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Effect of quantitative feed restriction and realimentation on growth, carcass traits and economics in stallfed Barbari kids

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ABSTRACT

Four months old 24 Barbari kids were allotted randomly to *ad lib.* feeding up to 12 months age, 20% (mild) and 40% (moderate) feed restriction at 5th and 6th months (MMFR) and 20, 40, 60% (severe) feed restriction (MMSFR) each of 20 days duration during 5th and 6th months followed by realimentation up to 12 months age. At the end of realimentation, 4 kids from three groups were slaughtered and carcass traits evaluated along with its economics. The kids did not differ significantly in growth and carcass traits. Body weight change indicated that the occurrence of compensatory growth in feed restricted kids proportional to body weight loss occurred during restriction. The feed cost/kg gain was lowest in MMSFR kids followed by *ad lib.* fed and MMFR kids. Therefore, stallfed Barbari kids shall easily be maintained up to 60% lower feed for 60 days thereby increasing the profit of stallfed kid rearing.

Key words: Barbari goat kids, Carcass traits, Feed restriction, Growth, Stall feeding

The goat production system is gradually shifting from less input extensive production for livelihood and nutritional security to medium and high input semi intensive and intensive production, respectively, for commercial large scale enterprise. Feeding alone accounts nearly about 65–75% of total variable cost of goat production under intensive stall feeding system. Any reduction in cost of feeding will make the goat enterprise more remunerative and thereby more attractive. Besides the use of cheap and non conventional feeding materials and nutritional manipulations, there is a need to manipulate management practices to improve feed conversion efficiency of animals especially stallfed goats raised under broiler kid production system to meet the ever increasing demand for goat meat.

Feed restriction occurs in livestock and poultry either naturally during drought, disasters or induced artificially as a management tool to reduce feed cost while maintaining productivity of meat animals by exploiting compensatory growth mechanism. Similarly, feed restriction can be either quantitative by reducing the amount of feed offered or qualitative by reducing the nutrient content in feed. The response in terms of compensatory growth after feed restriction and realimentation varies with species, breed, age, sex, physiological stage, rearing system, quantity and quality of feed, duration and severity of feed restriction. In monogastric animals, feed restriction methodologies have been standardized through many experiments and are in practice since decades for maximum production (Lee *et al.* 2002, Demir *et al.* 2004). Similarly, in ruminant animals like cattle and sheep, several studies reported the occurrence of nil, partial and complete compensatory growth after feed restriction (Thornton *et al.* 1979, Keogh *et al.* 2015, Babu *et al.* 2017, Ohja *et al.* 2018). Ryan *et al.* (1993) observed that complete compensation occurs in sheep but not in cattle during realimentation and the compensatory growth was mainly due to increased efficiency of restricted animals during first 12 weeks of realimentation and thereafter due to increased feed intake. Raju *et al.* (2015) reported that with 15% feed restriction with dietary protected lipid supplementation in Deccani lambs yielded higher ADG, feed efficiency and carcass traits than 30% restricted and *adlib* fed lambs. Similarly, Abouheif *et al.* (2015) suggested that the implementation of 10% feed restriction followed by two weeks of realimentation just before slaughtering would be appreciated by both consumer and sheep producer and can thus be adopted as a nutritional practice for finishing and fattening Najdi lambs. Even up to 30% feed restriction in 3 months old ram lambs revealed higher weight gain, FCE and carcass yield as compared to *ad lib.* fed lambs (Babu *et al.* 2017).

Compared to other livestock species and poultry, the studies of the effect of feed restriction on performance and economics in growing goat kids are lacking especially in Indian goat breeds and needs detailed experiments covering all the factors affecting the response of feed restriction on productivity and profitability of goat production so as to recommend the feed restriction as routine feeding

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intervention under package of practices for commercial goat kid production. Salem *et al.* (1989) studied the effects of periodic feed restriction for 5, 10 and 15 days and realimentation for 10 days on body weight change, feed digestibility and nitrogen balance in mature Baladi bucks. Realimentation in 8 months old kids of Iran after 75 days of feed restriction was associated with a greater daily gain without any deleterious effect on carcass composition (Dashtizadeh *et al.* 2008). The feed restriction up to two months followed by six months realimentation period did not affect the carcass characteristics of the kids adversely in post weaned Sirohi kids (Sharma *et al.* 2009). In pre weaned Jamunapari kids, milk restriction with normal access to creep feeding encouraged solid feed consumption by goat kids with early adaptation for intake of solid foods leading to higher weight gain and average daily gain (Vyas *et al.* 2012). Kumar *et al.* (2017) reported that feed restriction considerably reduced methane emission and improved the energy utilization efficiency in one year old female goats.

Considering the paucity of information on effect of feed restriction on performance, carcass traits of growing post weaned stallfed goat kids, the present study was planned with the aim to assess the weight gain, feed intake, carcass traits and economics of different degrees of feed restriction followed by realimentation in stallfed Barbari kids, which is proved to be the best suited goat breed for intensive stall feeding conditions based on its small body size.

MATERIALS AND METHODS

Four months old 24 kids of Barbari breed (12 females and 12 males) were divided equally in to 3 groups based on their body weight, age, sex and type of birth and allotted randomly to Group-1: *ad lib.* feeding up to 12 months age; Group-2: Feeding @ 80% of *ad lib.* consumption (mild restriction) during 5th month and 60% (moderate restriction) during 6th month of age, i.e. mild and moderate feed restriction (MMFR) followed by realimentation up to one year of age; Group-3: Feeding @ 80, 60 and 40% (severe restriction) of *ad lib.* consumption each of 20 days duration during 5th and 6th month age, i.e. mild, moderate and severe feed restriction (MMSFR) followed by realimentation up to one year of age. The kids were maintained in individual kid pens with 1.2 m × 1.2 m cages under asbestos sheet roofed shed. They were taken out of cages for about two h daily in the morning. All management practices were uniformly followed throughout the trial period.

The kids were fed complete feed individually which consisted of 50% concentrate mixture (Maize 25%, Til cake 10%,wheat bran 17%, mineral mixture 2%, common salt 1%) and 50% dry fodder of arhar (*Cajanus cajan*)/gram (*Cicer arietinum*) crops. The weighed quantity of complete feed pellets were offered to kids daily at about 10.00 AM and the refusal, if any, was recorded at about 08.00 AM next day. The feed intake for individual kids was recorded at start and end of each feed restriction stages at 10 days interval and at monthly interval thereafter, i.e. during realimentation stage. The average feed intake (% of body weight) in group-l at 10 days interval during dietary restriction and at 15 days during realimentation which served as the basis for calculating quantity of feed served during different stages of growth in group-2 and group-3. On similar intervals, body weight recording of individual kids was carried out. Each time, body weight was recorded for 3 consecutive days and average was considered. Fresh water was offered twice daily.

After six months of re-alimentation period, 4 male kids from each group were slaughtered, after 16–18 h fasting and free access to potable water. Bleeding, evisceration and dressing were done as per the standard commercial procedures. The carcass component as expressed in this study was hot carcass weight excluding any offal or fat. Empty live weight was calculated as the difference between slaughter weight and weight of digestive content. The dressing percentages on the basis of pre-slaughter weight (SW) as well as an empty live weight (ELW) were also recorded as per Agnihotri *et al.* (2006). The data were statistically analysed using mixed model least squares maximum likelihood programme PC-2 as per Harvey (1990).

RESULTS AND DISCUSSION

The body weight has been the only measuring criteria while deciding the price of the meat animals reared under different production systems. Research data reveals that the feed restriction technology could strategically be used as a management tool to reduce feed cost for growing animals.

Growth: The body weight of *ad lib.* and feed restricted kids during restriction and realimentation phases is given Table 1. It is evident from table that the body weight of feed restricted kids decreased marginally during restriction phase whereas reverse trend was true in *ad lib.* fed kids. During the initial 30 days of feed restriction (5th month age), the body weight increased by 10.16% in *ad lib.* fed kids and decreased by 3.52 and 8.44% in MMFR and MMSFR kids, respectively. However, the difference of body weight between *ad lib.* fed and feed restricted kids during first 30 days of feed restriction was statistically nonsignificant. Similarly, there was no difference between body weight of kids underwent two levels of restriction during this period which indicated that kids can be maintained easily with lower quantity of feed for shorter duration up to one month in situations like disaster, feed shortage and inclement weathers, and as a measure to save feed without compromising the growth of stall fed kids. However, the second month of feed restriction (6th month age) significantly ($P<0.01$) reduced body weight in feed restricted kids as compared to *ad lib.* fed kids, though the reduction among two restricted groups was statistically similar. The change in body weight during this period was –6.96% in MMFR kids, –10.01% in MMSFR kids and 3.39% in *ad lib.* fed kids. Salem *et al.* (1989) reported 8% body weight loss in 10% concentrate restriction followed by 10 days realimentation with repeated cycles till 105 days experimental period. Muna and Ammar (2001) observed

Table 1. LSM±SE for live weight (kg) of Barbari kids during feed restriction and realimentation

Period of weighing	ADLIB	MMFR	MMSFR	Significance
Dietary Restriction Phase				
0th day	8.08±0.39	8.08±0.39	8.08±0.09	NS
10th day	8.48±0.41	7.86±0.41	8.04±0.41	NS
20th day	9.21±0.41	8.04±0.41	8.11±0.41	NS
30th day	9.48±0.46	8.41±0.46	8.13±0.46	NS
40th day	9.98^{a}±0.45	8.26^{ab}±0.45	8.17^{b}±0.45	*
50th day	10.83^{a}±0.46	8.36^{b}±0.46	7.95^{b}±0.46	**
60th day	11.37^{a}±0.46	8.46^{b}±0.46	7.83^{b}±0.46	**
Realimentation Phase				
75th day	12.44^{a}±0.51	9.23^{b}±0.51	8.47^{b}±0.51	**
90th day	12.99^{a}±0.56	9.95^{b}±0.56	9.23^{b}±0.59	**
105 th day	13.54^{a}±0.57	10.49^{b}±0.61	10.28^{b}±0.61	**
120 th day	14.55^{a}±0.63	11.63^{b}±0.75	11.55^{b}±0.66	**
180 th day	17.72±0.96	15.57±0.89	16.49±0.83	NS
235 th day	21.73±0.99	19.42±0.99	21.88±1.08	NS

ADLIB- *ad lib.* fed group; MMFR, mild and moderate feed restricted group; MMSFR, Mild, moderate and severe feed restricted group; RES, Feed restriction; REA, Feed realimentation. * P<0.05, **P<0.01.

1.78% weight loss in 12–15 months aged male desert goats during one week feed restriction along with water restriction during summer season.

During realimentation phase, the body weight of feed restricted kids at both levels continued to be significantly (P<0.01) lower than *ad lib.* fed kids even after 60 days of realimentation, though the body weights of kids between two levels of restriction after realimentation did not differ significantly which corroborates the findings of Dashtizadeh *et al.* (2010) in eight months old native goats of Iran. Thereafter, the body weights of kids of all three groups were statistically similar till the end of trial. The body weight change during first 15 days of relimentation phase in MMFR and MMSFR kids were 13.09 and 15.32% as against just only 3.55% in *ad lib.* fed kids. The trend of higher body weight in restricted kids as compared to *ad lib.* fed kids continued till the end of trial. The respective body weight change during 15–30, 30–60, 60–120 and 120–175 days of relimentation phase were 14.88, 17.26, 12.58; 21.93, 17.1, 12.37; 20.12, 22.24, 21.44 and 21.29, 21.27, 14.50%. The trend of body weight change indicated the occurrence of compensatory growth in feed restricted kids proportional to the body weight loss occurred during restriction phase. The magnitude of body weight increase was observed to be highest in MMSFR kids followed by higher in MMFR kids during 60–120 and 120–180 days of realimentation in comparison to *ad lib.* fed kids. The data indicated that feed restriction helped in utilizing the physiologically occurring compensatory growth in growing feed restricted stallfed kids, as it was evident from the similar body weight of feed restricted and *ad lib.* fed kids at the marketing age, i.e. 9–12 months of age. Similar growth between normal and feed restricted animals after realimentation was also reported by previous researchers (Ryan *et al.* 1993, Kamalzadeh *et al.* 1998, Raju *et al.* 2015, Suwignyo *et al.* 2015, Babu *et al.* 2017). However, Suwignyo *et al.* (2017) reported that 60% feed restriction up to 30 days followed by 60 days realimentation in eight months old Kacang goat kids yielded significantly higher weight gain (7.39 kg) as compared to 60 days feed restriction with 30 days realimentation (2.21 kg) and control kids (5.90 kg).

The trend of average daily gain of kids during restriction and realimentation phase has been depicted in Fig. 1. The overall mean ADG of MMFR and MMSFR kids were 6.3 and –4.2 g, respectively as against 54.8 g in *ad lib.* fed kids during feed restriction of 60 days. This indicates that the stallfed Barbari kids shall be able to withstand feed restriction up to 40% without body weight loss and even up to 60% restriction for 20 days (MMSFR) with minimum weight loss. Ohja *et al.* (2018) also observed similar body weight gain and ADG in 15% feed restricted 3–4 months old crossbred male calves as compared to *ad lib.* fed calves.

On realimentation, the ADG of kids underwent restriction increased sharply *vis-à-vis ad lib.* fed kids. The ADG in MMSFR kids showed steady increase throughout the realimentation phase whereas, it did not show any specific trend in MMFR kids. The overall ADG during realimentation phase after feed restriction was significantly higher (80.3 g) in MMSFR kids followed by 62.6 g in MMFR kids and lowest (59.2 g) in *ad lib.* fed kids. The higher ADG in severely restricted kids could be due to the body weight loss during restriction phase. The mean ADG in MMSFR kids during 40–60 and 0–30 days of realimentation were –12.5 and –10 g as compared to 10.0 and 1.7 g in MMFR kids. Sahlu *et al.* (1999) observed body weight loss of 10 g/day only at severe feed restriction as compared to body weight gain of 5 g/day at moderate restriction and 24 g/day at low restriction and 13 g/day in *ad lib.* fed Angora wethers. On relimentation, the ADG in respective wethers were reported as 87, 31, 36 and 14 g/day. Abouheif *et al.* (2015) observed body weight loss (ADG) of 7.6 and 26.9% in 10 and 20% feed restriction during restriction phase that lead to 35 and 30.5% faster ADG than the control, respectively, during realimentation period in lambs. Suwignyo *et al.* (2017) recorded mean ADG in control, 30 days feed restriction with 60 days realimentation and 60 days feed restriction with 30 days realimentation in eight months old 60% feed restricted Kacang goat kids of Indonesia as 75.00, 65.49 and 15.58 g, respectively. In contrary, Hooda and Upadyay (2014) reported that kids underwent 50% feed restriction followed by thermal stress could not compensate growth after removal of thermal stress and *ad lib.* feeding in four months old Alpine × Beetal crossbred kids.

Dry matter intake: Table 2 shows the DMI in Barbari kids during different stages of feeding. It is obvious from the data that DMI increased steadily in *ad lib.* fed kids with the increase in body weight over the period (Table 1). The quantity of DMI in feed restricted kids was calculated taking in to consideration of DMI in *ad lib.* fed kids as explained

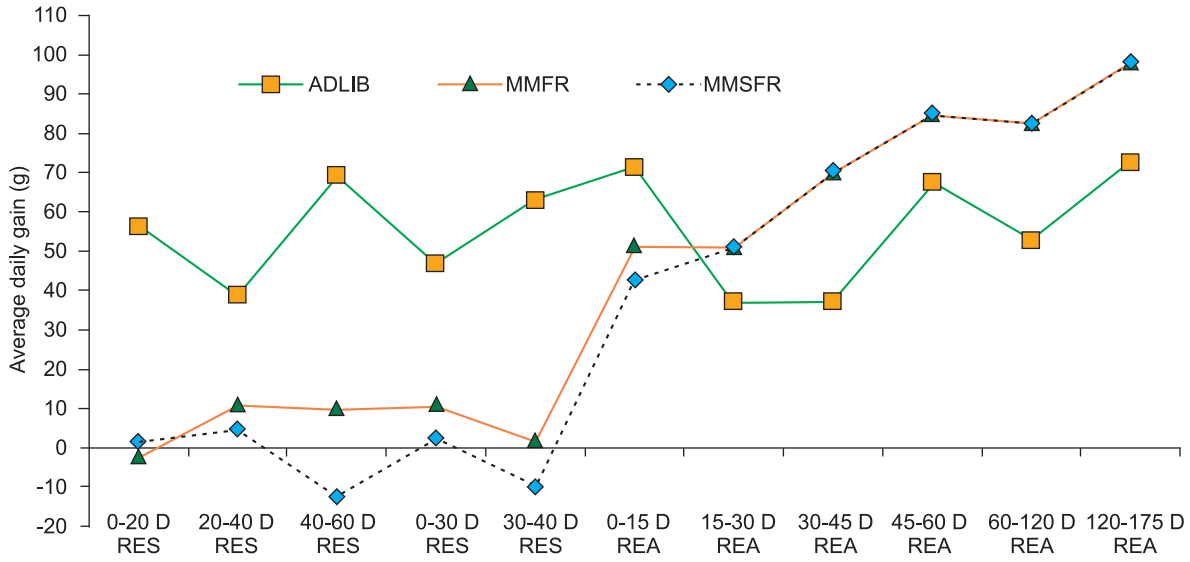

Fig 1. Effect of feed restriction on average daily gain in Barbari kids. ADLIB, *ad lib.* fed group; MMFR, Mild and moderate feed restricted group; MMSFR, Mild, moderate and severe feed restricted group; RES, Feed restriction; REA, Feed realimentation. *P<0.05, **P<0.01.

Table 2. Effect of feed restriction and realimentation on dry matter intake (g/kid/day) in Barbari kids

Period	ADLIB	MMFR	MMSFR
	Feed Restriction Phase		
0–10th day	362.3 (4.37)	252.0 (3.16)	252.0 (3.13)
10–20 th day	434.8 (4.92)	251.9 (3.17)	250.9 (3.11)
20–30 th day	487.7 (5.22)	309.6 (3.77)	239.4 (2.95)
30–40 th day	531.5 (5.46)	265.9 (3.19)	241.8 (2.97)
40–50 th day	562.1 (5.40)	264.5 (3.18)	181.0 (2.24)
50–60 th day	591.1 (5.32)	268.3 (3.19)	168.1 (2.14)
	Feed Realimentation phase		
0–15 th day	579.4 (4.87)	371.7 (4.20)	290.9 (3.57)
15–30 th day	569.1 (4.48)	441.2 (4.60)	402.7 (4.55)
30–45 th day	597.9 (4.51)	468.9 (4.59)	495.3 (5.08)
45–60 th day	587.1 (4.18)	541.2 (4.89)	604.2 (5.54)
60–120 th day	618.0 (3.83)	616.1 (4.53)	653.5 (4.66)
120–175 th day	723.7 (3.67)	702.0 (4.01)	719.6 (3.75)

Value in parentheses indicates dry matter intake expressed as percentage of body weight.

previously. The DMI/kid/day during restriction phase averaged 494.9, 268.7 and 222.3 g in *ad lib.* MMFR and MMSFR kids, respectively. The respective DMI during realimentation period ranged from 569.1±5.8 to 723.7±8.1, 371.7±9.8 to 701.2±8.1 and 290.9±9.8 to 719.6±8.1 g/kid/day. Similar DMI were reported by Sahlu *et al.* (1999) during restriction and realimentation trials. Suwignyo *et al.* (2017) recorded mean DMI in control, 30 days feed restriction with 60 days realimentation and 60 days feed restriction with 30 days realimentation in eight months old 60% feed restricted Kacang goat kids of Indonesia as 686.30, 552.26 and 474.73 g, respectively. The total DMI for respective three groups during restriction and realimentation phases were recorded to be 29.70, 16.13, 13.34 and 111.89, 102.87, 103.68 kg. The DMI up to 45 days of feed realimentation was significantly (P<0.01) lower in feed restricted kids and thereafter, it was remained almost equal in all three groups.

The DMI in terms of percentage of body weight in *ad lib.* kids showed decreasing trend with the advancement of age. During restriction phase, it varied from 4.37 to 5.46, 3.16–3.77 and 3.13 to 2.14% in *ad lib*. MMFR and MMSFR kids, respectively. During realimentation phase, a sharp increase in DMI was recorded in feed restricted kids. During first 15 days, the increase was to the tune of 31.66 and 66.82% in MMFR and MMSFR kids, respectively and this increasing trend continued up to 60 days of realimentation period. Thereafter, the percent DMI tended to decrease in all the groups. The overall DMI/100 kg during the trial was found to be 4.04, 3.68 and 3.38% in *ad lib.* fed, MMFR and MMSFR kids, respectively.

Carcass traits: The least squares means and analysis of variance for carcass traits of feed restricted and *ad lib.* fed Barbari kids (Table 3) revealed that there was no significant difference among groups for any of the carcass traits studied which is in agreement with the reports of Sahlu *et al.* (1999), Sharma *et al.* (2009) and Suwignyo *et al.* (2015) in goats. Similarly, the nonsignificant difference in carcass traits after the end of different levels and duration of restriction and realimentation trial was also observed in lambs (Abouheif *et al.* 2015, Raju *et al.* 2015). However, the dressing percentage on live weight basis was marginally higher in *ad lib.* fed kids and so was on empty live weight basis.

Economics of dietary restriction: The quantity of feed saved in terms of dry matter intake and the cost per kg weight gain due to dietary restriction have been calculated by considering total dry matter intake in different groups during the trial period and the cost of feed. The cost of complete feed (50:50) was calculated as ₹ 1200.00 per quintal considering the present cost of concentrate mixture and dry fodder @ ₹ 1700.00 and

Table 3. Effect of feed restriction and realimentation on carcass traits in Barbari kids

Particular	Least Squares Means±SE			Significance
	ADLIB	MMFR	MMSFR	level
Slaughter weight (kg)	20.75±l.36	18.86±1.21	20.02± 1.11	NS
Empty live weight (kg)	17.82±1.18	16.18±1.01	17.25± 0.96	NS
Carcass weight (kg)	9.90±0.72	8.68± 0.64	9.45±0.56	NS
Dressing rate (%)				
On live weight basis	47.52±1.06	46.09± 0.95	47.19± 0. 87	NS
On Empty live weight basis	55.43± 0.87	53.71±0.78	54.62±0.71	NS

ADLIB, *ad lib.* fed group; MMFR, mild and moderate feed restricted group; MMSFR, mild, moderate and severe feed restricted group; NS, non-significant.

Table 4. Economics of dietary restriction in Barbari kids

Particular	ADLIB	MMFR	MMSFR
Total DMI/kid (kg)	141.59	119.9	117.02
Cost of feed @ ₹ 1200.00/Q DM (₹)	1699.08	1438.8	1404.24
Weight gain (kg)	13.65	11.34	13.80
Cost/kg weight gain (₹)	124.47	126.88	101.76
Feed saved/kg gain (kg)	Basis	1.91	1.78
Cost of feed saved (₹)/kg gain	—	22.95	21.37
Cost of feed saved/100 kg gain (₹)	—	2295.24	2136.52

ADLIB, *ad lib*. fed group; MMFR, mild and moderate feed restricted group; MMSFR, mild, moderate and severe feed restricted group.

₹ 700.00, respectively. It is evident from Table 4, the total DMI and feed cost was lower in feed restricted kids as compared to *ad lib.* fed kids. The feed cost per kg gain was lowest in kids underwent up to 60% feed restriction (MMSFR) followed by *ad lib.* fed kids and MMFR kids. Suwignyo *et al.* (2017) reported that the feed cost of shorter duration of 30 days feed restriction@ 60% followed by 60 days realimentation produced the optimal profit followed by control and animals with 60 days restriction and 30 days realimentation. However, Suwignyo *et al.* (2015) opined that similar feed cost/kg gain in feed restricted and normal fed goat kids. Abouheif *et al.* (2015) observed 27.5 and 21.8% higher feed: gain ratios than the control, respectively, in lambs that underwent 10 and 20% feed restriction during realimentation phase.

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