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Effect of feeding cauliflower leaf meal on blood-biochemical, immunity status and carcass characteristics of growing goat kids

A P BANSOD[1], S K SAHA[1✉], A K VERMA[1], L C CHAUDHARY[1] and THEERTHESH M[1]

ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh 243 122 India

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ABSTRACT

An experiment was conducted to evaluate the effect of feeding cauliflower leaf meal (CLM) on blood biochemical, immunity status and carcass characteristics of growing goat kids. Fifteen male non-descript goat kids of 6-8 months of age were divided equally into three groups (T_0, T_1 and T_2). T_0 group was fed with basal diet and T_1 and T_2 group were fed with 20 and 30% CLM in concentrate mixture for 120 days. The Hb, PCV, DLC, TLC, albumin, globulin, total protein, A:G ratio, Ca, P, Urea N and glucose levels were comparable among all groups of goat kids. However, total cholesterol was significantly lower in T_1 and T_2 group. The enzymatic profile including ALT, AST and ASP levels were comparable among all groups of kids. The serum antioxidants such as glutathione peroxidase and catalase were significantly higher in T_2 group as compared to T_1 and control group without affecting superoxide dismutase level. The thyroid hormones were non-significant among all groups of kids. The humoral and cell mediated immunity was improved in CLM fed group of kids. The carcass characteristics and meat composition were comparable among all groups of kids while TBAR value was lower in T_2 group. Therefore, it may be concluded from the study that 20-30% CLM in concentrate mixture reduces the total cholesterol level, increases serum catalase and glutathione peroxidase level and improved keeping quality of meat, cell mediated and humoral immunity status of growing goat kids.

Keywords: Antioxidant, Cauliflower, Carcass characteristics, Enzymatic, Goat kids immunity, Hormonal

In India, the scarcity of feed and fodder often enforces a major challenge in livestock production (Aregheor 2000). Due to the higher livestock population and a shortage of feed, there is a scarcity of conventional feeds, which results in higher commercial feed prices (Soybean meal @ ₹70/kg, Maize grain @ ₹20/kg). Therefore, there is need to search for new feed resources for feeding the huge livestock population in India to reduce the gap between demand and supply of conventional feeds. So, to get rid of this problem, fruit and vegetable waste are used for animal feeding by many researchers. Globally, 10-20% of horticultural wastes are disposed in landfills leading to environmental pollution (Sahoo *et al*. 2021). Recycling these wastes as animal feedstuff will lessen food-feed competition and minimize environmental hazards. According to the National Horticulture Database (2018), vegetable production was 169.1 million MT. Among this vegetable waste, cauliflower waste is a good unconventional feed source in the winter season. The dietary cauliflower leaves are only accessible for a limited period, but they can be conserved and kept for use during the lean season (Singh *et al*. 2006). The cauliflower leaves are high in carotene (43.11 mg), iron (60.38 mg/100 g), copper (1.55 mg/100 g), manganese (5.86 mg/100 g) and zinc (5.10 mg/100 g) (Wani and Kaul 2011). The dehydrated leaves are also a rich source of ß-carotene and iron, which can be used in lean seasons (Rao 1993). Furthermore, the functional value of meat and its shelf-life can be improved by dietary fortification with nutraceutical components. Polyphenols are phytochemicals produced by plants (secondary metabolites) to defend against environmental stress and pathogens and improve immunity status of animals (Havsteen 2002). In context of such scenario, the present experiment was designed to study the effect of dried cauliflower leaf meal on blood-biochemical, carcass characteristics and immunity status of growing goat kids.

Present address: [1]ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh. ✉Corresponding author email: subodhksaha@yahoo.com

MATERIALS AND METHODS

Collection and processing of cauliflower leaves: The cauliflower leaves were collected in march from local vegetable market, Delapeer, Bareilly, Uttar Pradesh, India. After chopping, the cauliflower leaves were dried under sunlight and finely ground in grinder for subsequent use in concentrate mixture preparation.

Study site: The experiment was conducted in the Animal Nutrition shed, ICAR-IVRI, Izatnagar, Uttar Pradesh. All procedures and protocols followed in this experiment were approved by Institute Animal Ethic Committee (IAEC) of ICAR-IVRI, Izatnagar, India.

Experimental animals and diets: Total of 15 weaned male goat kids (average age: 6-8 months and weight: 10.79±0.20 kg) were divided equally into three groups (T_0, T_1, and T_2) having five kids in each group. The animals were dewormed at the beginning of the experiment. The kids were vaccinated against PPR as per standard Institute's schedule. The feeding schedules followed during the entire experimental period (up to slaughter study) were, T_0 control: concentrate mixture + wheat straw (50:50); T_1: concentrate mixture containing CLM at 20% + wheat straw (50:50) and T_2: concentrate mixture containing CLM at 30% + wheat straw (50:50). The chemical composition of experimental diet of all three groups is presented in Table 1.

Table 1. Ingredients and chemical composition (DM basis) of concentrate mixture

Ingredient (kg)	T_0	T_1	T_2
Maize	47	42.5	41
SBM	25.5	18.5	15
Wheat bran	24.5	16	11
CLM	0	20	30
Mineral mixture	2	2	2
Salt	1	1	1
Chemical composition			
CP (%)	19.13	18.65	18.59
EE (%)	3.25	4.12	4.18
CF (%)	8.43	8.51	8.56

Blood collection and analysis: At 0, 60 and 120 d of experimental trial, blood from all goat kids was collected by puncturing the jugular vein with the help of a clean sterilized needle to study the haematological, biochemical, enzymatic, hormonal and antioxidant profile. The serum was stored at -20°C until further analysis. Haemoglobin (Hb), packed cell volume (PCV), TLC and DLC were estimated with the haematocrit analyzer. Glucose, total cholesterol, urea, total protein, albumin, globulin, A:G ratio, Ca and P were estimated colorimetrically using commercial diagnostic kits (Coral Clinical Systems, India). Urea values were multiplied by 0.467 to get the urea nitrogen content. The serum enzymes, viz. asparate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP) were estimated colorimetrically using commercial diagnostic kits. Superoxide dismutase (SOD) activity of RBC haemolysate samples was measured using nitro blue tetrazolium as a substrate after suitable dilution (Marklund and Marklund 1974, Minami and Yoshikawa 1979). Glutathione peroxidase (Gpx) activity was estimated from RBC by the method described by Paglia and Valentine (1967) and catalase activity by method described by Bergmayer (1983). The serum hormones such as Triiodothyronine (T_3), Thyroxine (T_4) and TSH were estimated using ELISA kits.

Immunity status: At the end of trial, humoral immune response in kids was assessed by qualitative measurement of antibody production in response to intravenous injection of 0.5 ml of 20% CRBC (Chicken red blood cells). The antibody production against the CRBC was assessed in serum collected on the 7, 14, 21 and 28 day post-injection. After humoral immune response, the cell-mediated immune response was assessed through a delayed type hypersensitivity (DTH) reaction against phytohaemagglutinin-P (PHA-P).

Carcass characteristics: After the completion of feeding trial, goat kids were slaughtered to study the carcass characteristics and keeping quality of meat. The goat kids were fasted overnight by withdrawing the feeding trays. They had free access to water. All the experimental goat kids were transported to slaughterhouse, LPT division, IVRI, Izatnagar. After arrival, kids were allowed to rest for 4-5 h and after rest, slaughtered via standard halal method. All the organs were weighed and for further analysis, *longissimus dorsi* muscle sample was collected from all experimental goat kids. The dressing percentage was calculated by using the formula given as follows:

Dressing percentage = (Hot carcass weight/ live weight of animal)×100

Weight of visceral organs: The liver, kidneys, heart, lungs, trachea, spleen and thyroid gland were weighed during slaughter and, thereafter, all the weights of offal's were summed up to know the offal's weight.

Furthermore, *p*H of meat sample was measured by immersing *p*H meter (Waterproof Double Junction *p*H Testr®30 digital, OKATON, USA). The water holding capacity was measured by the press method. The extraction method described by Witte *et al.* (1970) was used for determination of TBARS value with slight modifications. *Longissimus dorsi* muscle of either side from the carcasses was separated and kept in a polyethylene bag at -20°C for 24 h for further analysis of moisture, protein, fat, and ash (AOAC 1995).

Statastical analysis: The data generated from the study was analysed as per the standard statistical procedure Snedechor and Cochran (1994) and using SPSS (Version 26.0) software.

RESULTS AND DISCUSSION

Haematological profile: The haemoglobin (g/dl), PCV (%), TLC (10^9/l) and DLC (%) level of experimental kids have been given in Supplementary Table 1. There was no significant (P>0.05) difference of haemoglobin, PCV, TLC and DLC level among different experimental groups of kid and for different periods. The results of the present study corroborated with Purushothaman *et al*. (2019) who reported no significant (P>0.05) changes in haematology of buffalo calves fed agricultural byproduct. Thakur *et al*. (2015) reported that there were no significant changes (P>0.05) in goat fed with karanj cake. Mueller *et al*. (2012) supported the present findings and reported that piglets were in good health, no clinical abnormalities were seen throughout the trial, and blood profile was in the normal range when the broccoli extract was added into their diets.

On the other hand, Mahmoud (2022) mentioned that counts of RBCs, Hb, PCV, MCV and MCH were higher in kids fed diets containing different levels of broccoli byproduct compared with that of control. Mahmoud (2016) reported higher Hb and PCV concentration in broccoli byproduct fed group of lambs.

Biochemical profile: The data pertaining to different serum biochemical parameters, viz. serum glucose, urea, BUN, serum total protein, albumin, globulin, A: G ratio, Ca, P and total cholesterol have been furnished in Supplementary Table 2. The mean blood glucose, BUN, serum total protein, serum albumin, serum globulin, A: G ratio, Ca and P levels were found non- significant (P>0.05) among all groups of goat for different period. However, the total cholesterol level (mg/dl) was significantly lower in T_2 (70.59) group as compared to T_1 (71.08) and control (71.13) group of goat kids. It was found that as the inclusion level of CLM increased, the total cholesterol level was reduced among experimental groups for different period. These findings were in line with Partovi *et al*. (2020) who reported no effect on total protein, albumin and globulin concentrations in the fattening lambs fed mixture of broccoli byproduct and wheat straw silage. Physiologically, albumin is an important protein for maintaining stability of osmotic pressure in the blood (Craig 1999). The findings for albumin and globulin reflect in the animal's ability to store spare proteins even after their bodies have reached their maximum tissue sedimentation capacity (Stroev 1989). According to Onifade and Abu (1998), blood plasma, total protein and albumin levels are directly related to intake and quality of protein in the diet. On the other hand, Mahmoud (2022) reported that the albumin, globulin and total protein concentration was significantly (P<0.05) higher for does fed diet contained 20% broccoli by-products (BB), followed by 10% BB ration than those fed the control diet. Mahmoud (2016) reported that the total protein and albumin concentrations were significantly (P<0.05) higher with lambs fed diets containing different levels of broccoli byproduct compared to those of control diet. The lack of differences in blood biochemistry parameters among the treatments was probably due to similar intake and nutrient digestibility (Partovi *et al*. 2020). The similar concentrations of blood albumin among the lambs suggested normal liver function as the liver is the main organ of albumin synthesis. The values of albumin and globulin in the serum of the lambs showed that these animals did not suffer from any health problems that might have affected their performance (Radostits *et al*. 2007).

Table 2. Effect of feeding CLM on antioxidant and hormonal activity of kids

Attribute	Days	Dietary treatments			Mean	SEM	P-value		
		T_0	T_1	T_2			T	P	T*P
Antioxidant profile									
Catalase (U/mg Hb)	0	10.06	10.15	10.23	10.15^A	0.026	0.001	0.001	0.001
	60	10.28	10.47	11.22	10.66^B				
	120	10.78	12.24	12.85	11.96^C				
	Mean	10.37^a	10.95^a	11.43^b					
Gpx (µmol/mg Hb)	0	81.95	81.44	82.07	83.16^A	0.29	0.001	0.001	0.001
	60	82.75	84.98	88.65	87.03^B				
	120	83.95	87.7	88.31	85.41^C				
	Mean	83.22^a	85.37^b	87.01^c					
SOD (U/mg Hb)	0	20.64	21.55	21.35	21.18	0.76	0.167	0.000	0.98
	60	21.40	22.55	22.79	22.25				
	120	23.43	24.91	25.41	24.58				
	Mean	21.82	23.00	23.18					
Hormonal profile									
T3 (ng/mL)	0	1.30	1.52	1.52	1.44	0.112	0.802	0.329	0.14
	120	1.46	1.37	1.23	1.35				
	Mean	1.37	1.45	1.39					
T4 (ng/mL)	0	39.12	40.01	39.67	39.07	6.185	0.022	0.879	0.12
	120	38.35	38.62	37.49	38.15				
	Mean	38.73	39.51	38.92					
TSH (µlU/mL)	0	1.49	1.38	1.35	1.40	0.169	0.043	0.307	0.31
	120	1.45	1.34	1.33	1.37				
	Mean	1.47	1.36	1.34					

$^{a, b, c}$ Mean (± S.E) with different superscript in a row differ significantly (P<0.05). $^{A, B, C}$ Mean (± S.E) with different superscript in a column differ significantly (P<0.05).

Table 3. Effect of feeding CLM on carcass characteristics and meat quality of goat kids

Attribute	Dietary treatment			SEM	P-value
	T_0	T_1	T_2		
Pre- slaughter weight (kg)	15.02	15.39	16.40	0.69	0.23
Dressed weight (kg)	6.20	6.575	7.17	0.67	0.81
Dressing percentage (%)	40.73	42.61	43.39	4.32	0.55
Water holding capacity	27.73	27.35	26.83	0.40	0.14
Yield of wholesale cut (% of carcass weight)					
Neck	4.15	4.17	4.29	0.39	0.93
Rack	9.03	8.24	9.48	1.06	0.52
Shoulder	6.48	6.29	6.74	1.37	0.95
Breast and shank	6.78	7.57	7.36	1.46	0.86
Loin	2.48	2.42	2.54	0.66	0.99
Hind legs	10.59	11.09	10.33	1.62	0.92
Yield of visceral organs					
Thyroid	3.66	3.50	3.49	0.963	0.99
Liver	176.50	178.03	178.85	5.59	0.91
Kidney	38.23	39.41	40.75	1.47	0.14
Heart	84.02	85.03	85.65	4.06	0.92
Lungs and Trachea	165.52	168	170.25	25.10	0.89
Meat composition (%)					
Moisture	75.17	74.53	75.42	0.213	0.28
CP	19.23	19.75	19.87	0.210	0.31
Fat	3.26	3.22	3.18	0.103	0.85
Keeping quality					
*p*H	5.76	5.41	5.58	0.012	0.92
TBAR (mg MDA/kg)	0.30^c	0.26^b	0.25^a	0.008	0.001

$^{a, b, c}$ Mean (± S.E) with different superscript in a row differ significantly (P<0.05).

The blood urea and urea N were comparable among all the experimental groups of kid. The blood urea nitrogen is correlated with forage CP content (Wilson *et al*. 2016). Similar findings were documented by Natarajan (2020) who reported similar urea and urea N in cabbage fed group of lambs as compared to control group. Similarly, Mahomoud (2016) reported no changes in Urea and Urea N concentration in broccoli fed group of lambs.

The blood glucose concentration was comparable among treatments but for different periods. Similarly, Natarajan (2020) reported similar glucose levels in all groups of lamb fed cabbage waste. Similarly, Jadhav (2017) reported similar glucose levels among all groups of goats feeding on tree leaves. Cox-Ganser *et al*. (1994) reported glucose level was not affected by brassicas feeding in lambs. On the other hand, Chorfi *et al*. (2015) reported glucose level was decreased at different periods of experimental trial fed 50% kale to calves.

The cholesterol concentration was statistically (P<005) lower in 30% CLM fed group as compared to control group of kids. In agreement with present study, Bansod *et al*. (2023) found that total cholesterol level was significantly lower in 30% CLM fed group of rabbits as compared to control group. Mahomoud (2016) also reported that the cholesterol concentration was significantly (P<0.05) higher in control group as compared to broccoli fed group. Similarly, Cox-Ganser *et al*. (1994) found reduction in plasma cholesterol in brassica fed group of sheep. While human intervention studies have provided evidence that diets rich in cruciferous vegetables may modify plasma lipid and cholesterol profile. It is also possible that the cholesterol decreasing effect resulted from the presence of SMCO (S-methyl cysteine super-oxide) in the Brassicas. Studies in Japan (Fujiwara *et al*.1972, Itokawa *et al*. 1973) showed that SMCO significantly lowered serum cholesterol concentrations in rats, and Smith (1978) suggested that its hypocholesterolemic action might be mediated by dimethyl disulfide. Generally, the values obtained for blood constituents in this study indicate normal physiological and healthy status of all kids.

Enzymatic profile: The data pertaining to different serum enzymes (ALP, AST and ALT) have been presented in Supplementary Table 3. The ALP, AST and ALT level was comparable among all groups of goat kid. These results were in agreement with Bansod *et al*. (2023) who found that enzyme profile was not affected by cauliflower leaf meal feeding in rabbits. Natarajan (2020) also found that serum enzymes were not affected by cabbage feeding in lambs. Partovi *et al*. (2020) reported that the fattening lambs fed broccoli byproduct and wheat straw silage had no effect on ALT, AST and ALP enzymes. Cox-Ganser *et al*. (1994) reported there were no significant differences (P>0.05) in serum enzymes alanine aminotransferase for brassica waste fed group of lambs. Contrary to this study, Mahmoud (2022) documented that ALT and AST concentrations were increased linearly as the inclusion level of broccoli byproduct was increased in diet of lactating goats. Mahmoud (2016) found that AST and ALT concentrations were significantly (P<0.05) higher in lambs fed with diets containing different levels of broccoli byproduct as compared with those of control diet. The concentration of specific enzymes in serum serve as indicators of tissue damage (Kramer 1989) or metabolic disorders (Puoli *et al*. 1992). Overall, enzymes are intimately related to metabolic processes which in turn, are easily and often influenced by the external environment including feeding practice, climate, and all other factors of management (Young *et al*. 1969).

Antioxidant profile: The data pertaining to the antioxidants was presented in Table 2. The concentration of catalase was found significantly (P<0.05) higher in T_2 (11.43) group as compared to T_0 (10.37) and T_1 (10.95) group and also significantly (P<0.05) higher at 120 days of feeding trial. The mean glutathione peroxidase concentration was found significantly (P<0.05) higher in T_2 (87.01) group as compared to T_0 (83.22) and T_1 (85.37) group and significantly (P<0.05) higher at 120 days of trial. Whereas, the concentration of superoxide dismutase was found to be comparable among all groups and different period of trial. Similar to the present study, Dosoky *et al*. (2022) documented the feeding 4% pomegranate peel powder to broilers increases catalase, SOD and glutathione peroxidase concentration as compared to control group. Natarajan (2020) reported that the serum glutathione peroxidase and catalase was statistically (P<0.05) higher in cabbage fed group of lambs. Similarly, Seham *et al*. (2011) reported the catalase, glutathione peroxidase and superoxide dismutase were increased due to feeding cauliflower leaf meal to rabbits. The high concentration of SOD and CAT in the body leads to improved protection of cell membranes against oxidative stress and ROS (Lin *et al*. 2001). The polyphenols present in cauliflower leaf meal can induce antioxidant enzymes such as glutathione peroxidase and catalase, which decompose hydro peroxides, hydrogen peroxide and superoxide anions and inhibiting the expression of enzymes such as xanthine oxidase (Muzzaffar *et al.* 2016).

Hormonal profile: The data pertaining to different serum thyroid hormones, i.e. Tri-iodothyronine (T_3), thyroxine (T_4) and TSH have been presented in Table 3. The mean values of T_3 **(**ng/mL**)**, T_4 **(**ng/mL**)** and TSH (μIU/mL) were comparable (P>0.05) among various dietary treatment groups. This study showed similarity with Natarajan (2020) who reported thyroid hormones were unaffected by cabbage feeding in lambs. Partovi *et al*. (2020) fed broccoli byproduct wheat straw to fattening lambs and found there were no changes in serum thyroid hormones profile. Similarly, feeding different concentrations of ensiled kale (*Brassica oleracea*) in lambs did not affect blood triiodothyronine and thyroxin concentrations (Vipond *et al*. 1998). On the other hand, Cox-Ganser *et al*. (1994) reported there were changes in thyroid hormones as the inclusion level of broccoli waste increased in sheep diet. In the present study, there were no changes in thyroid hormones which noted that 20-30% CLM could be suitable in goat feeding without any adverse effect on health of goats.

Immunity status: The CMI response of experimental kids have been presented in Supplementary Table 4. The CMI response was provided in different treatment groups of kids. The absolute mean value for skin thickness was maximum at 24 h, and gradual decline up to 72 h post-injection, which was the typical immunity pattern. The CMI's absolute mean values were 4.02, 5.37 and 5.07 mm in T_0, T_1 and T_2 group of kids, respectively. The mean absolute and relative response were found significant (P<0.05).

The humoral immunity of experimental kids have been shown in Supplementary Table 5. The humoral immunity was provided in different treatment groups of kids. The antibody titre against chicken RBCs was maximum up to 14 days and declined up to 28 days which was the typical immunity pattern. Similar results to present study were supported by Kumar *et al*. (2019) who reported improvement in cell mediated and humoral immunity in sugarcane press mud fed groups of lambs. Jadhav (2017) reported improved humoral and cell mediated immunity in *Moringa oleifera* fed group of kids. The present study showed disagreement with Natarajan (2020) who reported a non-significant (P>0.05) difference in humoral immunity by feeding cabbage waste to lambs. Raza *et al*. (2018) reported the vegetable waste feeding in broilers did not show any significant changes in immunity status. Also, Mandal (2015) reported there were no significant changes (P>0.05) in cell mediated immunity of goats fed karanj cake.

Carcass characteristics: The data regarding carcass characteristics have been presented in Table 3. The dressing percentages was found non-significant (P>0.05) among all the groups of kids. The feeding of cauliflower leaf meal to goats had no effect on dressing percentage, dressing weight, yield of wholesome cuts and visceral organs weight. Similar to present results, Natarajan (2020) reported dressing percentage, wholesome cut yield and edible organs weight were unaffected (P>0.05) due to feeding of cabbage waste to lambs and Chanjula (2018) reported there was no effect of feeding vegetable waste on carcass length, carcass width of goats. Kotsampasi *et al*. (2014) also reported the same result due to feeding of pomegranate silage in lambs. Contrary to obtained result, Dutta *et al.* (2023) reported carcass traits were improved due to feeding of different level of barley grain in concentrate to Barbari goats. According to Ngu and Ledin (2005), goat liver weight was increased due to pesticide/ insecticide/ glucosinolates content of cabbage which increase the metabolic activity of liver. Barry *et al.* (1982) reported statistically (P<0.05) decreased empty body weight and carcass weight by supplementation of kale in sheep and increased liver and kidney weight of experimental lambs but there was no difference in the thyroid weight. Reid *et al.* (1994) reported the dressing percentages of lambs fed with brassica feed were higher than lambs fed with stockpiled grass-legume pastures.

Meat quality: Data pertaining to meat's physico-chemical properties and chemical composition of meat have been produced in Table 3. Both the *p*H and water holding capacity of meat sample did not vary statistically (P>0.05) among the treatment groups of kids. The moisture, CP, total ash and fat per cent also was found non-significant (P>0.05) among the groups. It was found that TBAR concentration was significantly (P<0.05) lower in T_1 (0.26) group as compared to T_0 (0.30) group of kids. Similar to the present study, Natarajan (2020) reported chemical composition, *p*H and water holding capacity were not affected by cabbage feeding to lambs. Chanjul (2018) reported that there was no effect of feeding vegetable waste oil on *p*H and water holding capacity of chevon.

In contrast to present investigations, Otmani *et al.* (2021) reported significantly (P<0.05) high protein, low fat and ash content in meat of goat fed olive cake. The *p*H value of the muscle after slaughter is one of the most important factors that affect meat quality because the *p*H can influence the tenderness, colour and water retention capacity. This process involves the depletion of muscle glycogen stores with the production and accumulation of lactic acid. This process also triggers rigor mortis, which in sheep or goat carcasses occurs when the *p*H is between 5.6 and 5.8 for the *Longissimus* muscle.

The feeding of cauliflower leaf meal to growing goat kids have comparable effect on haematological, biochemical, enzymatic, hormonal profile and carcass characteristics. The inclusion of 20–30% CLM in concentrate lowered the total cholesterol level, increased catalase and glutathione peroxidase level, improved keeping quality and the immunity status of goat kids.

REFERENCES

AOAC. 1995. *Official Methods of Analysis* (16th ed.). Association of Official Analytical Chemists, Washington, DC.

Aregheore E M. 2000. A note on the nutritive value of dry ripe plantain peels as a replacement of maize for goats. *Journal of Animal and Feed Sciences* **7**(1): 55–62.

Bansod A P, Verma A K, Chaudhary L C, Chaturvedi V B and Saha S K. 2023. Effect of feeding graded levels of dried cauliflower leaf meal on blood biochemical, hormonal and antioxidant profile of rabbits. *Animal Nutrition and Feed Technology* **23**(2): 415–25.

Barry T N, Duncan S J, Sadler W A, Millar K R and Sheppard A D. 1982. Iodine metabolism and thyroid hormone relationships in growing sheep fed on kale (*Brassica oleracea*) and ryegrass (*Lolium perenne*)–clover (*Trifolium repens*) fresh-forage diets. *British Journal of Nutrition* **49**(2): 241–53.

Bergmeyer H U. 1983. *Methods of Enzymatic Analysis* **3**(2): 165–66.

Chanjula P. 2018. Use of crude glycerin as an energy source for goat diets: A review. *Journal of Dairy and Veterinary Sciences* **2**: 1–6.

Chorfi Y, Couture Y, Tremblay G F, Berthiaume R and Cinq-Mars D. 2015. Growth and blood parameters of weaned crossbred beef calves fed forage kale (*Brassica oleracea spp. acephala*). *Advances in Agriculture* **2015**(4): 1–7.

Cox-Ganser J M, Jung G A, Pushkin R T and Reid R L. 1994. Evaluation of *Brassica* in grazing systems for sheep: II. Blood composition and nutrient status. *Journal of Animal Science* **72**(7): 1832–841.

Craig W J. 1999. Health-promoting properties of common herbs. *American Journal of Clinical Nutrition* **70**(3): 491S–99S.

Dosoky W, Abdel Rahman M H and Al-Rumaydh Z I. 2022. Effect of propolis as natural supplement on productive and physiological performance of broilers. *Journal of the Advances in Agricultural Researches* **27**(4): 674–86.

Dutta T K, Chatterjee A, Bhakat C, Mandal D, Rai S, Mohammad A, Satpathy D, Yadav S K and Das A K. 2023. Effect of different levels of concentrate supplementation on feed intake, growth performance, carcass traits and composition in finisher Barbari kids reared under intensive system. *Indian Journal of Animal Sciences* **93**(1): 82–89.

Fujiwara M, Itokawa Y, Uchino H and Inoue K. 1972. Anti-hypercholesterolemic effect of a sulfur containing amino acid, S-methyl-l-cysteine sulfoxide, isolated from cabbage. *Experientia* **28** : 254–55.

Havsteen B H. 2002. The biochemistry and medical significance of the flavonoids. *Pharmacology and Therapeutics* **96**(2-3): 67–202.

Itokawa Y, Inoue K, Sasagawa S and Fujiwara M. 1973. Effect of SMCO, S-allylcysteinesulphoxides and related S-containing amino acids on lipid metabolism of experimental hypercholesterolemic rats. *Journal of Nutrition* **103**: 88.

Jadhav R. 2017. 'Effect of feeding tree leaves on performance of goats.' MVSc. Thesis, IVRI, Izatnagar, UP, India.

Kotsampasi B, Christodoulou V, Zotos A, Liakopoulou-Kyriakides M, Goulas P, Petrotos K, Natas P and Bampidis V A. 2014. Effects of dietary pomegranate byproduct silage supplementation on performance, carcass characteristics and meat quality of growing lambs. *Animal Feed Science and Technology* **197**: 92–102.

Kramer J W. 1989. Clinical enzymology, pp. 338–63. *Clinical Biochemistry of Domestic Animals* (4th Ed.). (Ed) Kaneko J J. Academic Press, San Diego.

Kumar R, Saha S K, Vineetha S and Sharma A K. 2019. Effect of feeding of graded levels of sugarcane press mud on immune status and histopathological changes in Muzaffarnagri lambs. *Indian Journal of Pathology* **43**(1): 17–22.

Lin C C, Hsu Y F, Lin T C and Hsu H Y. 2001. Antioxidant and hepatoprotective effects of punicalagin and punicalin on acetaminophen-induced liver damage in rats. *Phytotherapy Research* **15**: 206–12.

Mahmoud Y M. 2016. Using broccoli plant wastes in sheep rations. *Egyptian Journal of Nutrition and Feeds* **19**(2): 277–87.

Mahmoud Y M M. 2022. Improving performance of lactating goats fed rations containing boroccoli by products (*Brassica oleracea*). *Advances in Animal and Veterinary Sciences* **10**(7): 1623–632.

Mandal T. 2015. 'Effect of feeding karanj cake on performance of goat.' MVSc. Thesis, IVRI, Izatnagar, UP.

Marklund S and Marklund G. 1974. Involvement of superoxide anion radical in autoxidation of pyrogallol and a convenient assay for superoxide dismutage. *European Journal of Biochememistry* **47**: 469–74.

Minami M and Yoshikawa H. 1979. A simplified assay method of superoxide dismutase activity for clinical use. *Clinical*

Chemica Acta **92**: 337–42.

Mueller K, Blum N M, Kluge H, Bauerfeind R, Froehlich J, Mader A, Wendler K R and Mueller A S. 2012. Effects of broccoli extract and various essential oils on intestinal and faecal microflora and on xenobiotic enzymes and the antioxidant system of piglets. *Open Journal of Animal Science* **2**(2): 78–98.

Muzaffar S, Rather S A, Khan K Z and Akhter R. 2016. Nutritional composition and i*n vitro* antioxidant properties of two cultivars of Indian saffron. *Journal of Food Measurement and Characterization* **10**: 185–92.

Natarajan A. 2020. 'Studies on the effect of feeding cabbage waste as an alternative feed for lambs.' MVSc Thesis. IVRI, Izatnagar, U P, India.

Ngu N T and Ledin I. 2005. Effects of feeding wastes from *Brassica* species on growth of goats and pesticide/insecticide residues in goat meat. *Asian-Australasian Journal of Animal Sciences* **18**(2): 197–202.

Onifade A A and Abu O A. 1998. Productive response of rabbits to supplemental copper in a diet based on tropical feedstuffs. *Journal of Applied Animal Research* **13**(1-2): 129–35.

Otmani S, Chebli Y, Hornick J L, Cabaraux J F and Chentouf M. 2021. Growth performance, carcass characteristics and meat quality of male goat kids supplemented by alternative feed resources: Olive cake and cactus cladodes. *Animal Feed Science and Technology* **272**: 114746.

Paglia D E and Valentine W N. 1967. Studies on the quantitative and qualitative characterization of erythrocyte glutathione peroxidase. *The Journal of Laboratory and Clinical Medicine* **70**(1): 158–69.

Partovi E, Rouzbehan Y, Fazaeli H and Rezaei J. 2020. Broccoli byproduct-wheat straw silage as a feed resource for fattening lambs. *Translational Animal Science* **4**(3): 78.

Puoli J R, Reid R L and Belesky D P. 1992. Photosensitization in lambs grazing switchgrass. *Agronomy Journal* **84**: 1077–080.

Purushothaman S K, Ally K, Dildeep V and Anil K S. 2019. Evaluation of rumen fermentation parameters and hematological profile in Murrah buffalo calves maintained on total mixed ration containing agricultural byproducts. *Journal of Entomology and Zoology Studies* **7**(4): 974–77.

Radostits O M, Gay C, Hinchcliff K W and Constable P D. 2007. *Veterinary Medicine E-Book: A Textbook of the Diseases of Cattle, Horses, Sheep, Pigs and Goats*. Elsevier Health Sciences.

Rao B S N. 1993. Use of carotene rich foods for combating vitamin A deficiency, pp. 273–89. (Eds) Gopalan C and Kaur H. *Towards Better Nutrition – Problems and Policies*. Nutrition Foundation of India

Raza A, Hussain J, Hussnain F, Zahra F, Mehmood S, Mahmud A, Amjad Z B, Khan M T, Asif M, Ali U and Badar I H. 2018. Vegetable waste inclusion in broiler diets and its effect on growth performance, blood metabolites, immunity, meat mineral content and lipid oxidation status. *Brazilian Journal of Poultry Science* **21**(1).

Reid R L, Puoli J R, Jung G A, Cox-Ganser J M and McCoy A. 1994. Evaluation of brassicas in grazing systems for sheep: I. Quality of forage and animal performance. *Journal of Animal Science* **72**: 1823–831.

Sahoo A, Sarkar S, Lal B, Kumawat P, Sharma S and De K. 2021. Utilization of fruit and vegetable waste as an alternative feed resource for sustainable and eco-friendly sheep farming. *Waste Management* **128**: 232–42.

Seham S, Kassem, Maha H, Mahmoud, Madiha M, Abdel- Kader and El-Shobaki F A. 2011. Evaluation of the health value of some beverages prepared from vegetable and fruit wastes. *Journal of American Science* **7**: 328–39.

Singh J, Upadhyay A K, Bahadur A, Singh B, Singh K P and Rai M. 2006. Antioxidant phytochemicals in cabbage (*Brassica oleracea* L. *var. capitata*). *Scientia Horticulturae* **108**(3): 233–37.

Smith R H. 1978. S-Methylcysteinesulphoxide, the brassica anaemiafactor (a valuable dietary factor for man?). *Veterinary Science Communications* **2**(1): 47–61.

Snedecor G W and Cochran W G. 1994. *Statistical Methods*, 6th edn. Oxford and IBH Publishing Co., Calcutta.

Stroev E A. 1989. *Biochemistry Textbook*. MIR Publishers, Moscow.

Thakur S, Reddy B S V, Agrawal V K and Singh P K. 2015. Effect of detoxified karanj seed cake (*Pongamiaglabra vent*) based diets on haematological parameters and body weight gain in goat kids. *Journal of Animal Research* **5**(3): 519–26.

Vallejo F, Gil-Izquierdo A, Pérez-Vicente A and García-Viguera C. 2004. *In vitro* gastrointestinal digestion study of broccoli inflorescence phenolic compounds, glucosinolates and vitamin C. *Journal of Agricultural and Food Chemistry* **52**(1): 135–38.

Verhagen H. 1993. Cancer prevention by natural food constituents. *International Food Ingredients* 1–2.

Vipond J E, Duncan A J, Turner D, Goddyn L and Horgan G W. 1998. Effects of feeding ensiled kale (*Brassica oleracea*) on the performance of finishing lambs. *Grass and forage science* **53**(4): 346–52.

Wani M S and Kaul R K. 2011. Nutritional and sensory properties of roasted wheat noodles supplemented with cauliflower leaf powder. *Annals of Food Science and Technology* **12**(2): 102–07.

Wilson T B, Long N M, Faulkner D B and Shike D W. 2016. Influence of excessive dietary protein intake during late gestation on dry lot beef cow performance and progeny growth, carcass characteristics, and plasma glucose and insulin concentrations. *Journal of Animal Science* **94**: 2035–046.

Witte V C, Krause G F and Bailey M E. 1970.A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. *Journal of Food Science* **35**: 582–85.

Young J E, Younger R. L, Rodeleff R D, Hunt L M and Melaren I K. 1969. Some observations on certain serum enzymes of sheep. *American Journal of Veterinary Research* **21**: 641–45.