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Effect of herbal feed additive containing saponins on the performance of goat kids

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ABSTRACT

This study was taken up to assess the effect of supplementing *Macrotyloma uniflorum* (an herbal feed additive; HFA) on nutrient utilization, productive performance and meat quality of goat kids. Eight male Beetal goat kids (5 months old; body weight 14.05±0.41 kg) divided in to 2 equal groups were either fed a control total mixed ration (TMR) containing concentrate and green fodder in 50: 50 ratio on DM basis or control TMR supplemented with *M. uniflorum* @ 2.0% of DM intake for 90 days. Simultaneously, rumen studies were conducted on three rumen fistulated male bucks. Higher total-N, trichloroacetic acid precipitable nitrogen (TCA-N) and nonprotein nitrogen (NPN) concentration was observed in strained rumen contents (SRC) of animals fed *M. uniflorum* supplemented TMR as compared to control. Supplementation of TMR with *M. uniflorum* increased the production of volatile fatty acids (VFAs) and fermentation efficiency while efficiency of conversion of hexose to methane decreased in *M. uniflorum* supplemented TMR in comparison to control TMR. Nutrients digestibility, N-retention, urinary excretion of purine derivatives, blood profile and average daily gain were comparable in both the groups. The higher ready to cook (RTC) carcass percentage resulted in higher RTC carcass yield in *M. uniflorum* supplemented group. Overall, the weight of most of the primal cuts expressed as per cent of dressed weight improved in goat kids fed TMR supplemented with *M. uniflorum* as compared to those fed control diet. Hence, the higher weight of most of the primal cuts can be achieved in Beetal goat kids by supplementing the TMR with *M. uniflorum* (kulthi) at 2% of DM intake.

Key words: Beetal goat kids, Blood profile, Carcass quality, Herbal feed additive, Nutrient utilization, Purine derivatives

The ever increasing demand of meat and milk for human consumption can be met to considerable extent by improving the efficiency of rumen fermentation. It will not only affect productivity of the animal, but will also have profound effect on the output of waste products from animal system, which pollute the environment. Efforts are afoot to find safer rumen-modulating herbal feed additives (HFAs) which have specific and desirable impact on the productivity of ruminants without polluting the environment. The success of HFAs in animal system is attributed to the presence of number of plant secondary metabolites/ phytochemicals which provide protection against predators, pathogens and environmental stress (Iason 2005) but are not part of the primary biochemical pathways. Among various PSM, essential oils, saponins and tannins received extensive attention due to their widespread occurrence in plant species. The saponins or saponin like substances have showed potential to modulate rumen fermentation patterns and mitigate *in vitro* CH_4 production (Patra *et al.* 2006, Pen *et al.* 2006, Goel *et al.* 2008) but inconsistent results were observed in some *in vivo* experiments (Pen *et al.* 2007, Holtshausen *et al*. 2009). Most of the studies were conducted by using pure extracts from plants, which may not be easy to use/handle by the farmers under field conditions. But, use of finely ground HFAs rich in plant secondary metabolites (PSMs) and easy to handle may have synergistic effect on the rumen fermentation pattern.

Supplementation of HFAs [seeds of *Macrotyloma uniflorum* (kulthi), roots of *Asparagus racemosus* (shatavari) and pods of *Acacia concina* (shikakai)] to TMR revealed that *M. uniflorum* @ 2% of TMR was the best with respect to rumen fermentation pattern and *in vitro* methane mitigation as compared to control and TMR supplemented with other HFAs (Hundal *et al.* 2019). The present study was, therefore, taken up to assess the effect of supplementing *M. uniflorum* (Kulthi) seeds @ 2% of DM intake on palatability, nutrient digestibility, rumen metabolites and carcass quality of male Beetal kids.

MATERIALS AND METHODS

Selection, distribution and maintenance of animals: A 90 days growth trial was conducted on male Beetal goat kids (8; 5 months old; average live weight 14.05±0.41 kg)

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randomly distributed into 2 equal groups. The animals in control group were fed TMR containing concentrate mixture (maize 32%, barley 20%, soybean meal 15%, groundnut cake 15%, wheat bran 15%, mineral mixure 2% and salt 1%) and green oats in 50:50 ratio on DM basis as per NRC (2007) feeding standard. Those in experimental group were fed control TMR supplemented with *M. uniflorum* dry extract @ 2% of DM intake. The daily record of feed intake and orts was maintained. The kids were weighed for 3 consecutive days every fortnight and the feeding schedule was revised accordingly. The animals were stall fed individually at 9:00 AM daily and had free access to fresh water twice a day and were taken out in the yard for 1 h exercise daily.

Digestion-cum-metabolism trial: A 7-day digestion-cum-metabolism trial was conducted before the termination of growth trial. During metabolic trial, the animals were kept individually in specially designed metabolic cages where urine and faeces were collected automatically in separate containers. For urine collection, a narrow mouth plastic container (2.5 L capacity) containing 30 ml of 20% H_2SO_4 was used. The faeces, urine and orts (if any) were weighed daily at 9.00 AM before feeding. On the last day of trial, blood sample was taken from each animal (4 h post feeding) by puncturing jugular vein.

Sampling of feed, orts, faeces and urine: Samples of feedstuffs and orts were collected at 24 h interval and dried in duplicate at 80°C in a hot air oven. The samples were pooled for 7 days and finely ground to pass through 1 mm sieve.

After thorough mixing, 20% of 24 h fresh faecal material of each animal was weighed in duplicate in aluminum tray for DM determination. The samples were dried at 100°C in a hot air oven for 24 h. The dried faeces were pooled finely ground to pass through 1 mm sieve and kept in airtight glass sampling bottles.

The faecal and urine samples were analyzed for nitrogen (AOAC 2007). The urine samples were diluted 5 times with distilled water and stored at –20ºC till analyzed for purine derivatives.

Rumen studies: Two trials were conducted on three adult Beetal goat bucks fitted with permanent rumen fistula. In 1st trial; animals were offered control TMR once a day at 9:00 h as per NRC (2007). After 30 days adaptation period, rumen contents were collected at 0, 2, 4, 6, 8, 12 h post feeding for 3 days. Equal quantity of SRC, from each collection, was pooled for the respective animal. A few drops of $HgCl_2$ were added in each bottle to stop microbial action. The samples were stored in a refrigerator till analyzed for nitrogen fractions, i.e. total nitrogen; ammoniacal-N (AOAC 2007), NPN, TCA (Cline *et al.* 1958) and VFA by GLC (Cottyn and Boucque 1968). In 2nd trial, rumen fistulated bucks were offered control TMR supplemented with *M. uniflorum* @ 2% of DM intake for 30 days. The procedure for collection, processing and preservation of samples of rumen contents was same as adopted in 1st trial. The efficiency of rumen fermentation (E), efficiency of fermented hexose energy to VFA energy (E_1) and methane energy (E_2) were calculated as described by Baran and •itòan (2002).

Blood profile: The blood samples were collected on the last day of metabolic trial from the jugular vein of all animals at 4 h post parandial. The serum was separated and stored at 0°C till analyzed.

Carcass studies: On the last day of feeding trial, goat kids were slaughtered as per standard procedure following animal welfare guidelines in the experimental slaughter house of Department of Livestock Products Technology. The feeding was withheld 12 h prior to slaughtering. However, they were given free access to the drinking water. All the animals were humanely slaughtered using Seydelman double pronged electrical stunner with 90 V–120 V current for 15 sec. The properly stunned animals relaxed their legs and then immediate sticking done by bilateral severance of jugular arteries and veins close to the extended head. The animals were hung by tying chains at tarsal joint of hind limbs. After giving 4–6 min bleeding time, the head was decapitated from the occiptoatlantal joint and weighted. The skin was removed manually by giving central incision on ventral side of carcass and tearing the subcutaneous fascia with the help of fisting and blunt knife. The separable tissue and fat were trimmed off from the skin and final weight of skin was recorded. The fore feet were removed from carpometacarpal joint and hind feet from tarso-metatarsal joint and animals were hung by both legs with placing of hook at tendo-achlis joint. The animals were eviscerated by giving a cut at lower mid ventral region from sternum to anus. The stomach, intestine and visceral organs fell by their own weight. The rumen, reticulum omasum and abomasum were separated from intestines and weighted as such and after removing their fill content. The intestine, testes and visceral organs (heart, liver, lung, kidney and spleen) were removed and their weights recorded. The dressing percentage was calculated based on pre slaughter weight.

Preparation of primal cuts of the dressed carcass: The primal cuts were made by following the standard procedure of BIS (1999). Each dressed carcass was cut between 12th and 13th rib perpendicular to the back with a saw to separate fore saddle and hind saddle. Fore saddle portion was cut between 4th and 5th rib at a right angle to spine to separate double chunk and bracelet. Then, 4 inches were measured from rib eye muscle from loin and chunk end of bracelet and saw in a straight line between two points separating double hotel rack and plates. A point was located as a juncture of 1st rib and anterior extremity of breast bone and from here cut was given parallel to spine to separate shank and brisket from shoulder. A cut was given perpendicular to back at anterior tip of hip to separate legs and loin. The carcasses were divided into 8 primal cuts; neck, foreshank, shoulder, rack, brisket, breast, loin and flank and leg. After removal of all separable connective tissue, fat, fascia and blood vessels, the meat was packed in colourless low density polythene (LDPE) bags and stored in a deep freezer at –20ºC till analyzed.

Table 1. Effect of supplementing *M. uniflorum* (kulthi) seed to the TMR of Beetal kids on the biochemical changes in rumen (mg/dL)

Parameter	Control	*M. uniflorum*	PSE	P value	Control	*M. uniflorum*	PSE	P value
Total N	0.19[a]	0.31[b]	0.022	0.000	As per cent of total-N			
TCA N	0.12[a]	0.20[b]	0.017	0.001	61.40	66.92	1.75	0.119
NPN	0.07[a]	0.10[b]	0.01	0.004	38.60	33.08	1.75	0.119
NH_3-N	0.033[a]	0.051[b]	0.0032	0.000	17.32	16.85	0.41	0.603

Figures with different superscripts in a row differ significantly (P<0.01); TN, Total nitrogen; TCA-N, Trichloro acetic acid precipitable nitrogen; NPN, Non protein nitrogen.

Colour profile was measured using CR-400, Konica Minolta, chromameter (Japan) set at 2° of cool whitelight (D65) and known as '*L**', *a**, and *b** values. '*L**' value denotes (brightness 100) or lightness (0), a (+redness/–greenness) and b (+yellowness/–blueness). The instrument was calibrated using a light trap (black hole) and white tile provided with the instrument. Then the above colour parameters were selected. The instrument was directly put on the surface of pork patties at different points and readily was taken in triplicate at different for each sample (Kumbhar *et al.* 2018).

Analytical methods: The finely ground samples of feedstuffs, orts and faeces were analyzed for CP and total ash (AOAC 2007) and cell wall constituents (Van Soest *et al.* 1991). Hemi-cellulose was determined by difference in NDF and ADF. The urine samples were analysed for total-N (AOAC 2007), purine derivatives (PD), allantoin (Young and Conway 1942), uric acid (Trivedi *et al.* 1978), and creatinine (Folin and Wu 1919). Purines absorbed were calculated from the daily urinary PD excreted (IAEA 1997). Serum samples were analysed for albumin (Doumas *et al.* 1971), urea (Evans 1968), triglycerides (McGowan *et al.* 1983) and cholesterol (Allain *et al.* 1974). The analysis was conducted on Erba (Mannheim) Chem 5 X (Transasia). The serum collected with sodium fluoride and oxalate was used for assay of blood glucose (Trinder 1969). The data were analyzed by using one way ANOVA (Snedecor and Cochran 1994) by using SPSS (2007) version 16.0 and the means were tested for the significant difference by using Duncan's multiple range test.

RESULTS AND DISCUSSION

The TMR contained 92.44% OM, 16.22% CP, 52.73% NDF, 24.90% ADF, 28.95% hemicellulose and 19.93% cellulose on DM basis.

Effect of M. uniflorum *on the biochemical changes in the rumen:* The TCA-N, NPN and ammonical-N increased significantly (P<0.01) in TMR supplemented with *M. uniflorum* as compared to un-supplemented group (Table 1). Supplementation of *M. uniflorum* resulted in 38.7, 66.7, 30.0 and 54.5% increase (P<0.01) in total N, TCA N, NPN and ammonical N levels respectively, in comparison to control. However, TCA, NPN and ammonical-N as percent of total-N were comparable in both the groups, but increase in TCA nitrogen was 9% and decrease in NPN was observed to be 14.3%. Increased ammonia N concentrations could be due to increased CP degradability (Getachew *et al.* 2000) and/or poor synchronization between N and carbohydrate release in the rumen. The results of rumen nitrogen fractions clearly indicated that supplementation of TMR with *M. uniflorum* may improve the availability of nitrogen for microbial protein synthesis.

Table 2. Effect of supplementing *M. uniflorum* (kulthi) seed to the TMR on the volatile fatty acids production (mM/dl) in rumen of Beetal kids

Parameter	Control	*M. uniflorum*	PSE	P value
TVFA	5.90[a]	8.06[b]	0.41	0.000
Acetate (A)	4.06[a]	5.03[b]	0.19	0.000
Propionate (P)	0.96[a]	1.36[b]	0.08	0.000
Isobutyrate	0.033	0.038	0.003	0.581
Butyrate	0.70[a]	1.43[b]	0.14	0.000
Isovalerate	0.05[a]	0.07[b]	0.005	0.041
Valerate	0.09[a]	0.144[b]	0.010	0.010
A:P	4.21[b]	3.70[a]	0.010	0.000
Relative proportion (%)				
Acetate	68.82	62.36	1.35	0.002
Propionate	16.34	16.85	1.03	0.035
Isobutyrate	0.03	0.04	–	0.294
Butyrate	11.85	17.68	1.22	0.002
Isovalerate	0.05	0.07	–	0.875
Valerate	1.60	1.79	–	0.379
Fermentation efficiency				
E	73.24[a]	74.53[b]	0.24	0.003
E_1	73.01[a]	74.37[b]	0.24	0.001
E_2	17.12[b]	15.69[a]	0.22	<0.001

TVFA, Total volatile fatty acid; E, Efficiency of rumen fermentation; E_1, Efficiency of fermented hexose energy to VFA energy; E_2, Efficiency of fermented hexose to methane. Figures with different superscripts in a row differ significantly.

Supplementation of *M. uniflorum* to the TMR increased (P<0.01) the production of total VFAs, acetate, propionate and butyrate in comparison to animals fed control TMR (Table 2). Similar trend was observed in branched chain fatty acids (BCFA). The concentration of TVFAs, acetate, propionate, butyrate and valerate increased by 37, 24, 42, 103 and 60% respectively as compared to animals fed control diet. Earlier studies also revealed increased total VFAs in lamb fed wild rye grass with concentrate mixture in 60: 40 ratio supplemented with *Camellia sinensis* (Mao

Table 3. Effect of supplementing *M. uniflorum* (kulthi) seeds to the TMR on the dry matter intake and digestibility of nutrients in Beetal kids

Parameter	Control	*M. uniflorum*	PSE	P value
Dry matter intake (g/d)				
Concentrate	290.95	288.61	6.27	0.878
Green fodder	218.32	218.81	6.35	0.973
Total DM	498.47	497.17	7.27	0.937
Digestibility of nutrients (%)				
DM	70.88	72.67	1.31	0.375
OM	74.22	75.92	1.25	0.375
CP	71.57	72.95	1.04	0.391
NDF	61.88	64.35	1.57	0.476
ADF	44.83	48.62	2.00	0.383
Cellulose	62.49	65.28	1.40	0.361
Hemicellulose	74.99	76.39	1.65	0.705
N retention (g/d)				
N-Intake	13.69	13.56	0.45	0.857
Faecal N	3.88	3.67	0.22	0.409
Digestible N	9.81	9.88	0.46	0.903
Urinary N	2.60	2.53	0.19	0.868
N Balance (g/d)	7.21	7.35	0.24	0.772
ABV %	73.44	74.54	1.59	0.759

ABV, Apparent biological value.

Table 4. Effect of supplementing *M. uniflorum* (kulthi) seed to the TMR on the blood profile of Beetal kids (mg/dl)

Parameter	Control	*M. uniflorum*	PSE	P value
Blood glucose	59.50	69.50	3.92	0.265
Total protein*	5.99[a]	6.66[b]	0.19	0.016
Albumin	2.54	2.56	0.13	0.955
Globulin	3.46	4.11	0.22	0.143
A:G ratio	0.74	0.63	0.04	0.471
Urea	49.56	51.99	1.54	0.547
Uric acid	0.55	0.73	0.07	0.305
Creatinine	0.96	0.96	0.02	0.943
Cholesterol	65.90	43.80	12.44	0.487
Calcium	9.70[b]	8.40[a]	0.38	0.023
Phosphorus	6.70	6.85	0.49	0.911

A:G::Albumin:globulin.

et al. 2010) or when forage and concentrate mixture supplemented with *Sapindus saponaria* was fed to sheep (Hess *et al.* 2014) or when mixed hay and concentrate mixture in 3:1 ratio supplemented with *Yucca schidigera* was fed to sheep (Wang *et al.* 2009). However, Lu and Jorgensen (1987) reported that 20 g lucerne saponin/kg DM reduced total rumen VFA concentration when diet containing forage and concentrate in 40:60 ratio were fed to small ruminants, but not when forage to concentrate ratio was reversed. The acetate to propionate ratio improved (P<0.01) by supplementation of TMR with *M. uniflorum* as compared to un-supplemented TMR confirming the results of an earlier study in which diet was supplemented with *S. saponaria* (Hess *et al.* 2014). Supplementation of diet with *M. uniflorum* improved fermentation efficiency

Table 5. Effect of supplementing *M. uniflorum* (kulthi) seed to the TMR on the urinary purine derivatives of Beetal kids (mM/d)

Parameter	Control	*D. biflorus*	PSE	P value
Uric acid	0.047	0.051	0.009	0.865
Allantoin	1.88	1.48	0.25	0.483
PD excretion	1.92	1.54	0.26	0.491
Allantoin (%)	96.97	96.62	0.64	0.808
UA (%)	3.03	3.38	0.64	0.808
PD absorbed (g/d)	0.38	–0.17	0.31	0.423
MNS (g/d)	0.38	–0.17	0.25	0.423
PNI	0.061	0.044	0.007	0.230
Creatinine	0.59[a]	0.52[a]	0.07	0.649

Figures with different superscripts in a row differ significantly, P<0.01; PD, Purine derivatives; UA, Urinary allantoin; MNS, Microbial nitrogen synthesis; PNI, Purine nitrogen index.

(E) (P<0.01) and efficicency of conversion of fermented hexose energy to VFA energy (E_1) in comparison to un-supplemented control diet. The efficiency of conversion of fermented hexose to methane (E_2) decreased (P<0.01) in diet supplemented with *M. uniflorum* in comparison to control TMR. The high fermentation efficiency in diet supplemented with *M. uniflorum* was probably due to the low methane production. Earlier studies also revealed that tea seed (*Camellia sinensis* L.) saponin (TSS) have antimethanogenic effect due to the antiprotozoal activity in small ruminants (Mao *et al*. 2010, Zhou *et al*. 2011).

Effect of M. uniflorum *on the utilization of nutrients in goat kids:* The DM intake (Table 3) in group of animals fed control TMR was comparable with those fed TMR supplemented with *M. uniflorum* (Singer *et al*. 2008). However, Lovette *et al.* (2006) observed decrease in feed intake in animals fed diet supplemented with *Yucca* extract. The digestibility of nutrients and N retention were similar in both the groups. Pen *et al.* (2007) and Wang *et al.* (2007) reported no affect on the digestibility of nutrients while Hess *et al*. (2014) showed decrease in digestibility of nutrients of the diet supplemented with saponins. Nasri *et al.* (2011) also reported that oral administration of saponins from *Quillaja saponaria* did not affect the crude protein digestibility, N retention and microbial protein synthesis in Barbarine lambs.

The blood profile of the animals was comparable in control and those fed TMR supplemented with *M. uniflorum,* except that the total protein was higher (P<0.05) in animals fed TMR supplemented with *M. uniflorum* than those fed control TMR (Table 4). Hu *et al.* (2006) also reported higher total protein and albumin in goats fed diet supplemented with 3 g tea saponin/d. Similar results were reported in sheep given oral administration of *Q. saponaria* in Barbarine lambs (Nasri *et al.* 2011). Serum calcium was lower (P<0.05) in animals fed TMR supplemented with *M. uniflorum* than those fed control TMR but reverse trend was observed by Hu *et al.* (2006). The serum cholesterol level was decreased by 33.5% in animals fed TMR

supplemented with *M. uniflorum* than those fed control TMR. Afrose *et al*. (2011) observed significantly lower serum cholesterol (23·0%) and triglycerides in laying hens fed diet supplemented with karaya-saponin. Owolabi *et al.* (2010) also observed significantly (P<0.05) reduced the levels of total cholesterol, triglycerides and LDL-cholesterol in saponin extract administered Albino rats. Oakenfull and Sidhu (1990) reported that saponins either directly inhibit the absorption of cholesterol from the small intestine or indirectly by inhibiting the reabsorption of bile salts. The levels of different parameters of blood profile were well within the normal physiological range of animals.

Table 6. Effect of supplementing *M. uniflorum* (kulthi) seed to the TMR on the performance of Beetal kids

Parameter	Control	*M. uniflorum*	PSE	P value
Initial BW (kg)	13.80	14.30	0.41	0.579
Final BW (kg)	16.72	17.72	0.74	0.537
Gain $_{90\ d}$ (kg)	3.07	4.27	0.82	0.525
Gain, g/d	34.07	47.40	9.09	0.526

The values of urinary excretion of uric acid, allantoin, total purine derivatives and microbial protein synthesis were similar in two groups (Table 5). Allantoin constituted 96.6–97% of total PD excretion and the values were comparable to those reported for sheep and goat (Lindberg 1985, Dapoza *et al.* 1999). The excretion of purine derivatives has been used to predict the amount of absorbed purine bases in the small intestine which is related to the synthesis of microbial protein (Chen and Gomes 1992).

Table 7. Effect of supplementing *M. uniflorum* to TMR on the carcass of Beetal kids

Parameter	Weight (kg)		PSE	P value	As percent of live weight		PSE	P value
	Control	*M. uniflorum*			Control	*M. uniflorum*		
Slaughter weight	15.51	16.48	0.72	0.546				
Dressed carcass	6.48	7.13	0.34	0.372	38.85	40.11	0.48	0.209
RTC carcass	6.25	7.09	0.50	0.272	37.36^{a}	39.89^{b}	0.53	0.003
Edible offal (g)	0.73	0.78	0.077	0.711	4.36	4.34	0.14	0.949
Inedible offals	3.41	3.78	0.25	0.346	20.38	21.28	0.26	0.083

RTC, Ready to cook.

Table 8. Effect of dietary supplementation of *M. uniflorum* to the TMR on non-carcass components in Beetal kids

Parameter	Weight (g)		PSE	P value	As percent of live weight		PSE	P value
	Control	*M. uniflorum*			Control	*M. uniflorum*		
Head	1308.6	1451.6	87.75	0.458	7.8	8.13	0.17	0.371
Feet	716.80	770.12	51.09	0.640	4.27	4.30	0.12	0.892
Tail	22.87	32.63	4.44	0.306	0.14	0.18	0.02	0.259
Skin	1291.8	1472.4	94.77	0.381	7.68	8.25	0.22	0.212
Heart	82.77	103.05	8.31	0.250	0.49	0.58	0.03	0.104
Lungs	166.49	210.42	15.95	0.186	0.99^{a}	1.18^{b}	0.05	0.047
Kidney	77.19	43.34	9.18	0.055	0.46^{b}	0.24^{a}	0.05	0.006
Spleen	43.92	43.27	5.64	0.959	0.26	0.24	0.02	0.623
L+ g. bladder	307.44	360.86	28.31	0.386	1.83	2.01	0.08	0.333
Intestine	1.56	1.64	0.11	0.648	9.31	9.23	0.13	0.775
Testis	45.28	32.29	0.47	0.265	0.27	0.18	0.03	0.064

Table 9. Effect of dietary supplementation of *M. uniflorum* to the TMR on weight and proportion of primal cuts from Beetal kids

Parameter	Weight of the organ (g)		PSE	P value	As percent of dressed weight		PSE	P value
	Control	*M. uniflorum*			Control	*M. uniflorum*		
Neck	415.0	525.19	36.78	0.143	6.38^{a}	7.32^{b}	0.22	0.012
Brisket	727.42	633.80	42.61	0.306	11.19^{b}	8.84^{a}	0.47	0.000
Rack	825.42^{a}	1179.8^{b}	90.37	0.035	12.70^{a}	16.48^{b}	0.74	0.000
Loin-ramp	1441.9	1580.0	83.67	0.452	22.20	22.11	0.21	0.849
Fore shank	1536.3	1557.9	77.43	0.901	23.72^{b}	21.78^{a}	0.42	0.005
Legs	1481.7	1745.6	101.5	0.216	22.84^{a}	24.40^{b}	0.35	0.009
Fore saddle*	3.12	3.58	0.24	0.212	18.59^{a}	20.17^{b}	0.32	0.001
Hind saddle*	2.63	2.98	0.22	0.303	15.71^{a}	16.75^{b}	0.25	0.018

*Expressed as per cent of live weight.

The average daily gain (ADG) in kids fed TMR supplemented with *M. uniflorum* was numerically higher than the kids fed control TMR. Supplementation of oregano leaves (Bampidis *et al.* 2005), *Agave americana* or oral administration of *Q. saponaria* (Nasri and Ban Salem 2012) to the diet also resulted in numerically higher ADG in weight in growing Barbarine lambs. However, a dose-dependent response of increased BW change was reported when goats were offered 90 to 160 mg *Y. schidigera* per kg DM intake. Higher DMI and enhanced nutrient digestibility in *Y. schidigera* treatment might explain the better growth performance (Aregheore 2005).

Effect of M. uniflorum *on carcass parameters of Beetal kids:* Supplementation of *M. uniflorum* in the TMR of Beetal kids affected various carcass traits. The carcass weight and dressing percentage in *M. uniflorum* supplemented group were numerically higher (P>0.05) as compared to those offered control diet (Table 7). The considerably higher carcass weight may be due to higher slaughter weight of goat kids, as slaughter weight is one of the major determinants of carcass weight and meat yield in ruminants (Kadim *et al.* 2004). The ready to cook carcass as percentage of live weight was higher (P<0.01) in animals fed TMR supplemented with *M. uniflorum* as compared to those fed control TMR. The results are in confirmation with those reported for Angora whether goat (McGregor 2000). Edible offals were comparable in both the groups. The inedible offals as percent of live weight in animals fed TMR supplemented with *M. uniflorum* was numerically higher (P>0.05) than those offered control diet. Nasri *et al.* (2011) also revealed that the administration of 30, 60 or 90 mg *Q. saponaria* per kg DM intake had a defaunation effect but failed to improve meat quality of Barbarine lambs.

The weight of almost all of the non-carcass components (Head, feet, skin, heart, lungs, intestine etc.) was improved considerably (P>0.05) in the group of animals fed diet supplemented with *M. uniflorum* as compared to un-supplemented control diet (Table 8). The weight of these non carcass components expressed as percent of live weight also exhibited similar trend except that weight of lungs was improved (P<0.05), while that of kidneys was decreased (P<0.01) in the group fed TMR supplemented with *M. uniflorum* as compared to un-supplemented TMR. The weight of non carcass components expressed as percent of live weight of the animals confirmed the earlier report (McGregor 2000).

The participation of cuts in the carcass allows a qualitative assessment because it should present the best possible proportion of cuts with higher content of edible tissues, mainly muscles or the best proportion of cuts of interest to consumers (Yanez *et al.* 2006). Supplementation of *M. uniflorum* in the TMR of Beetal kids improved the weight of rack significantly (P<0.05) (Table 9). When these primal cuts were expressed as per cent of dressed weight, the weight of neck, rack, legs, fore and hind saddle improved (P<0.05), while that of brisket and fore-shank decreased (P<0.05) in the group of animals fed TMR supplemented with *M. uniflorum* as compared to un-supplemented group. Overall it showed positive effect for *M. uniflorum* supplementation on primal cuts from goat kids.

Table 10. Effect of herbs on carcass parameters of Beetal kids

Parameter (kg)	Control	*M. uniflorum*	PSE	P value
Meat color (Hunter color values)				
Lightness	24.55	23.09	0.71	0.335
Redness	6.53	5.83	0.26	0.181
Yellowness	8.25	7.38	0.32	0.183
Chemical composition (%) of meat				
Dry matter	22.6[a]	23.9[b]	0.32	0.016
Total nitrogen	13.01	12.87	0.04	0.104
Fat	8.13[a]	11.30[b]	0.72	0.000

#based on ready to cook carcass, *Figures with different superscripts* in a row differ significantly, P<0.01

The colour of meat is a foremost attribute for the acceptance of the meat by the consumer. No significant differences were recorded for lightness (L^*), redness (a^*) or yellowness (b^*) as analogus colour values between control and *M. uniflorum* supplemented group (Table 10) which indicated no adverse effect of feeding test herb on meat colour of goat kids. However, the diet supplemented with *M. uniflorum* produced higher meat yield (P<0.05) with higher (P<0.01) fat but comparable protein content.

It can be concluded that supplementing the TMR with *M. uniflorum* (kulthi) at 2% of DM intake resulted in higher concentration of N-fractions, VFAs, fermentation efficiency in the rumen, nutrient digestibility and higher weight of most of the primal cuts expressed as per cent of dressed weight can be achieved in Beetal goat kids.

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