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Effect of herbal feed additives on intake, rumen fermentation, availability of nutrients and energetic efficiency of feeds in Barbari kids reared under confined condition

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ABSTRACT

Weaned male Barbari kids (24) were divided equally into three groups (T_1, T_2 and T_3) to investigate the effect of supplementation of herbal feed additives in the complete pelleted feed on intake of nutrients, rumen fermentation, availability of nutrients and energetic efficiency under stall-fed condition during an eight months feeding trial. Treatments were T_1, Concentrate mixture (40%) plus arhar (*Cajanus cajan*) straw (60%) in Total Mixed Ration (TMR) form fed *ad lib.*; T_2, Concentrate mixture (40%) plus arhar straw (60%) in Complete Feed Pellets form fed *ad lib.*; T_3, Concentrate mixture (40%) plus arhar straw (60%) in Complete Feed Pellets form supplemented with herbal mixture (four herbs; Tulsi: Haldi: Amla: Arni, ratio 1:1:1:1 on DM basis) @ 0.5% in complete feed fed *ad lib*. Rumen fermentation pattern was studied at 3rd and 25th weeks of experimental feeding. A metabolism trial was conducted at the last phase of the experiment. During metabolism trial, DMI (g)/kg $W^{0.75}$ and CPI (g)/kg $W^{0.75}$ was greater in kids under T_3 and T_2 than T_1. Pelleted complete feed supplemented with phytogenic feed additives resulted greater total VFA (mmol/dl SRL) concentration in rumen liquor of kids under T_3 than TMR fed kids (T_1) at three weeks of experimental feeding. The concentration of NH_3-N (mg/dl SRL) was depressed significantly in T_3 at 3rd and 25th weeks of feeding; T_1 showed highest values during both periods. TDN intake (g)/kg $W^{0.75}$ and Digestible Energy intake (MJ)/kg $W^{0.75}$ were increased significantly in T_3 and T_2 than T_1. DCP intake (g)/kg $W^{0.75}$ was also higher in T_2 and T_3 than T_1. Similarly, N-balance (g)/kg $W^{0.75}$ increased significantly in T_3 and T_2 than T_1. Therefore, it may be concluded that densification of feeds in the form of complete pelleted feed (T_2) and further supplementation (@ 0.5% in the complete feed) with herbal mixture (Amla, Haldi, Arni and Tulsi=1:1:1:1 on DM basis) (T_3) increased the intakes of DM, TDN, digestible energy and protein; enhanced rumen fermentation pattern, and increased N-balance in finisher Barbari kids.

Keywords: Barbari, Complete feed, Digestibility, Fermentation, Herbal additives, Kids

Phytogenics or herbal additives are reported to have potential effect in increasing appetite, growth of favourable microorganisms, feed consumption, digestion, weight gain in livestock and act as rumen fermentation modifiers to improve health status (Karásková *et al*. 2015, Brand *et al.* 2019). These additives are well accepted by the consumers over chemical compounds, because they are considered safe and healthy (Das *et al.* 2020). Use of phytogenic feed additives (PFA) improved the digestibility of all the nutrients, without any significant negative effect on dry matter intake or body weight changes (Choubey *et al*. 2016). *Emblica officinalis* primarily contains tannins, flavonoids, saponins, terpenoids, ascorbic acid, carbohydrates and many other compounds (Khan 2009). The average daily gain in lambs significantly improved ($P<0.05$) due to supplementation of *Emblica officinalis* fruit in the concentrate mixture (0.4 or 0.6 or 0.8%) as compared to control (Bostami *et al.* 2015). Oderinwale *et al.* (2019) concluded that breeds of kid and turmeric powder inclusion and their interaction influenced pre- and post-weaning performance of the kids. A significant increase in average body weight gain, feed intake and feed conversion efficiency was observed in crossbred (Holstein cross) calves when supplemented with *Allium sativum* extract @ 250 mg/d/kg BW (Ghosh *et al.* 2010). Similarly, feeding garlic powder increased growth performance, feed digestion, rumen fermentation and the health status of lambs infected with gastro-intestinal nematodes (Zhong *et al.* 2019). Higher gut fill in goats fed Kalmegh (*Andrographis paniculata*) suggested slow rate of digestion; which could have improved utilization of nutrients by the animals (Yusuf *et al.* 2014). Kids that received garlic or thyme had higher

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feed consumption and average daily gain (Usur 2019).

Hence, it is presumed that pelletization of complete feed and blending with Indian herbs in combination (phytogenic additives) may increase voluntary intake, rumen fermentation and nutrients utilization pattern in kids. Therefore, the present experiment was conducted to investigate the effect of supplementation of mixed herbal feed additives in the complete pelleted feed on intake of nutrients, rumen fermentation, availability of different nutrients and energetic efficiency of complete feeds in finisher Barbari kids reared under confined condition.

MATERIALS AND METHODS

Study site: The experiment was conducted in the experimental unit of Nutrition, Feed Resource and Products Technology Division, ICAR-Central Institute for Research on Goats (CIRG), Makhdoom, Farah, Mathura (Uttar Pradesh). Makhdoom is situated at 27°10'N latitude and 70°02'E longitude and at an altitude of 169 meter MSL in semi-arid region of Indo-Gangetic plain.

Experimental animals and diets: Twenty-four weaned male Barbari kids (age 144.67 days, weight, 11.99±0.49 kg) were divided equally into three treatment groups (T_1, T_2 and T_3) having eight kids in each group. The animals were dewormed at the beginning of the experiment. The kids were vaccinated against PPR, goat pox, enterotoxeamia, FMD and HS as per standard schedule. Four phytogenic (herbal) plant parts were selected such as leaf and small stems of *Ocimum sanctum* (Tulsi), roots of *Curcuma longa* (Haldi), fruits of *Emblica officinalis* (Amla) and leaves and small stem of *Clerodendrum phlomidis* (Arni) for evaluation in kids. After estimating DM content, the samples were grinded with laboratory Wiley mill and preserved in polythene bags. The concentrate mixture was prepared with feed ingredients, such as barley grain (*Hordium vulgare*) 40%, linseed cake (*Linum usitatissimum*) 15%, groundnut cake (*Arachis hypogaea*) 20%, wheat bran (*Triticum aestivum*) 10%, Bengal gram chuni (*Cicer arietinum*) 12%, mineral mixture 2% (Totavit Strong 1.75% , Vet Mankind + Supplevite-M 0.25%, Zydus AHL) and common salt 1%.

Above mineral mixture was used to avoid deficiency of vitamins, minerals and other critical nutrients (lysine, methionine) since no green fodder was fed to the experimental kids during the entire experimental period. However, same concentrate mixture was used in all three diets. The feeding schedule was followed as given here.

T_1: Concentrate mixture (40%) + Arhar (*Cajanus cajan*) straw (60%) in Total Mixed Ration (TMR) form fed *ad lib*.

T_2: Concentrate mixture (40%) + Arhar straw (60%) in Complete Feed Pellets form fed *ad lib.*

T_3: Concentrate mixture (40%) + Arhar straw (60%) in Complete Feed Pellets form supplemented with herbal mixture** fed *ad lib*. [**Herbal mixture: Combination of four phytogenic feed additives (Tulsi: Haldi: Amla: Arni, ratio 1:1:1:1 on DM basis) @ 0.5% in complete feed].

Evaluation of intake, nutrient utilization and energy value: The experimental kids in each group were allowed for feeding for 8 months by following the respective feeding schedule. Clean water was freely available to all the animals throughout the experimental period. A metabolism trial was conducted in all kids under three treatments at the last phase of growth trial (7^{th} month of feeding) with a collection period of 6 days using specially designed metallic goat cages. Intake of diets was measured on daily basis using double pan balance (Avery, India). Samples of feeds and herbal additives offered, residues left and faeces voided were analyzed for proximate composition (AOAC 1995) and cell wall components (Goering and Van Soest 1970) in order to estimate digestibility and availability of different nutrients in kids. Energy value (MJ) of feeds and faeces of each animal was estimated by Bomb Calorimeter (Model no. 6200, Parr Instrument Company, India).

Evaluation of rumen fermentation: Rumen liquor was collected from the donor kids of respective treatment groups (at 3^{rd} and 25^{th} weeks of feeding) before feeding (at 9.00 AM) with the help of stomach tube (Prakash *et al.* 2006) and taken in a clean thermo flask after filtering through double layer muslin cloth. The strained rumen liquors were stored in properly corked and labeled plastic bottles at -10 to -12°C for further analysis. The *p*H of the rumen fluid was determined by using digital *p*H meter (Elico, India). The N-fractions in the incubation medium were analyzed in accordance with Micro-Kjeldahl method (AOAC 1995). Total volatile fatty acid (TVFA) concentration in the incubation medium was estimated according to John *et al.* (1957). The TVFA was fractioned as per the method described by Ervin *et al.* (1961) using Gas Chromatograph (Amil Nucon 5700, India) fitted with chromosorb 101 column.

Statistical analysis: Data on intake of nutrients, rumen fermentation and nutrients utilization were analyzed with one-way ANOVA using randomized complete block design with eight replications (kids) in each group during animal experimentation (Snedecor and Cochran 1994). Computerized IBM SPSS 20.0 package was used for analysis of variance. Duncan's Multiple Range Test was used to measure the differences of means (Duncan 1955).

RESULTS AND DISCUSSION

Chemical composition of feed: Chemical composition of herbal additives, concentrate mixture, arhar straw (*Cajanus cajan*) and complete feeds (TMR and pelleted feeds) are presented in Table 1. The CP and NDF content (%) in herbal ingredients ranged from 13.31 (Haldi) to 14.06 (Arni) and 42.40 (Haldi) to 57.70 (Tulsi), respectively. CP content in different complete feeds was more than 12%. The gross energy value was estimated 18.97, 18.94 and 18.54 MJ/kg of feed in T_1, T_2 and T_3, respectively. Hence, complete diets under three treatment groups were made iso-caloric and iso-nitrogenous.

Intake, digestibility of nutrients and N-balance: DMI (g/d/kid) was significantly ($P<0.01$) higher in T_3 and T_2 than T_1 during metabolism trial (Table 2). Similarly, DMI (g)/kg $W^{0.75}$ was also statistically greater ($P<0.001$) in T_2 (98.83)

Table 1. Chemical composition (%) of feeds used during metabolism trial period in weaned Barbari kids

Ration	OM	CP	EE	TCHO	Ash	NDF	ADF	Hemi-cellulose	Cellulose	Lignin	Energy (MJ/kg)
Tulsi	89.45	13.58	2.78	73.09	10.55	57.70	37.93	19.77	25.67	9.67	-
Haldi	91.07	13.73	1.99	75.35	8.93	42.40	23.07	19.33	19.77	2.75	-
Amla	88.69	13.31	2.46	72.92	11.31	47.35	20.71	26.64	17.23	3.11	-
Arni	86.02	14.06	2.01	69.95	13.98	48.16	30.46	17.70	18.59	8.00	-
Arhar straw	89.57	8.08	1.91	79.58	10.43	71.69	52.90	18.79	45.99	6.02	-
Concentrate mixture	92.21	19.08	3.34	69.79	7.79	39.24	21.65	17.59	15.58	6.07	-
T_1	90.52	13.17	3.00	74.35	9.98	60.01	42.49	17.52	35.01	6.07	18.97
T_2	89.94	12.83	3.09	74.02	10.06	59.84	43.30	16.54	35.85	6.13	18.94
T_3	88.88	13.00	3.90	71.98	11.12	60.02	42.33	17.69	34.64	6.09	18.54

OM, Organic matter; CP, Crude protein; EE, Ether extract; TCHO, Total carbohydrate; NDF, Neutral detergent fibre; ADF, Acid detergent fibre; T_1, TMR (Concentrate: Arhar straw = 40:60); T_2, Complete pellet feed (Concentrate: Arhar straw = 40:60); T_3, Complete pelleted feed (Concentrate: Arhar straw = 40:60) with 0.5% herbal additive mixed in concentrate mixture (Tulsi : Arni : Haldi : Amla = 1 : 1 : 1 : 1).

Table 2. Intake, apparent digestibility of nutrients and N balance in kids under different treatments

Parameter (%)	T_1	T_2	T_3	SEM	P value
DM intake					
g/d/kid	684.11^a	962.13^b	1028.30^b	49.06	0.005
Kg/100 kg BW	3.52^a	4.37^b	4.53^b	0.12	0.002
g/ kg $W^{0.75}$	73.78^a	94.42^b	98.83^b	2.97	P<0.001
CP intake					
g/d/kid	90.87^a	124.33^b	130.92^b	6.32	0.014
g/100 kg BW	467.47^a	564.92^b	575.31^b	13.89	0.001
g/kg $W^{0.75}$	9.80^a	12.20^b	12.54^b	0.37	0.001
Water intake					
ml/d/kid	764.90	859.91	938.05	40.23	0.219
litre/kg DMI	1.12	0.90	0.95	0.00	0.073
ml/kg $W^{0.75}$	82.88	84.73	91.01	3.22	0.579
Apparent digestibility coefficients of nutrients (%)					
DM	55.13	54.05	55.15	0.88	0.853
OM	58.67	62.69	61.60	1.34	0.468
CP	56.98	60.13	59.65	1.41	0.635
EE	69.81	73.45	72.38	1.61	0.659
TCHO	58.62	62.66	63.22	1.31	0.306
NDF	52.69	57.40	59.19	1.64	0.257
ADF	44.69	51.22	49.59	1.99	0.396
Hemi-cellulose	55.45	57.70	59.63	0.79	0.091
Cellulose	59.52	61.70	63.68	1.53	0.160
N-balance study					
N-intake (g)	14.53^a	19.89^b	20.95^b	1.01	0.014
N-faeces (g)	6.20^a	7.72^b	8.30^b	0.33	0.017
N-urine (g)	5.09	6.83	7.40	0.61	0.284
N-balance (g)	3.26^a	5.35^b	5.24^b	0.32	0.006
N-balance/kg $W^{0.75}$	0.35^a	0.54^b	0.50^b	0.00	0.008

Means with different superscripts (a, b) in the same row are significantly different. BW, body weight.

and T_3 (94.42) than T_1 (73.78). Total CP intake (P<0.05) and CPI (g)/kg $W^{0.75}$ (P<0.001) increased significantly in T_2 and T_3 than T_1. Total water intake (ml/d/kid), water intake (litre)/kg DM intake and water intake (ml)/kg $W^{0.75}$ were measured similar among three treatment groups.

DM digestibility was statistically similar among all three groups (Table 2). The values ranged from 54.05% in T_2 to 55.15% in T_3. The digestibility (%) of OM and total carbohydrates (TCHO) ranged from 58.67 (T_1) to 62.69 (T_2) and 58.62 (T_1) to 63.22 (T_3), respectively. Digestibility of CP was found similar in kids among all three treatments. Similarly, such dietary treatments did not differ in EE digestibility. The digestibility of NDF and ADF were also similar in weaned Barbari kids under all treatments. The NDF digestibility (%) ranged from 52.69 in T_1 to 59.19 in T_3. The digestibilities of hemi-cellulose and cellulose were also similar among three treatments.

N-intake in Barbari kids was significantly increased (P<0.01) in T_3 and T_2 than T_1 (Table 2). N-intake increased in T_2 and T_3 due to greater DM intake; which was attributed to pelletization of feed as well as supplementation of herbal mixture in the pelleted feed. Nitrogen voided through faeces were also higher (P<0.01) in T_3 and T_2 than T_1. Whereas, nitrogen excreted through urine was similar among all treatments. N-balance (g) was significantly greater (P<0.01) in T_2 and T_3 than T_1. Similarly, N-balance (g)/kg $W^{0.75}$ increased significantly (P<0.01) in T_3 and T_2 than T_1.

Therefore, the increase in intakes of DM and CP in finisher Barbari kids could be attributed to densification of TMR in pelleted form (T_2) and adjunct effect of pelletization and herbal mixture (Amla, Haldi, Arni and Tulsi) (T_3). However, it was observed that T_2 and T_3 diets tended to enhance the digestibility of OM, CP, EE, TCHO, NDF, ADF, cellulose and hemi-cellulose; although, the variations were non-significant. It may also be inferred that pelleted feed (T_2) and herbal mixture added (T_3) pelleted feed increased availability of nutrients and N-balance. N-intake and nitrogen excretion through faeces were higher in T_2 and T_3 due to increased intake of nutrients (DM and CP) which may be attributed to greater density of nutrients due to pelleting and increased palatability of diets due to blending of phytogenic feed additives. Similarly, herbs influence the eating pattern, secretion of digestive juices and total feed

intake and play an important role as growth promoters (Woodward *et al.* 2001). Kids that received garlic or thyme had higher feed consumption and average daily gain (Usur 2019). However, earlier studies revealed that digestibility of DM and OM increased due to addition of different herbal additives. El-Foly *et al.* (2005) reported that addition of fenugreek seed or vegetable oil in the ration of sheep significantly increased organic matter and nitrogen free extract digestibility. Ishtiyak *et al.* (2010) also reported an improvement in the *in vitro* dry matter and organic matter digestibility after addition of *Trigonella foenumgraecum* in ration. The use of 50 mg/kg of *Aloe vera*, *Azadirachta indica*, *Moringa oleifera*, *Jatropha curcas*, *Tithonia diversifolia* and *Carica papaya* extract to a forage-based diet reduced methane production while improving feed digestibility under *in vitro* system (Akanmu *et al.* 2020). Herbal feed additives also enhance digestibility by stimulating endogenous enzyme activity and facilitating nitrogen absorption (Gill 2001). However, herbal components in these studies were different as compared to our study; which could be the reason for such type variation in the results. Presence of active biological properties of the herbal mixture (Amla, Haldi, Arni and Tulsi) supplemented in complete pelleted feed in T_3 of present study could have resulted in greatest values of intake pattern of DM and CP in finisher Indian Barbari kids. However, pelleting of feed ingredients in the form of complete diet may enhance voluntary intake in goats; since, Singh *et al.* (2010) reported higher DM intake in weaned Jamunapari male kids fed with complete pelleted feed (pulse straw based) than total mixed ration (TMR) (concentrate: roughage=50:50).

Table 3. Rumen fermentation pattern in kids under different treatments

Parameter	T_1	T_2	T_3	SEM	P value
3 weeks of feeding					
*p*H	6.45[a]	6.89[a]	6.64[b]	0.00	0.026
Total-N (mg/dl)	95.90	98.00	91.40	3.02	0.680
NPN (mg/dl)	36.40	34.30	34.65	1.10	0.728
TCA-ppt-N (mg/dl)	59.50	63.70	56.75	3.37	0.716
NH_3-N (mg/dl)	27.00[b]	21.18[a]	21.50[a]	0.84	0.002
TVFA (mmol/dl)	7.92[a]	9.46[b]	11.25[c]	0.39	0.000
Acetate %	68.42	67.47	66.95	0.30	0.132
Propionate %	20.29	21.23	22.00	0.32	0.090
Butyrate %	11.29	11.29	11.05	0.21	0.877
A/P ratio	3.39	3.19	3.06	0.00	0.078
25 weeks of feeding					
*p*H	6.38[a]	6.95[c]	6.62[b]	0.00	P<0.001
Total-N (mg/dl)	93.16	97.82	96.23	1.23	0.310
NPN (mg/dl)	34.67[c]	33.6[ab]	30.28[a]	0.75	0.037
TCA-ppt N(mg/dl)	58.48	64.22	65.95	1.40	0.070
NH_3-N (mg/dl)	29.32[b]	25.69[ab]	22.96[a]	0.95	0.016
TVFA (mol/dl)	8.50	9.51	9.98	0.36	0.098
Acetate %	67.62	67.45	66.06	0.30	0.066
Propionate %	20.81	20.73	22.05	0.28	0.098
Butyrate %	11.56	11.81	11.89	0.15	0.671
A/P ratio	3.26	3.27	3.00	0.00	0.084

Means with different superscripts (a, b) in the same row are significantly different. Total-N, total nitrogen; NPN, non protein nitrogen; TCA-ppt-N, Tricarboxylic acid precipitable nitrogen; NH_3-N, ammonia nitrogen; TFVA, total volatile fatty acids; A/P ratio, Acetate/Propionate ratio.

Rumen fermentation pattern: The *p*H in rumen liquor of kids was highest in T_2 estimated at 3rd (P<0.05) and 25th (P<0.001) weeks of feeding; however, the *p*H values was also higher in T_3 than T_1 during both the periods (Table 3). The concentration of total N was similar among three treatments during both the periods. NPN level (mg/dl of SRL) was also found similar among three treatments at initial phase of growth; whereas, it was reduced (P<0.05) in T_3 at the mid-phase of the experiment when compared with T_1. The concentration of NH_3-N (mg/dl SRL) was depressed significantly in T_3 at 3rd (P<0.01) and 25th weeks (P<0.05) of feeding; T_1 showed highest values during both periods. TCA-ppt-N (mg/dl SRL) was found similar in rumen liquor estimated during different time intervals; however, pelleting of TMR (T_2) and addition of herbal mixture in pelleted diet (T_3) tended to increase TCA-ppt-N concentration in the rumen liquor of finisher Barbari kids at 25th weeks of feeding. Pelleted complete feed (T_2) and pelleted complete feed added with phytogenic feed additives (T_3) resulted in greater (P<0.001) total VFA (mmol/dl SRL) concentration in rumen liquor of kids than TMR fed kids (T_1) after three weeks of experimental feeding. Whereas, TVFA level tended to increase in T_2 and T_3 than T_1 after 25 weeks of feeding, but the difference was non-significant. The proportion of acetate, propionate and butyrate were statistically similar in the kids of all treatments. However, propionate level was marginally improved in T_3 than T_1 and T_2. Similarly, acetate/propionate ratio was reduced marginally in T_3 during both times of sampling as compared to other treatments; but the difference was statistically non-significant.

Similarly, the results of the present study corroborated the findings of the earlier works who have supplemented different herbal component/s in the diet of small ruminants. Herbs influence the growth of favourable microorganisms in the rumen or stimulate the secretion of various digestive enzymes which in turn may improve the efficient utilization of nutrients (Karásková *et al.* 2015). Probably, due to this reason higher level of ammonia-N was utilized by rumen microbes for their growth; hence, greater concentration of TVFA and TCA-ppt-N was recorded due to supplementation of herbal additives in T_3. In the present study *p*H increased due to supplementation of herbal mixture. Whereas, Ishtiyak *et al.* (2010) reported no significant change in *in vitro* fluid *p*H after addition of different herbal plants with rumen liquor of goats. Feeding garlic powder increased rumen fermentation, and the health status of lambs infected with gastro-intestinal nematodes (Zhong *et al.* 2019). Methanolic extracts of *Azadirachta indica, Carica papaya, Jatropha curcas, Tithonia diversifolia and Moringa oleifera* leaves, and *Moringa oleifera* pods, resulted in reduced CH_4

production and superior OM digestibility under *in vitro* rumen fermentation system (Akanmu and Hassen 2018).

Availability of nutrients and energetic efficiency of diets: The total TDN intake (g) increased significantly (P<0.05) in finisher Barbari kids reared under T_3 and T_2 than T_1; similarly, TDN intake (g)/kg $W^{0.75}$ was also significantly greater (P<0.01) in T_3 (58.56) and T_2 (56.52) than T_1 (41.75) (Table 4). DCP intake (g) and DCP intake (g)/ kg $W^{0.75}$ were higher (P<0.05) in T_2 and T_3 than T_1. Gross Energy (GE) intake (MJ/d/kid) was significantly (P<0.01) higher in T_3 and T_2 than T_1. GE intake (MJ)/kg $W^{0.75}$ was increased (P<0.01) in T_3 and T_2 than T_1. Similarly, Digestible Energy (DE) intake (MJ/d/kid) was significantly greater (P<0.01) in T_3 and T_2 than T_1. Similarly, pelleted feed and pelleted feed blended with herbal additives increased (P<0.01) DE intake (MJ)/kg $W^{0.75}$ in T_3 and T_2 than T_1. Similarly, weaned kids consumed higher (P<0.01) metabolizable energy (ME) (MJ/d/kid) in T_3 and T_2 than T_1. However, ME intake (MJ)/ kg $W^{0.75}$ was found similar among three treatment groups. Intake of digested NDF (g)/kg $W^{0.75}$ was significantly (P<0.01) improved in T_2 and T_3 than T_1. Similarly, digested ADF intake (g)/kg $W^{0.75}$ were greater (P<0.05) in T_2 and T_3 than T_1.

TDN and CP percentages were statistically similar among three treatments. Digestible and metabolisable energy values (Mcal/kg feed) of feeds under T_2 and T_3 increased by 1.17 and 0.94; and 0.94 and 0.75 MJ/kg of feed, respectively as compared to T_1 feed. Therefore, pelletization of the complete diet and supplementation of selected herbal additives (Amla, Arni, Haldi and Tulsi) in the complete pelleted feed increased the energetic efficiency of feed and nutrient utilization.

Similarly, the results of the present study corroborated the findings of the earlier experiments done in small ruminants and supplemented with different herbal component/s. Herbs influence the growth of favourable microorganisms in the rumen or stimulate the secretion of various digestive enzymes which in turn may improve the efficient utilization of nutrients (Karásková *et al*. 2015). Supplementation of herbs mixture @ 2% (*Mentha piperita, Urtica dioica, Matricaria chamomilla, Thymus Vulgaris, Salvia officinalis, Foeniculum vulgare, Viola tricolor* and *Trigonella foenum- graecum*) resulted increased feed intake and body weight in calves (Kraszewski *et al.* 2002). Total Digestible Nutrient (TDN%) and starch equivalent (SE%) was increased significantly in sheep fed grams diet supplemented with fenugreek seeds (El-Foly *et al.* 2005). Feeding garlic powder increased growth performance, feed digestion, rumen fermentation, and the health status of lambs infected with gastro-intestinal nematodes (Zhong *et al.* 2019).

Densification of feeds in the form of complete pelleted feed and further supplementation with potential herbal components increased the voluntary intake of DM, digestible energy and protein as well as N-balance and also enhanced rumen fermentation pattern and energetic efficiency of feeds in finisher Barbari kids. Further, intake of DM, TDN and CP/DCP in kids under all three treatments were estimated adequate and higher than the recommended requirements of NRC (2007) for goats with ADG of about 50 g. Hence, this type of complete pelleted feeding module may be a practical option for increasing growth in finisher kids under stall-fed condition.

Table 4. Availability of different nutrients and nutritive value of feeds under different treatments

Parameter	T_1	T_2	T_3	SEM	P value
TDN intake					
g/d/kid	389.24[a]	580.88[b]	614.21[b]	37.82	0.024
g/kg $W^{0.75}$ (g)	41.75[a]	56.52[b]	58.56[b]	2.52	0.006
DCP intake					
g/d/kid	52.14[a]	76.10[b]	79.07[b]	5.01	0.048
per kg $W^{0.75}$ (g)	5.60[a]	7.40[b]	7.52[b]	0.33	0.022
GE intake					
MJ/d/kid	12.98[a]	18.22[b]	19.06[b]	0.93	0.009
MJ/kg $W^{0.75}$	1.40[a]	1.79[b]	1.83 [b]	0.00	0.000
DE intake					
MJ/d/kid	7.48[a]	11.70[b]	12.25[b]	0.74	0.009
MJ/kg $W^{0.75}$	0.80[a]	1.14[b]	1.17[b]	0.00	0.001
ME intake					
MJ/d/kid	5.99[a]	9.36[b]	9.80[b]	0.59	0.009
MJ/kg $W^{0.75}$	0.95	0.97	0.91	0.00	0.523
Digested NDF intake					
g/d/kid	228.41[a]	355.95[b]	388.82[b]	25.34	0.016
g/kg $W^{0.75}$	24.47[a]	34.54[b]	37.11[b]	1.79	0.004
Digested ADF intake					
g/d/kid	131.65[a]	218.62[b]	214.26[b]	16.29	0.041
g/kg $W^{0.75}$	14.04[a]	21.18[b]	20.35[b]	1.20	0.021
Nutritive value of feeds					
TDN % in feed	56.47	59.33	59.20	1.35	0.640
DE (Mcal)/kg feed	10.87	12.04	11.81	0.25	0.130
ME (Mcal)/kg feed	8.70	9.64	9.45	0.20	0.130
DCP % in feed	7.57	7.77	7.60	0.20	0.912

Means with different superscripts (a, b) in the same row are significantly different.TDN, Total digestible nutrients; DCP, Digestible crude protein; GE, Gross energy; DE, Digestible energy; ME, Metabolizable energy; NDF, Neutral detergent fibre; ADF, Acid detergent fibre.

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