and meat and wool from the animals maintained on grazing (Morales *et al*. 2000). Prevailing supplementary feeding system in field conditions involved feeding of cereal grains (wheat, barley, maize etc.) or by-products of cereal/ pulses (wheat bran, gram/*arhar churi* etc.) to only advanced pregnant, and lactating goats and to kids of early age, whereas other class of animals meets their nutrient needs from grazing only. Although lack of awareness of the benefits of strategic supplementation during fluctuating seasonal variations of the nutrient availability from grazing resources is one factor, however economic status of goat farmers has been another and the most vulnerable factor of suboptimum supplementary feeding of animals. Therefore, aim of the study was to assess productive and economic benefits of supplementation of only grain (barley), grain by-product (wheat bran), and barley grain or wheat bran with or without minerals mixture or concentrate pellet feed in the feeding of kids on grazing.

MATERIALS AND METHODS

Animals and feeding management: Male Barabri kids (30) of an average age of 288.46±6.67 days and live weight

Present address: [1]Principal Scientist and Head (ubchaudhary1958@gmail.com), [2]Principal Scientist (mktripathi@gmail.com),[3]Senior Scientist (prabat72 @gmail.com), [4]Senior Scientist (ravindra.srivastava@gmail.com), Nutrition Feed Resources and Product Technology Division.

12.96 ±0.59 kg, were selected from the general flock of the ICAR-Central Institute for Research on Goats. Kids were divided randomly in 5 equal groups of 6 in each and were penned in well-ventilated enclosures. Kids were allowed 8 h daily grazing and offered *arhar* straw (*Cajanus cajan*) *ad lib.* after grazing. Kids of control group were not given any concentrate supplement. While other kid groups received either concentrate pellet (containing: maize 67, groundnut cake 15, molasses 5, wheat bran 10, mineral mixture 2 and salt 1.0%) feed (CPF), barley grains (BG), wheat bran plus mineral mixture and salt (WBMS) or barley grain plus mineral mixture and salt (BGMS) at 1% of live weight after grazing.

Pasture and feeding resources: The rangeland available for grazing was unmanaged natural of chiefly *Cenchrus ciliaris*, with local forbs (ground vegetation) and tress of *Accacia nilotica*, *Prosopis cineraria*, *Azadirachta indica*, *Albizia lebbek*, *Salbodora persica*, *Capparis horrida* and *Leucaena leucocephala* provided lopping for fresh leaves feeding. Kids were maintained on the rangeland for 128 days from winter (January 15) to onset of summer (May 01).

Feed intake and live weight gain: Record of daily intakes of straw and supplements were maintained, whereas live weights were recorded on every 15 days. These live weights were used to determine average daily gain of the kids. The dry matter consumed from the grazing was not measured as this was the same for all groups.

Rumen fermentation: The rumen liquor samples were collected form intact animals with the stomach tube before grazing and offering the supplements. Samples were collected twice at equal intervals, strained with 4 layers of muslin cloth and a few drops of saturated mercuric chloride were added for stopping microbial activities. Samples were processed for enumeration of total counts of the ciliates (Ogimoto and Imai 1981). Total volatile fatty acids were estimated as per Barnett and Reid (1957) procedure and NH_3 nitrogen as per Conway (1957).

Hematology and serum minerals: Blood samples were collected after overnight fast towards at 59th and 88th day of the experiment from jugular vein into the di-potassium EDTA impregnated vacuumed tubes. Hematology attributes (hemoglobin, hematocrit, red blood cells, white blood cells, lymphocytes, monocytes, granulocytes, basophils, eosinophils and mean corpuscular volume) were determined in whole blood with hematology analyzer. Thereafter, tubes were centrifuged at 1,500 g for 10 min to separate plasma, and plasma minerals (Ca, P, Mg, Cu, Zn and Fe) were determined by the atomic absorption spectrophotometer after wet digestion.

Economics of kid production: The economics of the supplementary concentrate feeding was calculated by integrating the cost of feed inputs at the prevailing market prices and the sale of live animal on kg live weight basis.

Statistical analyses: Observations of the experiment were analyzed for statistical significance by the statistical software (SPSS base 15) using a general linear model. The significant means were separated by the LSD procedure.

Table 1. Chemical composition of different concentrate supplements

Concentrate supplements	Chemical composition (%) Dry matter	Crude protein	Organic matter
Pellet feed	93. 00± 0.32	18.09±0.12	93.56±0.17
Barley grain	93.42±0.02	12.45±0.32	94.96±0.51
Wheat bran	89.87±0.28	13.60±0.11	95.75±0.07
Cajanus cajan straw	96.18±0.13	5.51±0.09	92.78±0.89

RESULTS AND DISCUSSION

Intake and growth performance of kids: The intake of straw was higher whereas total intake was the lowest in kids of control group (Table 3). The final live weights were higher (P<0.05) in CPF supplemented kids, whereas other groups of kids had the similar final live weights (Table 2). Total live weight gains were higher (P<0.05) in CPF (12.33 kg), BG (10.20 kg) and BGMS (10.03 kg) supplemented kids in comparison of control (7.18 kg) and WBMS (9.05 kg) group of kids. Similarly, average daily gain (ADG) was also similar among CPF, BG and BGMS groups but higher (P<0.05) than the ADG of control, and WBMS group of kids (Table 2). The kids of CPF group had the highest (88.7 g/d) and control kids the lowest ADG (51.6 g/d). Reduced total intake and higher intake of straw in control kids were due to system of feeding, as the control kids did not receive any concentrate supplement hence they consumed more straw. The kid groups, which received one or other type of concentrate supplement, had the low straw intake and higher

Table 2. Live weight change and gain in kids on different concentrate supplements

	Kid groups* Control	CPF	BG	WBMS	BGMS
Initial live weight (kg)	11.2±1.64	15.3±1.00	12.6±0.64	12.7±1.36	13.1±1.47
Final live weight (kg)**	18.4±1.55^a	27.6±1.19^b	22.8±1.52^a	21.7.±2.42^a	23.2±1.52^a
live weight gain (kg)**	7.18±0.634	12.33±0.79^b	10.20±0.94^b	9.05±1.27^a	10.03±0.743^b
Daily gain (g/ day)**	51.6±4.57^a	88.7±5.68^b	73.2±6.88^b	65.1±9.18^a	72.2±5.35^b

*Control, no concentrate supplement; BG, barley grains; WBMS, wheat bran plus mineral mixture and salt; BGMS, barley grain plus mineral mixture and salt; concentrate pellet feed (CPF) at 1% of live weight.**Observations with different superscript in a row differ significantly (P< 0.05).

Table 3. Supplemented straw and concentrates intake (g/day/animal) in different kids groups

	Kid groups*				
	Control	CPF	BG	WBMS	BGMS
Straw intake (g/d)	190.5	166.7	168.0	221.2	190.2
Concentrate intake (g/d)	0.0	203.3	163.3	168.3	171.7
Total intake (g/d)	190.0	370.0	331.3	389.5	361.8

*Control, no concentrate supplement; BG, barley grains; WBMS, wheat bran plus mineral mixture and salt; BGMS, barley grain plus mineral mixture and salt; concentrate pellet feed (CPF) at 1% of live weight.

Table 4. Rumen fermentation metabolites and protozoa population of kids

	Kid groups*				
	Control	CPF	BG	WBMS	BGMS
Fermentation metabolites (100 ml SRL)					
TVFA (m mol)	12.8±2.32	11.8±1.31	11.8±1.76	13.9±2.64	10.1±1.51
NH_3-N (mg)	16.3±4.86	18.2±4.54	17.4±4.02	17.8±4.27	15.4±4.06
Protozoal count (10^5/ml SRL)**					
	16.2±0.88^{c}	20.8±3.19b^{c}	34.6±6.04^{a}	18.5±2.17^{c}	29.5±3.14^{ab}

*Control, no concentrate supplement; BG, barley grains; WBMS, wheat bran plus mineral mixture and salt; BGMS, barley grain plus mineral mixture and salt; concentrate pellet feed (CPF) at 1% of live weight.**Observations with different superscript in a row differ significantly (P< 0.05).

total intakes due compensatory intake of nutrients with concentrate supplement. The observations of ADG of the present study were in accordance with the ADG of grazing kids supplemented with forages (Sengar 1980, Rai *et al*. 1988). The higher daily growth of kids was accompanied with concentrate supplements from 13.9 to 73.2% than occurred in control kids, which was due to added nutrient supply. The CPF supplementation had maximum influence on growth promotion of kids, which was 73% followed by BG (42%). Experiment exhibited that energy availability was vulnerable during grazing with straw supplementation, whereas a balance supplement in terms of nutrients and minerals would have pronounced growth improvement.

Mineral supplements are recommended in animal feeding because of the known beneficial effects on vital physiological functions in the body including immune system (Underwood and Suttle 1999), however, present study did not observe growth promotional effect of mineral supplementation with barley grain feeding in grazing kids. Mineral supplements were also available in complete pellet feed, which improved growth. Kids might have received enough minerals from grazing and browsing resources in meeting their critical requirements (Tripathi *et al.* 2002a); hence growth promotional effects of mineral supplementation were not exhibited by BGMS group of kids. Mineral supplements have visible growth and other beneficial effects on sub-clinically mineral deficient animals (Tripathi *et al.* 2002b), whereas marginally deficient animals do not show immediate response of mineral supplement (Chaudhary *et al.* 2013). Therefore, growth promotional effect of concentrate supplements i.e., wheat bran, barley grain and complete pellet feed have been the influence of added nutrient supply and the supplementation of energy feeds, which increased the rumen microbial diversity and hence greater nutrient availability from roughages.

Rumen fermentation attributes: Total volatile fatty acids (TVFA) and NH_3-N were similar among control and supplemented groups (Table 4). The TVFA levels (m mol/ 100 ml) ranged from 10.1 to 13.9 m moles and NH_3-N concentrations (mg/100 ml) in rumen fluid ranged from 15.4 to 18.2 mg among different kid groups. Although, concentrate feeding influenced TVFA and NH_3-N concentrations of rumen fluid (Tripathi *et al.* 2007), however period of sampling of rumen fluid after post feeding have profound effects on rumen fermentation metabolites. Since, rumen samples were collected before grazing and concentrate feeding therefore differences in TVFA and NH_3-N concentrations were not observed. The fermentation metabolites were not different in rumen fluid of small ruminants at 0 h of sampling (Tripathi *et al*. 2007) and the observation of TVFA and NH_3-N concentrations were within the normal range of reported variations in small ruminates (Tripathi *et al*. 2007, Bhatt *et al.* 2011, Chaudhary *et al.* 2013, Tripathi *et al.* 2014). The population of protozoa was different among kid groups and was the highest (P<0.05) in BG kids, whereas control, CPF and WBMS kid groups had the similar protozoa population. Barley supplementation provided readily available energy in the rumen of the kids, which promoted protozoa population (Abe *et al.* 1981) with a greater diversity but within the rumen pH of 6.0 to 6.8 (Coleman 1988), and pH below 6.0 depressed fibrolysis in the rumen. However, protozoa populations of the kids were within the normal reported range of variations on grazing.

Table 5. Effect of feeding regime on blood mineral profile of growing male Barbari kids

Minerals	Kid groups*				
	Control	CPF	BG	WBMS	BGMS
Ca (mg%)	10.38±1.17	7.49±0.69	7.50±0.56	10.17±0.51	10.89±1.28
P (mg%)	5.87±0.58	6.78±0.63	6.32±0.48	8.32±0.17	7.36±0.18
Mg (ppm)	0.43±0.02	0.48±0.01	0.30±0.06	0.83±0.02	0.45±0.02
Cu (ppm)	0.89±0.17	1.44±0.31	0.72±0.06	0.63±0.05	0.66±0.04
Zn (ppm)	3.14±0.20	5.02±0.47	4.80±1.37	3.53±0.51	3.74±0.31
Fe (ppm)	4.95±0.32	4.94±0.15	4.56±0.19	5.41±0.11	3.41±0.22

*Control, no concentrate supplement; BG, barley grains; WBMS, wheat bran plus mineral mixture and salt; BGMS, barley grain plus mineral mixture and salt; concentrate pellet feed (CPF) at 1% of live weight. **Critical range of the elements (Ca, 8–12 mg/dl; P, 4–6 mg/dl; Mg, 1.9–3.2 mg/dl; Cu, 0.6–1.2 ppm; Zn, 1–2 ppm; Fe, 1–2 ppm).

Table 6. Effect of feeding regime on hematology of growing male Barbari kids

Attributes**	Kid groups*				
	Control	CPF	BG	WBMS	BGMS
Hemoglobin (g/dl)	7.28±0.56	7.80±0.42	7.47±0.28	6.88±0.38	6.68±0.15
Hematocrit (ml/dl)	22.53±1.47	25.10±1.66	23.02±0.76	21.85±1.03	21.82±0.31
RBC ($\times10^6$/μl)	12.66±0.82	16.79±4.87	13.61±0.48	11.85±0.86	11.51±0.49
WBC ($\times10^3$/μl)	12.66±0.82	16.79±4.87	13.61±0.48	11.85±0.86	11.51±0.49
Lymphocytes (%)	55.33±3.07	52.23±2.59	55.13±2.86	50.65±2.12	55.10±1.88
Monocytes (%)	4.33±0.26	4.15±0.34	4.43±0.34	4.87±0.29	4.45±0.20
Granulocytes (%)	36.80±2.36	40.27±2.86	37.50±2.88	40.85±3.27	36.07±3.14
Eosinophils (%)	2.68±1.04	2.25±0.33	2.10±0.21	2.78±1.44	3.50±1.30
Basocytes (%)	0.17±0.05	0.17±0.03	0.10±0.68	0.18±0.03	0.17±0.03
MCV (fl)	17.87±0.46	20.48±0.64	17.00±0.68	18.80±1.24	19.07±0.66

*Control, no concentrate supplement; BG, barley grains; WBMS, wheat bran plus mineral mixture and salt; BGMS, barley grain plus mineral mixture and salt; concentrate pellet feed (CPF) at 1% of live weight.** RBC, red blood cells; WBC, white blood cells; MCV, mean corpuscular volume.

*Mineral contents of plasma***:** The plasma concentrations of macro minerals Ca ranged from 7.5 to 10.9 mg, whereas P ranged between 6.3 and 8.3 ml/ 100 ml (Table 5). The levels of micro-minerals Cu, Zn and Fe varied from 0.6 to 1.4, 3.1 to 5.0 and 3.4 to 4.9 ppm, respectively, among kids groups. Plasma levels of Ca, P, Cu, Zn and Fe were with or above the reported critical range of these minerals in serum/ plasma of goats for different physiological functions (Underwood and Suttle 1999) and were within the reported range of variations (Chaudhary *et al.* 2013) in goat kids. The levels of Mg in plasma ranged from 0.3 to 0.8 ppm among 5 kid groups, which were below the critical range reported for goats (Underwood and Suttle 1999). Therefore, kids of present experiment had a sub-clinical deficiency of Mg. Tropical grasses and cereal grains have low levels of Mg (Suttle 2010) and possibly higher levels of potassium have interfered with the absorption of Mg, and that rendered dietary Mg unavailable to kids even in CFM and mineral mixture supplemented groups. The Mg has antagonism K in the rumen of ruminants (Tripathi and Karim 2008). Adequate concentrations of other minerals demonstrated that kids were receiving adequate quantities of macro and micro minerals from the pasture and tree leaves, since tree leaves contained the good source of minerals (Ammerman *et al.* 1995). Normal concentrations of micro and macro minerals in the plasma of the kids have also indicated that feeding of mineral mixture to grazing goats in semi-arid regions of India may not be essential since animals were receiving required amount of minerals from the grazing vegetation.

*Hematology attributes***:** Hematological attributes, viz. hemoglobin, hematocrit, red blood cells, white blood cells and deferential counts, and mean corpuscular volume of the kids of 5 groups were not similar (Table 6) and were within the normal reported range of variation (Kumar 2003, Chaudhary *et al*. 2013). Hematological observation indicated that kids under present feeding regimens have received optimum nutritional components. Further, hematological constituents change only in very adverse condition and for a prolonged period of experiment.

*Economics of supplementary feeding***:** The benefits of different forms of supplementation in terms of economic returns are presented in Table 7. Although the supplementary feeding increased cost of feeding from ₹ 227 to 401 on each

Table 7. Economics of different concentrate supplements in growing Barbari kid production

	Kid groups*				
	Control	CPF	BG	WBMS	BGMS
Straw intake (kg)	26.28	22.99	23.8	30.49	26.34
Concentrate supplement intake (kg)		26.77	21.52	21.30	22.75
Mineral mixture (₹)				0.80	0.80
Salt (₹)				1.00	1.00
Cost of intakes#					
Straw (₹)	78.84	68.97	71.40	91.47	79.02
Concentrate supplement (₹)		401.55	215.20	170.40	227.50
Cost of mineral mixture and salt (₹)				31.00	31.00
Total cost (₹)	78.84	470.52	286.6	292.87	337.52
Live weight gain (kg)	7.18	12.33	10.2	9.05	10.03
Sale price of live weight gain (₹)!	1795	3082.5	2550	2262.5	2507.5
Total income from live weight gain (₹)	1716.16	2611.98	2263.4	1969.63	2169.98
Added cost on account of concentrate feeds (₹)	0	391.68	207.76	214.03	258.68
Net profit on account of supplements (Rs/animal)	0	1287.50	755.00	467.50	712.50

*Control, no concentrate supplement; BG, barley grains; WBMS, wheat bran plus mineral mixture and salt; BGMS, barley grain plus mineral mixture and salt; concentrate pellet feed (CPF) at 1% of live weight.#Calculated on the prevailing market price (Straw ₹300/ quintals, concentrate pellet feed ₹ 1500/ quintals, barley grain ₹ 1000/ quintals, wheat bran ₹ 800/ quintals, mineral mixture ₹ 35/ kg and salt ₹ 3/ kg). !Market sale price of live weight ₹ 250/kg.

kid, however net returns over the control kids were ₹ 467, 712, 755 and 1,287, respectively, on each kid of WBMS, BGMB and CPF group. The supplementary feeding have a remunerative approach of meat kid production over grazing alone, and the supplementation of balanced feed have added benefits over a single cereal grain or grain byproduct feeding. The improved growth and higher economic returns were reported with strategic supplementation in goat and sheep production on grazing (Chaturvedi *et al*. 2006, 2010). Supplementary feeding promoted growth by providing adequate nutrients and therefore higher live weight and increased market sale prices, which in turn provided high net returns.

Present study concluded that supplementary feeding of concentrates in growing kids improved growth performance and provided economically viable kid production system on range management. Supplementation of concentrate at 1% of live weight of growing kids was recommended for higher economic returns and supplementation of complete feed pellet exhibited the highest net returns of ₹ 1,287 by the each animal.

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