Research Article

Improving Performance of Lactating Goats Fed Rations Containing Boroccoli by Products (*Brassica oleracea*)

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Abstract | A total of twenty-four lactating Damascus goats were selected one-month pre-calving, with an average body weight of 39.33±1.41 kg at the start point of the feeding trial and at the 3rd to 4th milking seasons. Experimental diets were used to estimate the effect of partially replacing berseem hay (BH) with broccoli by-products (BB) in goats' rations on nutrient digestibility, milk production, some physiological properties of blood and hematological profile. Animals were randomly divided individually into three comparable groups (eight does/group) in a comparative feeding trial. First group was received concentrate feed mixture (CFM) and BH (60:40 %) as control diet (T0). Tested groups T1 and T2 were given rations containing (BB) 10 % or 20 % as replacement of (BH) in the control diet, respectively, for 90 days as an experimental period. As digestibility trials were conducted on the goats to determine the digestion coefficients and feeding values of rations used. Results revealed that goat groups that received T1 and T2 recorded a significant increases ($P < 0.05$) in the digestion coefficients, feeding values, actual milk yield, 4 %-fat corrected milk, the composition of milk fat %, total solid %, lactose % and dry matter intake. Also, better ($P < 0.05$) feed conversion was observed with the tested rations based on control (T0). Blood analysis and hematological characteristics were also estimated. It is recommended to replace berseem hay with dried broccoli by-products up to 20 % in the diet of lactating goats regarding their digestibility, productive performance, blood parameters and hematological profile.

Keywords | Goats, Broccoli wastes, Productive performance, Digestibility

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INTRODUCTION

Droughts conditions are becoming more frequent and intense over the world, resulting in a lack of common cattle feedstuffs (Alipour and Rouzbehan, 2010). To address the problem of protein deficiency and reduce feeding expenses, potentially, unconventional feed sources, such as agricultural waste, should be researched as livestock diet ingredients (Mahmoud, 2016). According to Campas-Baibuli et al. (2009), several types of promising green leafy vegetables that are high in micronutrients and not used in the fields. Broccoli vegetable is among them where they are belonging to the family of *Cruciferae*, which includes crops of commercial interest such as cauliflower and cabbage.

Broccoli by-products (BB) are tasty and nutritious feeds that contain sufficient protein, ash, fiber contents and also fatty acids such as palmitic acid, linoleic acid and linolenic acid, and also contain amino acids like aspartate, glutamate, proline, valine and tyrosine Meneses et al. (2020). In addition, BB is rich in polyphenolic components and glucosinolates as well as other bioactive components like carotenoids, peroxidase and flavonoids which are known for their potentially health-promoting properties (Thomas et al., 2018). With more advantages such crop by-products could be encouraging the growth of the circular economy, minimize the use of water and land for food production, support the development of livestock feed availability, and reduce animal-human competition moreover, reduce pollution (Schader et al., 2015).

Food and Agriculture Organization of the United Nations (FAO, 2020) estimated that about 25,984,758 tonnes of broccoli were harvested worldwide in the year (2017). While, Jian et al. (2017) recorded that up to 20 million tonnes of broccoli and cauliflower crops are produced globally each year, with 15 million tonnes of waste left in the field. Also they, added that broccoli by-products mixed with dry forages, such as straw, before ensiling probably significantly improved forage conserving characteristics. Broccoli stem and leaf by-products (*Brassica oleracea* L. *Italica*) should be considered more as a concentrate ingredient than a forage one from the standpoint of animal feed due to their low fiber content and high protein level (Wiedenhoeft and Barton, 1974).

The inclusion of BB as a mixture with wheat straw silage (BBWS) in the diet of fattening lambs up to 200 g/kg DM is becoming equivalent to a diet of alfalfa-wheat straw in its feeding values. At this level, it is considered as a safe feed for sheep, with no negative effects on their growth performance or health (Partovi et al., 2020). Generally, de Evan et al. (2020) stated that dry matter of certain vegetable residues is high in fiber and protein and such residues could be fed to ruminants, however more researches is needed to determine and prove their nutritional value. Therefore, the objective of this experiment was to estimate the effect of berseem hay replacement with dried broccoli by-products as untraditional feed ingredients in goat rations on nutrient digestibility, milk production, certain physiological properties of blood and hematological profile.

MATERIALS AND METHODS

Ethical approval

This experiment was carried out according to the guidelines of the ethical committee of the Animal Production Research Institute. The current work was carried out in the goats' Research Unit, Sakha Research Station, Kafr El-Sheikh province, which belongs to the Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt.

Experimental animals and feeding trial

A total of twenty-four milking Damascus goats with an average body weight of 39.33±1.41 kg, at the 3rd to 4th milking seasons were randomly individually distributed into 3 comparable groups (eight does/ each group) through the trial period and given one of the three tested experimental rations. All of the experimental goats were provided a diet that included concentrate feed mixture (CFM) and berseem hay (BH). The does in the first group (T0) were served as (control) and fed the same ration without any substitutions. The treated groups (T1) and (T2) were included broccoli by-products (BB) in replacing BH at rates of 10 and 20 %, respectively. The concentrate feed mixture used in this work was consisted of 42.0 % yellow corn, 12 % un-decorticated cottonseed meal, 38.0 % wheat bran, 2.0 % limestone, 1.0 % salt, 1.0% minerals and 4.0 % molasses. The daily amount of CFM was calculated at 3.5 % of the goat's body weight and given in two equal portions at 8 am and 4 pm and in addition, 3 kg BH to meet the nutritional requirement of goats according to the National Research Council (1989). Fresh water and mineral salts were provided during the experimental period to satisfy the daily requirements of goats. Up to 3 months postpartum, goats were fed constantly with their kids until weaning time, which was extended up to 3 months as a suckling period. Throughout the study, a veterinarian care was done for monitoring the health of experimental animals regularly. The chemical analysis of the experimental CFM, BH and BB as well as the calculated composition of the experimental diets are shown in Table 1.

Table 1: Chemical composition of the experimental concentrate feed mixture, berseem hay and broccoli by-products, and calculated composition of experimental rations (on DM basis, %).

Item	DM	OM	CP	CF	EE	NFE	Ash
concentrate feed mixture	88.44	95.42	15.68	7.27	4.19	68.28	4.58
berseem hay	85.46	90.22	15.17	28.46	2.26	44.33	9.78
Broccoli by-products	90.17	83.75	24.87	12.97	1.17	44.74	16.25
Experimental rations							
T0	87.30	93.42	15.48	15.40	3.45	59.09	6.58
T1	87.57	92.78	15.90	14.92	3.28	58.67	7.22
T2	87.80	92.32	16.31	14.40	3.18	58.44	7.68

Ingredients of CFM: Concentrate feed mixture contained yellow corn 42.0%, un-decorticated cotton seeds 12%, wheat bran 38.0%, molasses 4%, minerals 1%, common salt 1%, lime stone 2%. T0= control ration, T1= 10 % broccoli by-product and T2= 20 % broccoli by-product.

Sundried broccoli by-products which included stems and leaves were collected immediately after harvesting and chopped into pieces 2-3 cm (~ 90 % moisture content) and then sundried for 15 days was accomplished. Then it was ground before being mixed with the other ingredients and stored to make the experimental diets.

Digestibility trials

Three digestibility trials were conducted simultaneously on the same animals of the feeding trial (3 goats per each treatment) to determine the digestibility and feeding values of the experimental diets. To facilitate the collection of all faces during the experiments, animals were fed individually in a metabolic cages and the amount of feed consumed was measured daily. Representative samples of feces (~ 200 g.) were taken twice daily from the rectum at 8 am and 8 pm during the 7-days collection period as recorded by Maynard et al. (1979). Each animals' daily feces samples were promptly frozen at -20 ºC until the completion of the collecting phase and after that a composite sample was prepared for analysis. Before drying feces, 10 % of sulfuric acid was added into samples to catch volatilizable compounds to be lost during drying in the oven at 65 ˚C overnight. Representative samples of feedstuffs of (CFM, BH and BB) and samples of feces were oven-dried for 24 hours at 65 ˚C, after which, ground to pass through (1mm sieve), Samples were analyzed for dry matter, crude fiber, crude protein, ether extract and ash contents using the AOAC (2007) method. According to Abou-Raya (1967) nutrient digestion coefficients and feeding values were calculated.

Milk production

Goats were kept in a shady area and manually milked twice a day (6.0 am and 6.0 pm hours) whereas, weekly milk yields were recorded. Total milk production was computed by summing the milk yields during the whole trial period. Samples were collected analyzed for milk fat, protein, total solids, and lactose content. Milk samples were analyzed for total solids using the Majenier Method Laboratory Manual (1949), and fat % was determined using Gerber's method as reported by Ling (1963). The macro-kjeldahle method (N = 6.38) was used to determine the protein content in milk. The total solid percentage of milk was measured by weighing 5 mL of milk, drying it on a sand bath to remove excess water, and drying it for three hours at 105°C in a drying oven. Finally, lactose content level was calculated by differences and milk ash content was measured using AOAC (2007). The 4 %-Fat corrected milk was calculated according to the following equation:

4 % Fat corrected milk = 0.4 M + 15.0 F, Where, M = milk yield and F = fat yield. While, feed conversion was estimated as intakes of dry matter (DM), total digestible nutrient (TDN) and digestible crude protein (DCP) per one kg. of milk.

Blood parameters

At the end of the feeding experimental period, blood samples were taken from the jugular vein of goats at 8.0 am hrs before morning feeding (three in each/ group) in 2 sterile tubes for each doe. The first blood samples were centrifuged at 3000 rpm for 20 min. then plasma was separated and the supernatant was stored at -20°C till subsequent chemical analysis in the laboratory. The supernatant was used to estimate total protein Armstrong and Carr (1964); total albumin was measured by Doumas et al. (1971); and the concentration of globulin was calculated as the difference between the total protein and albumin. Activities of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were determined according to Reitman and Frankel (1957); total cholesterol was measured according to Allian et al. (1974) using bio Merieux test kits; Plasma creatinine was determined according to Henry et al. (1974). All biochemical blood constituents were determined using spectrophotometer (Spectronic 21 DUSA) and commercial diagnostic kits (Combination, Pasteur Lap.). The second blood samples were taken in heparinized tubes as an original whole blood for determined hematological parameters comprising mean of corpuscular volume (MCV %) using microhematocrit centrifuged at 4000 rpm for 20 min. as described by Mitruka and Rawnsley (1977); the hemoglobin percentage using cyanomethemoglobin technique Mitruka and Rawnsley (1977) and the counts of red blood corpuscular and white blood cells were immediately estimated on fresh blood using hematocytometer according to Mitruka and Rawnsley (1977).

Statistical analysis

Data were statistically analyzed using one-way analysis of variance procedure (SAS, 2000) computer program and using the following fixed model:

$$Y_i = \mu + T_i + ie$$

Where; Yi = The individual observation; μ = Overall mean; Ti = Effect of treatments. (i = 1, 2 and 3) and ie = Random error component assumed to be normally distributed. Significant differences between treatment means were determined at P<0.05 by Duncan's multiple-range test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical composition

Data of chemical composition of CFM; BH, BB and the calculated composition of experimental rations (on DM basis, %) are presented in Table 1. Results showed that BB had significant higher crude protein (24.86 %) and ash (16.23 %) than those of BH, but had a lower crude fiber (12.97 %) than that of BH (28.46 %). These findings are consistent with those recorded by Alpuche-Solis and Paredes-Lo'pez (1992) who showed a reasonably high protein content in floret flours in broccoli plant (36.6 %) on dry matter basis vs. (18.6 %) in stalk flours of this plant. They also reported that the protein content of the flour of the whole plant was ranged from 23.2 % to 32.0 % in some broccoli varieties. While, Ibrahim et al. (2011) reported remarkable chemical similarities between broccoli by-product and lucern hay being, 14.26, 23.87, 2.35, 45.96, and 13.56 percent in respect of CP, CF, EE, NFE, and ash for broccoli by-product and 15.19, 25.04, 1.52, 45.96, and 12.29 percent for lucern hay, respectively. There were also minor changes in the contents of NDF, ADF, ADL and cellulose between the two ingredients. Comparatively, Hu et al. (2012) recorded higher CP (27.13 %) and lower CF (8.85%) for broccoli leaf and stem meal than those reported in the present study.

It could be observed that all mentioned values are in favorable of broccoli by-products and in proceeding of berseem forage accordingly. Regarding the calculated composition of the experimental rations, all values of chemical composition appeared to be so similar among the three rations.

Digestion coefficients and feeding values

Data presented in Table 2 showed significant differences between the experimental diets respecting digestibility coefficients and feeding values in which inclusion BB in goats' rations. Results revealed that digestion coefficients of all nutrients were higher ($P < 0.05$) significantly with tested ration (T2) than those of T1 and control one (T0), but the digestibility for OM, CP and EE being higher ($P < 0.05$) significantly with the tested ration (T1) than those of control one (T0). The obtained results revealed that the digestibility coefficient of dry matter and crude fiber were significantly ($P < 0.05$) higher with BB diets T1 and T2 compared with those of control one (T0), being the differences were not significant between the tested groups T1 and T2 in these items. These findings were reflected in the feeding values for (TDN) and (DCP), which followed the same trend of nutrient digestibility, among the experimental rations, where the highest values were associated with the (T2) ration. These important findings can be attributed to the presence of glucosinolates and other bioactive compounds in broccoli that includes nitrogen and sulfur which submit the favorable digestion gastrointestinal conditions such as enzyme, chemical conditions, pH and temperature as reported by Vallejo et al. (2004). These findings are on line with those reported by Mahmoud (2016) who demonstrated that digestibility of CP and NFE and thus feeding values as TDN and DCP are significantly ($P < 0.05$) higher with lambs fed diets containing different levels of BB compared to those of control diet that free from BB ingredient. Also, Wadhwa et al. (2006) showed that good nutrient digestibility for DM, OM, CP, and NDF when fresh cauliflower (*Brassica oleracea*) was fed to goats bucks. Also, de Evan et al. (2020) demonstrated that rumen CP degradability of broccoli stems was 9.8% higher ($P<0.001$) than that of florets and in contrary, *in vitro* intestinal DM and CP digestibility of stems was lesser than those of florets. On the other hand, Partovi et al. (2020) demonstrated that fattening lambs fed a mixture of BB with wheat straw silage substituted up to 200 g of forage had no effect on the apparent digestibility of DM, EE, OM and CP. Contrary, Nkosi et al. (2016) mentioned that the digestibility of OM and NDF were decreased with increasing the levels of discards cabbage (*Brassica oleracea*) incorporation into lambs diets (73 % vs. 65 %; 56 % vs. 47%, respectively; compared with those fed the control ration that free from discarded cabbage. The best nutritional value of T2 20 % BB as potentially proved in the present experiment can be used for the synergistic interaction of the nutrients released from the appropriate levels of both coarse types in these servings. It is also well known from a nutritional point of view as a type of associated positive effect that is likely to positively affect feed utilization and thus the productive performance of ruminants Huhtanen (1991). Additionally, in many cases two feeds may have similar nutritional value but differ in feeding value when mixed together due to their effect on feed intake or their antagonistic or synergistic interaction with each other in the whole diet (Thomas, 1990).

Table 2: Effect of experimental rations on digestion coefficients and feeding values.

Item	Experimental rations			± SE
	T0	T1	T2	
Digestion coefficients				
DM	67.20 ^{b}	68.27 ^{a}	68.66 ^{a}	±0.299
OM	70.26 ^{c}	71.54 ^{b}	72.65 ^{a}	±0.392
CP	68.46 ^{c}	71.10 ^{b}	73.96 ^{a}	±0.859
CF	50.46 ^{b}	53.92 ^{a}	55.36 ^{a}	±1.143
EE	74.61 ^{c}	77.33 ^{b}	80.18 ^{a}	±0.889
NFE	75.72	75.88	76.18	±0.329
Feeding values				
TDN	68.90 ^{c}	69.58 ^{b}	70.29 ^{a}	±0.274
DCP	10.60 ^{c}	11.31 ^{b}	12.06 ^{a}	0.218

a, b and c means in the same row with different superscripts are significantly ($P < 0.05$) different. SE=Standard error. T0= control ration, T1= 10 % broccoli by-product and T2= 20 % broccoli by-product.

Milk production and its Macro-composition

The actual daily milk yield and its composition for does fed the experimental diets are shown in Table 3. Daily milk yield was significantly ($P < 0.05$) higher for does fed diet contained 20 % broccoli by-products (T2), followed by 10 % BB (T1) ration than those fed the control diet (T0). These result are in agreement with those reported by Aziz (2021) who found that milk production was increased ($P < 0.05$) significantly with increasing the levels of BB in diets of ewes. Feeding T2 scored the highest yield

($P < 0.05$) 4 %-FCM (fat corrected milk) per day, then (T1) ration that contained 10 % BB, while the lowest values were recorded with T0. The improvement of the digestibility coefficients and feeding values for all nutrients with the tested rations T1 and T2 were positively reflected on the milk yield or 4 %-FCM. Similarly, Yi et al. (2015) showed that replacement of concentrate feed mixture (CFM) with pelletized broccoli by-products at rate of 20 % in lactating cows was increased milk yield and 4 %-FCM numerically but not significantly when compared with the free BB group. On the other hand, Monllor et al. (2020) stated that no significant differences in the yield of 4 %-FCM for dairy goats which fed diet containing different levels of BB compared to that of control group. Integrating BB with the experimental rations resulted in a higher ($P < 0.05$) protein, total solid, fat and lactose yields with T2 as compared to T1 and control one (T0). In agreement with the present findings of Aziz (2021) mentioned that the yield of milk components (g) increased ($P < 0.05$) significantly as the level of BB increased in the diet of ewes. Concerning chemical composition of milk, most milk constitutes are not significantly affected by treatments, however, the proportion of fat and ash were markedly increased ($P < 0.05$), while the proportion of protein in milk was somewhat decreased by increasing the replacement of BH by BB in the tested diets compared to the control (T0) in the current study. Similarly, Monllor et al. (2020) employed varied levels of the broccoli by-products in diet of goats in which they found significantly ($P < 0.05$) higher fat and total solids percentages, while having no effect on solid not fat, protein or lactose. Also, Yi et al. (2015) reported that concentrated feed mixture substituted with pelleted broccoli by-products (PBBs) at a rate of 20 % in dairy cow diets led to a significant ($P < 0.05$) increase in milk fat content compared to the control diet. The same authors was found no significant differences in the percentages of lactose, protein, total solids and non-fat solids in milk among the mentioned dietary treatments. In more explanation Sutton et al. (1998) showed that the higher fat content can be responding to higher NDF and ADF contents in BB, as well as a slightly higher percentage of acetate when compared to other concentrated components such as soybean meal and corn. This is as well known, because the acetate and butyrate contents have a strong positive relationship to be affecting in milk fat concentration, whereas; the propionate compound has a negative relationship on milk fat status. Physiologically, Salem and Abd El-Galil (2014) demonstrated that the increases in fat content with dairy cow rations could be attributed to the high fermentation of its high quality fiber content into volatile fatty acids in the rumen which are naturally converted to fat in milk. The same authors showed that protein and lactose contents increased in parallel with increasing DCP and TDN intake. Also, Eastridge et al. (2009) found that increasing the content ADF in cows' rations leads to a higher milk fat content and thus increased fat-corrected milk production for hay-fed cows. Basically, nutritional strategies that improve rumen functions can significantly increase milk production and composition. So, there are several strategies that producers can be use to increase rumen functions and as a result, increasing the production of milk and its components (Varga and Ishler, 2007). Moreover, nutritional strategies that favorably affect milk components must be include an adequate level of forage NDF and degradable rumen protein in the diet especially for the early lactating cow. Additionally, Varga and Ishler (2007) and Bachman (1992) showed that milk fat content can vary over a range of approximately 3 % units through dietary manipulation, while, lactose, minerals and other solid contents of milk have somewhat weak respond for that. Meanwhile, protein content can vary around 0.6 units. Huhtanen (1991) stated that dietary energy utilization depends not only on the nutritional content, but also on the nutrients provided by other forages introduced into the diet. Because TVFAs are the main products of microbial carbohydrate fermentation, their concentration in the cecum and other fermentation areas can be used as an indirect technique for monitoring the rumen environment. In general, Madrid et al. (2002) indicated that the efficient utilization of agricultural by-products as feedstuffs are dependent on a number of parameters such as available nutrient contents in proportion to processing cost, nutritional requirements of accessible animals, by-product uniformity, and the marked availability of competitively priced feedstuffs.

Table 3: Milk production and milk composition of goats fed the experimental rations.

Item	Experimental rations			±SE
	T0	T1	T2	
Body weight (kg)	38.50 [b]	40.34 [a]	40.26 [a]	±0.846
Milk yield (g/h/ d)	1099.7 [c]	1151.9 [b]	1228.9 [a]	±22.37
4 %-FCM, Yield (g/h/d)	957.3 [c]	1036.2 [b]	1124.4 [a]	±34.72
Milk composition %				
Fat %	3.14 [b]	3.33 [ab]	3.42 [a]	±0.102
Total solids (TS) %	11.18	11.34	11.33	± 0.113
Solid not fat (SNF) %	8.04	8.01	7.90	± 0.157
Protein%	3.43	3.25	3.32	±0.110
Lactose %	3.87	4.09	3.86	±0.157
Ash %	0.73[b]	0.75 [b]	0.79 [a]	±0.018
Yields of milk components (g/h/d)				
Fat	34.49 [c]	38.36 [b]	42.19 [a]	±1.786
Total solids	122.94[c]	130.65[b]	139.15[a]	±2.798
Protein	37.72 [b]	37.42 [b]	40.76 [a]	±1.162
Lactose	42.59[b]	47.15[a]	47.37 [a]	±1.918

a, b and c means with different superscripts within same row are significantly different ($P < 0.05$). 4 %-FCM yield = 0.4× milk yield + 15 × fat yield. T0= control ration, T1= 10 % broccoli by-product and T2= 20 % broccoli by-product.

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Feed consumption and feed conversion

Data of daily feed intake by dairy goats during the experimental period are shown in Table 4. The daily feed intake that expressed DM, TDN and DCP were significant ($P < 0.05$) higher with the two tested rations (T1 and T2) than those of control one (T0) and also the values of such items were significant higher with T2 than those of T1. These findings are supported by Mahmoud (2016) who documented that TDNI was significantly ($P < 0.05$) higher with lambs fed diets containing different levels of BB compared to those of control diet. Ngu and Ledin (2005) fed goats 4 diets with leaves from cauliflower (*Brassica oleracea var. botrytis*), cabbage (*Brassica oleracea var. capitata*), Chinese cabbage (*Brassica campestris subsp. pekinensis*) or control that free from any leaves and they showed a significantly ($P < 0.05$) higher of feed intake and body weight gain (529 g DM/day and 87.5 g/day, respectively) for cauliflower group and significantly lower of feed intakes of cabbage and Chinese cabbage groups comparing with those of control ration. On the other hand, Partovi et al. (2020) documented that fattening lambs fed on BB-wheat straw silage in substituting up to 200 g of forage had no effect on DMI values between the tested groups and the control one. Also, Hu et al. (2011) claimed that productive performance did not affected by inclusion of broccoli leaf and stem powder in laying hens diets at 0, 30, 60 and 90 g/kg of the diets. Nkosi et al. (2016) showed that the DMI were decreased with increasing the levels of discards cabbage (*Brassica oleracea*) incorporation into lambs diets comparing with those fed the control diet.

Table 4: Feed intake and feed conversion of goats fed the experimental rations.

Item	Experimental rations			±SE
	T0	T1	T2	
Feed intake				
DMI (g/head/day)	1026 ^{c}	1082 ^{b}	1085 ^{a}	±0.265
TDNI (g /head/day)	707 ^{c}	753 ^{b}	763 ^{a}	±1.716
DCPI (g /head/day)	109 ^{c}	122 ^{b}	131^{a}	±0.320
4 % FCM (g/h//d)	957.3^{c}	1036.2^{b}	1124.4^{a}	±34.72
Feed conversion (kg/kg)				
Kg DMI / FCM/ (kg milk)	1.07 ^{a}	1.05 ^{ab}	0.97 ^{b}	±0.027
Kg TDNI / FCM (kg milk)	0.721^{a}	0.674^{b}	0.629 ^{c}	±0.019
g DCPI/ FCM (g milk)	0.111	0.110	0.108	±0.025

a, b and c means in the same row with different superscripts are significantly ($P < 0.05$) different. SE=Standard error. T0= control ration, T1= 10 % broccoli by-product and T2= 20 % broccoli by-product.

Feed conversion in term of (DMI), (TDNI) or (DCPI) kg DMI/FCM kg milk was significant ($P < 0.05$) improved with the tested rations compared with those of control one, with the best ones whose occurred with the 20 % BB-ration (T2) as illustrated in (Table 4). Otherwise, Partovi et al. (2020) documented that fattening lambs fed mixture of BB -wheat straw silage in substitution up to 200 g of forage had no effect on feed conversion ratio. According to Mueller et al. (2012) their results showed that piglets fed broccoli extract diets had a positive impact on body weight gain and feed conversion in the first week. While, over whole trial period, there were non-significant differences in the productive performance between the tested groups and the control one.

Some blood biochemical parameters

Results of blood biochemical parameters for goats fed the dietary treatments are illustrated in Table 5. The concentration of total protein (TP) was significantly ($P < 0.05$) higher for both tested rations (T1 and T2) than those of un-received diet (T0). Albumin concentration was significantly ($P < 0.05$) higher for does fed diet contained 20 % broccoli by-products (T2), followed by 10 % BB (T1) ration than those fed the control diet (T0). Increased crude protein digestibility could explain the rise in blood plasma total protein and its fraction (Kassab, 2007). In agreement with these results Mahmoud (2016) estimated that TP and AL concentrations were significantly ($P < 0.05$) higher with lambs fed diets containing different levels of BB compared to those of control diet. Otherwise, Partovi et al. (2020) mentioned that fattening lambs fed mixture of BB -wheat straw silage substituted up to 200 g of forage in their diets had no effect on blood total protein, albumin and globulin concentrations. Physiologically, albumin is an important protein for maintaining stability of osmotic pressure in the blood (Craig, 1999). The findings for albumin and globulin being reflect 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), they were revealed that blood plasma total protein and albumin levels are directly related to intake and quality of protein in the diet. On the other hand, total protein and its fraction concentrations are considering as biological indicators for animal health and performance (Singh and Jha, 2009). In addition, dietary protein and energy levels are among the most effective factors for blood plasma profile for sheep Singh et al. (2013). Respecting, globulin concentration, its values did not affected significantly by the dietary treatments, being the highest with T1 ration, while cholesterol concentration was significantly decreased with both levels of BB compared with T0 that free from BB ingredient. Griminger (1986) cleared that an increase in the globulin concentration by the liver may reflect the good hepatic function of these animals and also correlate with a higher immune state. Regarding, the results of liver enzymes aspartate aminotransferase (AST) and alanine aminotransferase (ALT), its values in Table 5 were significantly higher with the tested rations (T1 and T2) than that of control one (T0), being the highest values were occurred with (T2), while, createnine concentration was insignificant decreased with T1 and significant decreased with T2 in comparison with the control value T0. Creatinine concentration in the blood clearly represent the kidney status of the animal, making it a good indicator of the animal's health. These results are in consistent with those reported by Mahmoud (2016) found that AST and ALT concentrations were significantly ($P < 0.05$) higher with lambs fed diets containing different levels of BB compared with those of control diet. On the other hand, Partovi et al. (2020) mentioned that fattening lambs fed BB-wheat straw silage substituted up to 200 g of forage in the whole ration had no effect on cholesterol and creatinine concentrations. 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). The data clearly that there was no pathological lesion in the liver, which is the main organ responsible for serum albumin synthesis. Serum albumin has been shown to be an accurate predictor of nitrogen status, particularly for small ruminants (Laborde et al., 1995). The increases in blood plasma components studied could be attributed to the role of broccoli by-products (stem and leaves) as a biological treatment in enhancing digestibility of nutrients overall.

Table 5: Blood parameters of goats fed the experimental rations.

Item	Experimental rations			± SE
	T0	T1	T2	
Total protein (g/dl)	7.08 [b]	7.23 [a]	7.29 [a]	± 0.032
Albumin (g/dl)	3.98 [c]	4.11 [b]	4.24 [a]	± 0.059
Globulin (g/dl)	3.09	3.12	3.05	±0.041
Cholesterol (mg/dl)	141.1 [a]	121.1 [b]	133.1 [ab]	± 2.584
AST U/L	31.90 [b]	32.43 [b]	35.32 [a]	± 0.728
ALT U/L	21.32 [c]	23.11 [b]	24.56 [a]	± 0.695
Createnine (mg/dl)	1.34 [a]	1.23 [ab]	1.09 [b]	±0.0429

a, b and c means in the same row with different superscripts are significantly ($P < 0.05$) different. SE=Standard error. T0= control ration, T1= 10 % broccoli by-product and T2= 20 % broccoli by-product.

The blood component values obtained in this study indicated that all groups of goats have a good physiological and health status.

Blood haematology profile

Data of hematological parameters for goats fed the experimental diets are presented in Table 6. Results revealed that there were significant ($P < 0.05$) differences amongst dietary treatments in respect of most measured items in hematiological profile. Does fed ration with the highest level of BB (T2) had the highest ($P < 0.05$) values of hemoglobin concentration (Hb), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentrations (MCHC), whereas, the lowest ($P < 0.05$) values were mostly recorded with the control one (T0). Also, data presented in Table 6 revealed that the differential of white blood cells (WBCs) count, monocytes and eosinophils percentages were higher ($P < 0.05$) significantly in tested diets that contained either 10% or 20% (BB) than those of control diet that free from BB ingredient (T0). Finally, there were no significant differences among dietary treatments with regard to red blood cells counts, Hematocrit (Hct) %, mean corpuscular volume (MCV), neutrophils and the percentage of lymphocyte (L) to total leukocytes, with the highest values observed with T2. These findings are in agreement with those recorded by Mahmoud (2016) who mentioned that counts of RBCs, Hb, Hct, MCV, and MCH were higher with lambs fed diets containing different levels of BB compared with that of control. Mueller et al. (2012) supported the present findings by demonstrating that piglets being in good health, no clinical abnormalities throughout the trial, and no parameter of blood hemogram outside the normal range when the broccoli extract added into their diets. Coles (1986) reported that a total leukocyte count of 13.000 / µl might represent a minor leukocytosis, whilest, 20.000 /µl might be reflected a marked status of leukocytosis. The leukocyte alteration can be the result of a normal physiological response or a pathological conditions and also they were showed that other than physiological status, the most common causes of leukocytosis are generalized/ localized infections, intoxication, including those caused by metabolic disturbances, drugs, chemicals, venoms, and so on. In this regard, the dietary antioxidants Vit. C and E, which are considered as an important components in broccoli by-products, could have a significant impact because they stimulated some distinct changes in the pattern of total leukocytes and its fractions (neutrophils, lymphocytes, eosinophils, mesophils and basophils) as recorded by Kamal et al. (2012). Certainly, the white blood cell counts is considered as an important indicator for diagnosing health conditions and either emergent or chronical problems, and it can be used to assess physiological changes related to pregnancy, immune response and production stresses (Bike, 2003). These results might be optimize resistance to diseases by enhancing the lymphocyte populations (Ndiweni and Finch, 1995). These changes in differential leukocytes count may refer to positive improvement of the immune response in the body. So, the current study demonstrated that because broccoli by-product is rich in most micro/macroelements, amino acids and highly varieties of vitamins, so an improvement in hematological parameters of does fed broccoli residues

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ration can be recognized favorably.

Table 6: Hematological parametes of goats fed the experimental rations.

Item	Experimental rations			± SE
	T0	T1	T2	
Red blood cells (RBCs) 10^6/cmm	2.90	2.88	2.91	±0.047
Hemoglobin (Hb) g%	7.50^b	7.80^a	7.98^a	±0.136
Hematocrit (Hct) %	22.0	22.0	22.31	±0.210
Mean corpuscular volume (MCV) fl	76.0	76.14	76.67	±0.689
Mean corpuscular hemoglobin (MCH) pg	26.0^b	27.0^{ab}	27.42^a	±0.415
Mean corpuscular hemoglobin concentration (MCHC) g%	34.0^b	35.0^{ab}	35.77^a	±0.512
White blood cells (WBCs) 10^3/cmm	3.20^c	3.80^b	3.99^a	±0.088
Neutrophils (N) %	69.00	66.00	68.00	±1.660
Lymphocytes (L) %	28.00	29.00	28.00	±1.790
Monocytes (M) %	2.00^b	3.00^a	3.00^a	±0.381
Eosinophils (E) %	1.00^b	2.00^a	2.00^a	±0.241

a, b and c means in the same row with different superscripts are significantly ($P < 0.05$) different. SE=Standard error. T0= control ration, T1= 10 % broccoli by-product and T2= 20 % broccoli by-product.

CONCLUSIONS AND RECOMMENDATIONS

Using such these promising crop by-products could be potentially improving the nutritional status for ruminant animals and on the same effectively reducing the environmental pollution.

NOVELTY STATEMENT

The results declare that Brassica oleracea By-products are nutritious feeds that contain sufficient protein and fiber contents, also contain fatty acids, carotenoids and flavonoids which affected positively the productive performance of goats.

Conflict of interest

The author declared there is no conflict of interests.

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