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Effect of dietary supplementation of inulin with low and high concentrate diet on growth performance and nutrient digestibility in Barbari goats

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ABSTRACT

This study aimed to determine the effect of dietary supplementation of inulin on growth performance, feed conversion and nutrient digestibility in Barbari goats fed high and low concentrate diet for a period of 90 days. Twenty four yearling female Barbari goats were randomly divided into four equal groups (n=6) according to average body weight (18.24±1.16 kg). Treated animals in Group 1 were fed low concentrate diet (LCD; concentrate roughage ratio 40:60) and Group 2 (LCIN) with 2% inulin supplementation (% DM basis). Similarly, Group 3 was fed high concentrate diet (HCD; concentrate roughage ratio 60:40) and Group 4 (HCIN) with 2% inulin supplementation. Results showed that average daily gain (ADG) and feed conversion efficiency (FCE) were higher in inulin supplemented groups than the non-supplemented group. There was no increase in mean live body weight (BW) and dry matter intake (DMI) with inulin supplementation either in LCD or HCD treatment groups.The mean body condition score (BCS) was also similar in all groups. However, faecal score (FS) was superior in inulin supplemented group observed after 30 days of feeding trial. There was significant improvement in the digestibility coefficient of crude protein and DCP intake. It was concluded that inulin supplementation either in high concentrate and low concentrate diet of growing goats resulted in improvement in growth performance, faecal score and nutrient digestibility.

Keywords: Barbari goats, Digestibility, Faecal score, Growth performance, Inulin

Inulin as prebiotic in animal feed has several advantages as compared to other functional foods and has a range of different physiological functions such as bowel movement, gut microflora activities, absorption of minerals, lipid homeostasis and immunity mechanisms (Samanta *et al.* 2011, Waseem *et al.* 2019). It also has capability to restore the gut health through increase in number of beneficial microorganisms like *Bifidobacteriaceae* and decreasing the harmful ones like *Streptococcus, Clostridium* and *Enterococcaceae.* Although, most studies on inulin are limited to monogastric animals and poultry. Effect of inulin supplementation and mechanism of action in adult ruminants is still less known. Rumen is an anaerobic, bacteria-rich organ that provides energy to the body mainly through microbial fermentation. Goats being the preferred source of meat next to poultry are raised under extensive, semi-intensive and intensive production system. Under extensive and semi-intensive system, animals have an easy access to feed and fodders, and thus rely less on concentrate supply to meet their nutrient demands. However, in commercial livestock production, the animals are kept under stall-fed conditions and have reduced access to roughage-based diet (feed and fodders) and therefore fed with concentrate rich diet to achieve faster growth. Inulin as prebiotics in diet of animals having greater and lesser proportion of concentrate may bring the usefulness of inulin in goat production. Prebiotics specifically inulin has potential to address these issues and capable to bring out the desired effects on animal performances. The addition of prebiotics in the diets of animals is a relatively recent endeavour and preliminary studies are very encouraging. Therefore, the present study was conceived to evaluate the effects of dietary supplementation of inulin on growth performance, body condition score, faecal score and nutrient digestibility in growing Barbari goats fed high and low-concentrate diet.

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MATERIALS AND METHODS

Ethical approval: The procedures and protocols of this experiment were approved by the Animal Ethics Committee, SVPUAT, Meerut, and CPCSEA-DADF (Approval Number: V-11011(13)/06/2020), Government of India.

Animals, experiment design, and feeding: For a period of 90 days, 24 yearling female Barbari goats of uniform age and conformation were selected and divided into

four groups with six animals per treatment based on their body weights using completely randomized block design. Feeding regimen of experimental animals in Group 1 included low concentrate diet (LCD; concentrate roughage ratio 40:60) without inulin supplementation and in Group 2 (LCIN) with 2% inulin supplementation (% DM basis). Similarly, Group 3 was fed high concentrate diet (HCD; concentrate roughage ratio 60:40) and Group 4 (HCIN) with 2% inulin supplementation (% DM basis). The nutrient requirements of experimental animals were met by feeding total mixed ration (TMR) consisting of concentrate: green berseem fodder and wheat straw in the given proportion (Table 1) following NRC guidelines.

Table 1. Ingredients and nutrient composition of experimental diet (DM basis)

Item	LCD	HCD
Ingredients (g/kg DM)		
Wheat straw	200	150
Berseem fodder	200	150
Oat fodder	200	100
Yellow maize (ground)	210	310
Wheat bran	55	85
Mustard cake	75	110
Groundnut cake	55	90
Mineral and vitamin premix*	5	5
Nutrient level (g/kg DM)		
Organic matter	904	910
Crude protein	140	160
Crude fibre	236	198
Nitrogen free extract	506	528
Neutral detergent fibre	581	557
Acid detergent fibre	345	317
Total ash	96	90

LCD, Low concentrate diet (R:C::60:40); HCD, High concentrate diet (R:C::40:60). *Mineral and vitamin per kg: Vit A 600,000 IU, Vit D3 30,000 IU, Vit E 300 IU, Niacinamide 4 g, Calcium pantothenate 1 g, Choline chloride 120 g, Ca 300 g, P 36 g, Na 20 g, Cu 0.8 g, I 0.8 g, Fe 8 g, Mn 22 g, Zn 21 g and Co 40 mg.

Observations and laboratory analysis: Fortnightly live body weight (BW, Kg), dry matter intake (DMI, g/day), average daily gain (ADG, g/day), feed conversion ratio (FCR), feed conversion efficiency (FCE), body condition score (BCS), faecal score (FS) were recorded for each treatment groups using standard procedures and protocols. Dry matter (DM), crude protein (CP), ether extract (EE), and total ash of feed samples were analyzed using the AOAC method. A six days digestion trial was conducted after 90 days of experimental feeding during which quantitative collection of total faeces voided on 24 h basis was made.

Statistical analyses: Generated data of feed intake, growth performance, and feed efficiency measured on days 0, 15, 30, 45, 60, 75, and 90 were analyzed by a mixed model procedure (PROC MIXED) in Statistical Package for the Social Sciences (SPSS for windows, v20.0; SPSS Inc., Chicago, IL, USA). A two diet types (LCD and HCD) by supplementation levels of 0 and 2% of inulin factorial arrangement of treatments in a randomized complete block design was employed in the analysis of variance for data of growth performance, condition score and nutrient digestibility. Fixed effects included diet type, inulin supplementation level, and their interaction. The animals within the same diet type and inulin supplementation level were considered as the random effect. Following statistical model was used for the analysis of results:

$$Y_{ij} = \mu + T_i + I_j + A_k + (T \times I)_{ij} + e_{ij}$$

where, Y_{ij} is the dependent variable, μ is the overall mean of the population, T_i is the fixed effect of type of diet, I_j is the fixed effect of inulin supplementation, A_k is random effect of animal (goat), $(T \times I)_{ij}$ is the fixed effect of the diet × inulin interaction and e_{ijk} is the unexplained residual element assumed to be independent and normally distributed. Tukey multiple range test was applied to treatment means which showed a statistically significant variation in the samples.

RESULTS AND DISCUSSION

Growth performance: Effect of inulin supplementation on growth performance of Barbari goats fed high and low concentrate diet is presented in Table 2. Body weight and dry matter intake were non-significantly ($P>0.05$) influenced by the inulin supplementation during various fortnights among the treatments. However, difference in body weight at 0 and 90 day showed significant ($P<0.01$) effect of inulin on body weight which was computed as 4.76, 5.78, 6.08 and 6.96 kg in various treatment groups. Average daily body weight gain was significant ($P<0.01$) in inulin treated LCD, LCIN, HCD and HCIN groups computed as 52.87, 64.28, 67.78 and 77.43 g/day, respectively. However, significantly higher gain in body weight was found in LCIN and HCIN groups than LCD and HCD groups. The present results are in agreement with the reports of Samanta *et al.* (2012), Bhutharit (2016) and Tian *et al.* (2019) who reported that supplementation of prebiotics in ruminant diets have showed better gain in body weight. Although, dry matter intake remained non-significantly affected by the feeding of inulin in various tratments groups. Increase in body weight gain and better performance of goats by feeding of inulin may be due to improved nitrogen retention in rumen.

Feed conversion ratio and feed conversion effeciency was observed significantly higher in inulin treated groups during the study period. Both the parametres were found to have better performance having inulin as compared to the treatments having no inulin in goat diet. This probably showed that inclusion of inulin in diet, irrespective of the level of concentrate has improved efficiency of feed utilization. Similar findings were reported by Samanta *et al.* (2012) and Tian *et al.* (2019) who reported that feeding of inulin at different levels of concentrate diet has significant

Table 2. Effect of inulin supplementation on growth performance of Barbari goats fed high and low concentrate diet

Parameter	Treatment					P value		
	LCD	LCIN	HCD	HCIN	SEM	Diet	Inulin	Diet × Inulin
BW, kg (Initial)	18.23	18.27	18.20	18.25	1.09			
BW, kg (Final)	22.99	24.05	24.28	25.21	1.23			
BW, kg (Overall)	20.58	21.09	21.37	21.56	1.18	0.598	0.767	0.895
DMI, g/day	657.76	647.52	683.34	687.62	39.33	0.388	0.937	0.847
ADG, g/day	52.87^{a}	64.28^{b}	67.78^{b}	77.43^{c}	2.29	<0.001	<0.001	0.704
FCR	12.39^{a}	10.04^{b}	10.27^{b}	8.89^{b}	0.46	0.002	0.001	0.313
FCE	0.08	0.10	0.10	0.11	0.01	0.002	0.004	0.719
BCS	2.62	2.72	2.78	2.81	0.09	0.441	0.497	0.548
FS	3.94^{a}	4.22^{ab}	3.08^{a}	4.35^{b}	0.10	<0.001	<0.001	<0.001

Means within row having different superscripts differ significantly (P<0.05). LCD-Low concentrate diet; LCIN, Low concentrate diet with 2% inulin supplementation; HCD, High concentrate diet; HCIN, High concentrate diet with 2% inulin supplementation. BW, body weight; DMI, dry matter intake; ADG, average daily gain; FCR, feed conversion ratio; FCE, feed conversion efficiency;BCS, body condition score; FS, faecal score, SEM, standard error of mean.

effect on feed conversion ratio and feed utilization efficiency. It might be due to that inulin supplementation in ruminant diet showed increased propionate to acetate ratio, which is responsible for better feed efficiency.

Body condition score of experimental goats in treatment groups did not differ significantly (P>0.05) among the groups. Fortnightly BCS showed an increase in mean body condition score which was significant (P<0.01) at 90 days. Similar results were reported by Sri Lekha *et al.* (2021) who observed no significant effect of inulin on body condition score. However, Berry *et al.* (2006) revealed that average change in body weight per unit change in BCS (scale of 1 to 10) was 31 kg in cattle.

Inulin supplementation had significant effect on faecal score among various treatments. There was significant (P<0.01) diet×inulin interaction for the faecal score in experimental groups. Present findings are in agreement with the reports of Kara *et al.* (2012), Ghosh and Mehla (2012) and Bhutharit (2016) who reported similar faecal score of milk-fed Saanen goat kids supplemented with inulin. It may be attribiuted that improved faecal score due to supplementation of prebiotic might be because of suppression of pathogenic bacteria responsible for toxin production leading to intestinal secretion and diarrhoea.

Apparent digestibility of nutrients and nutritive value: Effects of dietary supplementation of inulin on nutrient digestibility coefficient (%) and nutritive value in Barbari goats is given in Table 3. Digestibility of dry matter, organic matter, crude protein and crude fibre improved significantly in goats receiving inulin supplemented diets compared to non-supplemented groups. Highly significant (P<0.01) effect of inulin on digetible crude protein intake was found in all the treatment groups. There was a significant diet × inulin interaction for DCP and TDN intake per kg metabolic

Table 3. Effects of dietary supplementation of inulin on nutrient digestibility coefficient (%) and nutritive value in Barbari goats

Attribute	Treatment				SEM	P value		
	LCD	LCIN	HCD	HCIN		Diet	Inulin	Diet × Inulin
Digestibility coefficient (%)								
DM	63.84^{b}	62.89^{b}	64.08^{a}	67.57^{b}	1.86	0.005	0.024	0.005
OM	70.49^{ab}	69.79^{ab}	64.25^{a}	73.21^{b}	1.38	0.011	0.026	0.011
CP	65.92^{a}	65.49^{a}	62.98^{a}	74.48^{b}	1.57	0.036	0.219	0.369
EE	86.82	86.58	80.05	82.09	3.43	0.460	0.756	0.460
CF	62.12^{b}	60.77^{b}	63.04^{a}	66.43^{b}	1.59	0.002	0.013	0.002
NFE	72.66	72.02	74.71	75.27	2.96	0.154	0.109	0.154
Nutritive value								
DCP intake								
kg/d	0.06^{a}	0.06^{a}	0.07^{ab}	0.08^{ab}	0.00	0.008	0.293	0.008
g/kg $W^{0.75}$	5.67^{a}	6.03^{a}	7.34^{b}	8.44^{b}	0.28	0.000	0.624	0.000
TDN intake								
kg/d	0.45	0.43	0.46	0.52	0.06	0.118	0.187	0.118
g/kg $W^{0.75}$	39.87^{a}	42.11^{a}	47.50^{b}	54.64^{b}	2.54	0.014	0.571	0.014

Means within row having different superscripts differ significantly (P<0.05). LCD, Low concentrate diet; LCIN, Low concentrate diet with 2% inulin supplementation; HCD, High concentrate diet; HCIN, High concentrate diet with 2% inulin supplementation. DM, dry matter; OM, organic matter; CP, crude protein; CF, crude fibre; EE, ether extract; NFE, nitrogen free extract; DCP, digestible crude protein; TDN, total digestible nutrients; SEM, standard error of mean.

body weight in barbari goats. Results were in conformity with the findings of Bhutharit (2016) who reported that nutrient intake in terms of crude protein was significantly increased from Jerusalem artichoke at 2% and commercial inulin at 2% of dry matter.

It was concluded that inulin supplementation either in high concentrate and low concentrate diet of growing goats resulted in significant improvement in growth performance and nutrient digestibility may have beneficial effects regardless of the type of diet fed to the animal in small ruminant production system.

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