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ผลของการเสริมสารสกัดจากกากพริกไทยดำต่อสมรรถภาพการเจริญเติบโต คุณภาพน้ำนม และค่าโลหิตวิทยาในแพะนมพันธุ์ลูกผสม

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บทคัดย่อ: การสกัดพริกไทยดำก่อให้เกิดกากพริกไทยดำ ซึ่งจัดเป็นผลพลอยได้จากอุตสาหกรรมการเกษตร กากพริกไทยดำอาจส่งผลทำให้เกิดมลพิษทางสิ่งแวดล้อม เช่น การเกิดแก๊สเรือนกระจก กากพริกไทยดำเป็นของเสียที่ไม่สามารถนำไปใช้ประโยชน์ต่อในด้านอื่นๆ ได้ วัตถุประสงค์ของการศึกษาครั้งนี้เพื่อศึกษาผลของอาหารที่ผสมกากพริกไทยดำต่อการเจริญเติบโต การผลิตน้ำนม และค่าเลือดต่างๆ แพะนมพันธุ์ลูกผสมไทย-ซาเนน อายุ 2 ปีขึ้นไป น้ำหนักเฉลี่ย 34.83 $\pm$ 1.94 กิโลกรัม แพะนมถูกเลี้ยงในซองเดี่ยว ในการศึกษาแพะนมถูกแบ่งเป็น 2 กลุ่ม กลุ่มควบคุม แพะนมได้รับอาหารพื้นฐาน ขณะที่กลุ่มทดลอง แพะนมได้รับอาหารพื้นฐานที่ผสมกากพริกไทยดำในระดับ 10% ตลอดการทดลองมีการเก็บข้อมูลทางด้านการเจริญเติบโต ค่าเลือดและคุณภาพน้ำนม อัตราการกินได้ (Feed intake) อัตราการเจริญเติบโตของแพะนม ปริมาณและองค์ประกอบของน้ำนมมีค่าไม่แตกต่างกันระหว่างกลุ่มที่ได้รับและไม่ได้รับอาหารผสมกากพริกไทยดำ ค่าโลหิตวิทยาและค่าชีวเคมีของทั้งสองกลุ่มไม่แตกต่างกัน ค่าไขมันในเลือดก็ไม่แตกต่างกัน สรุปผลการศึกษา การให้อาหารผสมกากพริกไทยดำไม่ส่งผลต่อสุขภาพของแพะนมในระยะที่มีการให้น้ำนม

คำสำคัญ: การสกัดพริกไทยดำ ผลพลอยได้ แพะนม ค่าโลหิตวิทยา คุณภาพน้ำนม

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Effects of Dietary Supplementation with Byproducts from Black Pepper Extraction on Growth Performance, Milk Quality and Hematological Parameters in Dairy Goats: A Preliminary Study

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Abstract: Black pepper extraction generates black pepper-extracted byproducts (BEB), which are categorized as agricultural industrial waste products. The byproducts may contribute to environmental issues including greenhouse gas emissions and are not valuable to other industrial businesses. The objective of the present study was to investigate the effects of diet supplementation with BEB on growth performance, milk yield, and hematological profiles. Six two-year-old Thai-Saanen crossbreed goats, with an average initial weight of 34.83 ± 1.94 kg, were used. The goats underwent individualized care and were randomly divided into two groups: a control group receiving a basal diet and a group fed the basal diet supplemented with 10% BEB. Throughout the experimental period, growth performance, hematological profiles, and milk quality were analyzed. Feed intake, growth performance, and milk yield and composition of the goats given the byproducts supplementation were not considerably different from those of goats fed the basal diet. Hematological and biochemical profiles were also unaffected by the supplemented diet. Following supplementation with the byproduct, blood lipid profiles were not altered significantly. In conclusion, the consumption of the byproduct as a dietary supplement had no negative effects on the physical well-being of dairy goats during the lactation period.

Keywords: Black pepper extraction, Byproduct, Dairy goat, Hematology, Milk quality

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Introduction

Black pepper *(Piper nigrum)* is sometimes referred to as the "King of Spices". It is a climbing crop that features black peppercorns (Meghwal and Goswami, 2012). The extraction process of essential ingredients from plants, including black peppers, generates byproducts or waste products that are mostly disposed of or buried in the environment (Koul et al., 2022). Piperine derives from the extraction process and is considered the essential active substance in black pepper as it possesses various pharmacological properties such as anti-inflammation, antitumor, antimicrobial, and antipyretic activities. In contrast, waste products extracted from black peppers contain fluctuating levels of essential chemical substances including piperine (Stojanović-Radić et al., 2019; Correddu et al., 2020).

The major chemical compounds of agro-industrial waste products consist of hemicellulose and lignin, which are not beneficial for monogastric animals. However, ruminant animals, such as cattle, sheep, and dairy goats, are able to digest hemicellulose and lignin through fermentative digestion, which requires microorganisms (Salami et al., 2019).

Currently, agro-industrial waste products are increasingly utilized for various purposes including livestock production. For example, spent coffee ground is used to supplement the diet of dairy goats and does not affect the blood parameters, quality and quantity of milk production, and health status (Carta et al., 2022). Moreover, adding palm oil byproducts to the goat diet does not generate health problems, whereas the quantity of protozoa that is essential to the fermentative digestion in the rumen is significantly altered after feeding goats with palm oil byproducts (Abubakr et al., 2013). Although piperine or black pepper has been extensively investigated and used to supplement diets for chicken or pigs, black pepper-extracted byproducts (BEB) have not been utilized as a feed supplement so far and their impact on health, growth performance, and milk production in animals including dairy goats has not been investigated (Al-Kassie et al., 2011; Ndelekwute et al., 2015; Melo et al., 2016; Sampath et al., 2020).

Therefore, it is necessary to determine the effects of BEB on animal health before utilizing it in ruminants as a feed additive. The objective of this study was to investigate the effects of diet supplementation with BEB on blood hematology and chemistry parameters, milk yield, milk composition, and growth performance in Saanen dairy goats. In particular, the health status of all dairy goats was closely monitored, and blood and milk samples were taken every fifteen days for laboratory analysis.

Materials and Methods

Study design and animal management

The experimental protocols were approved by the Committee on Animal Research and Ethics at the Prince of Songkla University, Thailand and follow the Ethical Principle and Guidelines for the Use of Animals (approval number 33/2021). This study was performed at the Animal Production Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University. Six Thai-Saanen crossbreed female goats used. The dairy goats were on average 2 years old and had an average initial weight of 34.83 ± 1.94 kg. Prior to the study, all goats were examined and dewormed with an anthelmintic drug (1% ivermectin). All goats were randomly allocated

Table1 Feed ingredients of the basal and supplemented diets.

Components	Diet (%)	
	CON	10%BEB
Maize meal	58	49
Soybean meal	31	30
Molasses	10	10
Mineral and vitamin premix	1	1
Black pepper -extracted byproduct (BEB)	-	10
Total	100	100

10%BEB: supplemented diet with 10% black pepper-extracted byproduct; CON: control diet

to a pen, which had a size of 1.0 × 1.0 m, throughout the 45 days of the experiment.

Experimental diets and feed sampling

The control group was fed a basal diet, whereas dairy goats of the experimental group consumed the basal diet supplemented with 10% BEB contributed by Faculty of Medicine, Prince of Songkla University. The diet contents are presented in Table 1. Additionally to the diets, Pangola grass hay and water were provided to feed ad libitum. The diets were regularly collected and pooled for proximate analysis. The nutritional composition of diets consisted of dry matter, crude proteins, crude fiber, fats, organic matter, ash, acid detergent fiber, acid detergent lignin, neutral detergent fiber, and nitrogen free extract as displayed in Table 2.

Milk collection and analysis

To evaluate the effect of diet supplementation with BEB, the production and chemical composition of milk were determined throughout the experiment. Goats were manually milked twice a day, 8 a.m. and 6 p.m. Milk volume was measured every day. For the analysis of the chemical, fat, total protein, lactose, solid not fat and total solid composition of milk, a sample of 30 mL milk was collected on the first and last days of the study and was evaluated using a Lactostar milk analyzer. Additionally, the cholesterol concentration in dairy goat milk was determined by gas chromatography after extracting it from 5 g of milk sample.

Blood collection and analysis

The dairy goats were restrained to collect 5 mL of blood from the jugular vein. Part of the blood was collected in EDTA- sterile tubes for hematology analysis and another part was transferred into EDTA free tubes for biochemical analysis. All tubes were initially labeled with the animal number, kept in a cooler bag, and brought for analysis at the Clinic Hatyai Laboratory. The hematological profile was analyzed using an automatic blood analyzer machine, and consisted of red blood cells (RBCs), hemoglobin (HGB), hematocrit (HCT),

Table 2 Chemical composition of the basal and supplemented diets.

Nutrient composition, % DM	CON	10%BEB
Dry matter	92.14	91.01
Crude proteins	20.84	20.36
Crude fiber	3.7	4.75
Fats	2.79	2.48
Organic matter	96.31	95.56
Ash	3.69	4.45
Acid detergent fiber	6.63	8.10
Acid detergent lignin	1.40	3.88
Neutral detergent fiber	18.33	21.97
Nitrogen free extract	63.74	62.37

10%BEB*:* supplemented diet with 10% black pepper-extracted byproduct; CON*:* control diet; DM*:* dry matter.

mean corpuscular volume *(*MCV*)*, mean corpuscular hemoglobin *(*MCH*)*, and mean corpuscular hemoglobin concentration *(*MCHC*)*, white blood cells *(*WBCs*)*, lymphocytes, monocytes, and granulocytes*.* The characteristics of the serum from all dairy goats were determined using automatic chemistry analyzer*.* Specifically, the levels of biochemical metabolites including blood urea nitrogen, total protein, albumin, globulin and serum glutamate pyruvate transaminase were analyzed every 15 days, whereas blood lipid, cholesterol, high density lipoprotein, low density lipoprotein, and triglyceride levels were determined on the initial and final of the study.

Statistical analysis

GraphPad Prism software was used to statistically analyze the experimental data. Analyses of growth performance and milk production were performed using an unpaired t-test. The effect of treatment, sampling time and treatment × time interaction on blood lipid levels, hematological and serum biochemical profiles were analyzed using a two-way analysis of variance (ANOVA) and followed by Tukey's multiple comparison post hoc test. Statistical significance was considered for $P < 0.05$.

Results

Body weight and feed intake of all dairy goats were measured and are presented in Table 3. The experimental diets did not affect the dry matter intake, total weight gain, and initial and final body weights.

Milk yield and composition were also analyzed and are presented in Table 4. The milk quality, yield and composition of dairy goats given BEB supplementation were similar those of the control group.

The serum lipid profiles are shown in Table 5. To elucidate the effects of BEB

Table 3 Effect of the diet on the growth performance of dairy goats.

Parameters	CON	10%BEB	SEM	P-value
Initial weight, *(kg)*	34.00 ± 2.18	35.67 ± 1.61	1.563	0.347
Final weight, *(kg)*	36.00 ± 1.00	36.67 ± 0.58	0.667	0.374
Total weight gain, *(kg)*	2.33 ± 3.82	2.67 ± 2.75	2.718	0.908
Dry matter intake, *(g/day)*	690.48 ± 42.87	747.62 ± 34.24	31.670	0.146

10%BEB*:* supplemented diet with 10% black pepper-extracted byproduct; CON*:* control diet; SEM*:* standard error of the mean. Different between means were considered significantly for P ≤ 0.05.

Table 4 Effect of the diet on milk yield and composition of dairy goats.

Milk yield parameters	Treatment		SEM	P-value
Milk yield, *(kg/day)*	CON	1.05 ± 0.37	0.339	0.395
	10%BEB	0.73 ± 0.46		
Fat, *(%)*	CON	3.53 ± 0.67	0.484	0.655
	10%BEB	3.77 ± 0.51		
Protein, *(%)*	CON	3.15 ± 0.21	0.140	0.876
	10%BEB	3.12 ± 0.12		
Lactose, *(%)*	CON	4.64 ± 0.33	0.220	0.831
	10%BEB	4.59 ± 0.18		
Solid not fat, *(%)*	CON	8.70 ± 0.51	0.343	0.942
	10%BEB	8.68 ± 0.30		
Total solid, *(%)*	CON	12.24 ± 1.16	0.754	0.798
	10%BEB	12.44 ± 0.61		
Cholesterol *(mg/100 g)*	CON	13.32 ± 1.24	0.735	0.126
	10%BEB	11.90 ± 0.30		
Specific gravity	CON	1.03 ± 0	0.005	0.519
	10%BEB	1.03 ± 0		
Freezing point, *(°C)*	CON	-0.58 ± 0.10	0.023	0.431
	10%BEB	-0.60 ± 0.04		

10%BEB*:* supplemented diet with 10% black pepper-extracted byproduct; CON*:* control diet; SEM*:* standard error of the mean. Different between means were considered significantly for P ≤ 0.05.

Table 5 Effect of the diet on blood lipid concentrations in dairy goats.

Parameters	CON		10%BEB		P-value		
	0 day	45 days	0 day	45 days	T	S	TxS
CHO, *(mg/dL)*	82.67±12.50	89.00±20.66	78.33±24.79	77.33±10.60	0.466	0.805	0.735
HDL, *(mg/dL)*	54.33±6.66	59.00±15.59	54.00±19.16	56.33±7.64	0.850	0.662	0.883
LDL, *(mg/dL)*	30.13±7.32	34.30±7.33	29.13±7.22	26.97±2.19	0.293	0.794	0.417
TG, *(mg/dL)*	13.67±3.79	13.67±6.43	16.33±10.21	19.33±8.14	0.365	0.739	0.739

10%BEB: supplemented diet with 10% black pepper-extracted byproduct; CHO: cholesterol; CON: control diet; S: sampling time; HDL: high density lipoprotein; LDL: low density lipoprotein; T: Treatment; TG: triglyceride. Different were considered significantly for P $\leq$ *0.05*.

components, the concentration of lipids in the blood was measured. Blood lipid profiles of goats given or not BEB supplementation were not influenced by the diets and sampling time.

The hematological profiles of six dairy goats were analyzed and the mean values are presented in Table 6. The interaction of the diet and sampling time did not significantly affect the RBC parameters. Some RBC parameters, i.e., HGB, HCT, MCV, and MCH, were influenced by the treatment as the value were lower than those measured in the control group. Moreover, the interaction of the experimental diet and sampling time did not significantly alter the WBC parameters. However, the treatment impacted the WBC and eosinophil counts that were higher in dairy goats fed BEB supplementation.

The biochemical profiles are shown in Table 7. The serum biochemical parameters were not affected by the interaction between the diet and sampling time except for albumin and SGPT levels. Albumin levels were different according to the sampling time, whereas the diet supplementation significantly decreased SGPT concentration. Additionally, dairy goats fed BEB had the highest albumin levels at the initial time.

Discussion

In small ruminants, fermentation digestion depends on the activity of rumen microorganisms that break plant fibers and other component down. (Martin et al., 2021). Thus, an alteration of rumen microorganisms not only influences the breakdown of fibers but also the growth prospects, and milk production in small ruminants (Correddu et al., 2020).

Growth performance

The use of BEB to supplement the diet of dairy goats has not been investigated although several studies have shown the effects of black pepper supplementation on livestock animals, particularly pigs and chickens (Abou-Elkhair et al., 2014; Ndelekwute et al., 2015; Yang et al., 2019; Sampath et al., 2020). Whether incorporating BEB changes the feed taste and acceptance in dairy goats is unknown. The

Table 6 Effect of the diet on hematological parameters of dairy goats.

Parameters	Sampling time				P-value		
	0 day	15 days	30 days	45 days	T	S	T × S
RBC, *(10^6/μL)*							
CON	3.26 ± 0.80	3.09 ± 0.90	3.18 ± 0.67	3.08 ± 0.92	0.955	0.919	0.940
10%BEB	3.31 ± 0.78	3.27 ± 0.45	2.88 ± 0.38	3.10 ± 0.20			
HGB, *(g/dL)*							
CON	9.70 ± 0.40	9.43 ± 0.93	10.20 ± 0.85	9.90 ± 0.98	0.026	0.960	0.898
10%BEB	8.77 ± 2.18	8.63 ± 1.27	8.47 ± 0.93	8.80 ± 0.70			
HCT, *(%)*							
CON	25.67 ± 0.58	25.67 ± 2.08	27.00 ± 2.00	27.00 ± 2.65	0.037	0.863	0.898
10%BEB	23.67 ± 6.11	23.33 ± 3.21	22.67 ± 2.08	24.67 ± 1.53			
MCV, *(fL)*							
CON	81.43 ± 17.23	86.23 ± 17.04	86.63 ± 12.81	91.00 ± 17.90	0.036	0.562	0.961
10%BEB	71.20 ± 2.72	71.43 ± 0.95	79.03 ± 4.57	79.67 ± 0.67			
MCH, *(pg)*							
CON	30.67 ± 5.86	31.60 ± 5.63	32.70 ± 4.45	33.33 ± 6.40	0.017	0.618	0.975
10%BEB	26.40 ± 0.70	26.43 ±1.20	29.50 ± 1.65	28.40 ± 0.44			
MCHC, *(g/dL)*							
CON	37.77 ± 0.90	36.73 ± 0.75	37.73 ± 0.42	36.67 ± 0.25	0.141	0.025	0.553
10%BEB	37.10 ± 0.44	36.97 ± 1.25	37.27 ± 0.70	35.67 ± 0.81			
White blood cells, *(10^3/μL)*							
CON	6.14 ± 1.37	6.21 ± 1.26	6.41 ± 1.46	6.53 ± 1.19	0.034	0.898	0.921
10%BEB	9.40 ± 2.74	8.43 ± 2.89	8.01 ± 2.73	10.12 ± 5.72			
PMN, *(%)*							
CON	46.67 ± 10.79	42.00 ± 15.62	36.67 ± 7.23	40.67 ± 8.39	0.406	0.518	0.995
10%BEB	43.67 ± 16.44	36.00 ± 14.73	33.67 ± 6.03	36.67 ± 6.81			
Lymphocytes, *(%)*							
CON	49.33 ± 11.72	54.67 ± 14.22	61.00 ± 9.54	56.33 ± 8.39	0.957	0.366	0.965
10%BEB	49.00 ± 16.52	57.67 ± 12.86	61.00 ± 7.94	52.67 ± 2.89			
Monocytes, *(%)*							
CON	2.00 ± 1.00	2.67 ± 0.58	1.33 ± 0.58	1.33 ± 0.58	0.396	0.768	0.053
10%BEB	2.67 ± 1.53	1.00 ± 0	2.33 ± 0.58	2.67 ± 1.53			
Eosinophils. *(%)*							
CON	2.00 ± 1.00	0.67 ± 1.15	1.00 ± 1.73	1.67 ± 1.15	0.003	0.373	0.520
10%BEB	4.67 ± 3.06	5.33 ± 2.52	3.00 ± 3.00	8.00 ± 5.29			
NLR							
CON	1.03 ± 0.53	0.85 ± 0.44	0.63 ± 0.22	0.75 ± 0.24	0.679	0.313	0.989
10%BEB	1.02 ± 0.58	0.69 ± 0.47	0.57 ± 0.18	0.70 ± 0.16			

10%BEB*:* supplemented diet with 10% black pepper-extracted byproduct; CON*:* control diet; T = treatment; S*:* sampling time; RBC*:* red blood cells; HGB*:* hemoglobin; HCT*:* hematocrit; MCV*:* mean corpuscular volume; MCH*:* mean corpuscular hemoglobin; MCHC*:* mean corpuscular hemoglobin concentration; PMN*:* polymorphonuclear leukocytes; NLR*:* neutrophil to lymphocyte ratio. Different were considered significant for $P \leq 0.05$.

Table 7 Effect of the diet on biochemical parameters of all dairy goats.

Parameters	Sampling time			P-value		
	15 days	30 days	45 days	T	S	T × S
BUN, *(mg%)*						
CON	19.92 ± 4.59	26.25 ± 3.58	21.88 ± 3.21	0.329	0.116	0.606
10%BEB	19.68 ± 2.15	22.29 ± 1.32	21.15 ± 4.48			
TP, *(g%)*						
CON	6.59 ± 0.44	6.47 ± 0.22	6.09 ± 0.28	0.269	0.084	0.782
10%BEB	6.94 ± 0.59	6.51 ± 0.37	6.33 ± 0.33			
Albumin, *(g%)*						
CON	3.78 ± 0.10^{ab}	3.63 ± 0.08^{b}	3.76 ± 0.08^{ab}	0.912	0.002	0.292
10%BEB	3.88 ± 0.06^{a}	3.58 ± 0.09^{b}	3.73 ± 0.09^{ab}			
Globulin, *(g%)*						
CON	2.81 ± 0.33	2.83 ± 0.18	2.33 ± 0.22	0.211	0.061	0.862
10%BEB	3.07 ± 0.53	2.92 ± 0.30	2.61 ± 0.33			
SGPT, *(unit/L)*						
CON	20.33 ± 1.53	18.00 ± 2.00	19.33 ± 0.58	0.026	0.889	0.523
10%BEB	9.33 ± 11.85	15.00 ± 4.00	12.00 ± 6.93			

Note: ^{a,b} indicates the significant different mean in various time point *(P < 0.05)*, 10%BEB: supplemented diet with 10% black pepper-extracted byproduct; CON: control diet; T: treatment; S; sampling time; BUN: blood urea nitrogen; TP: total protein; SGPT: serum glutamate pyruvate transaminase.

amount of BEB *(10%)* provided to the diet was the same as that utilized previously to investigate the effects of other byproduct supplementation in dairy goats. For instance, spent coffee grounds *(10%)* were shown to be indeed an uncommon byproduct in livestock diets and the effects of using them as dietary supplementation on sheep growth and digestibility have been investigated *(*Choi et al., 2018*)*.

In the present study, diet supplementation with 10% BEB did not impact the body weight gain and dry matter consumption of dairy goats. BEB is regarded a residual waste product following the extraction of essential components from black peppers. According to previous reports, the industrial byproduct contain significant amounts of polyphenols, phenolic acids, flavonoids, and tannins, which can diminish feed intake, palatability, and rumen microbial activity in small ruminant animals *(*Correddu et al., *2020).* Dry tomato pomace, dry grape marc, and exhausted myrtle berries have a detrimental impact on sheep's feed consumption if included in the diet *(*Nudda et al., 2019*).* Contrarily, the incorporation of polyphenols and olive mill wastewaters *(3.2* mg/day) into the diet had no impact on the growth performance, body weight gain, or dry matter intake of weaned dairy goat offsprings (Cimmino et al., 2018). Additionally, pomegranate seed pulp supplementation had a positive influence on the average daily weight gain and dry matter intake of dairy goats (Modaresi et al., 2011). The amount of dry matter intake and body weight gain of dairy goats are also not influenced by the incorporation of 10% spent coffee grounds into the diet (Carta et al., 2022). Moreover, a higher average daily weight gain was reported in dairy sheep fed a diet containing grape seed extract (7.4%); however lamb and dairy goat growths is undisturbed by the inclusion of grape seed extract (5.6%) to the diet (Giller et al., 2021).

Goats are categorized as small ruminants, capable of generating salivary proteins, e.g., proline-rich proteins, which bind tannins to impede protein digestion in the rumen (Lamy et al., *2011*; Correddu et al., *2020).* The data from several studies demonstrated that tannins have a detrimental impact on the rumen bacteria, which are essential for fermentative digestion (Lamy et al., 2011; Tseu et al., 2020; Giller et al., 2021).

Ruminants have particular physiological mechanisms that can lessen or prevent the action of tannins in their diet. One of the key mechanisms for diminishing the activity of tannins in the diet is the saliva of small ruminants. Proline-rich proteins are found in the saliva of humans, cattle, sheep, and goats, different concentrations. Low levels of proline-rich proteins were reported in human and sheep compared with those found in goat (Lamy et al., 2011). Thus, the supplementation of the diet with byproducts consisting of polyphenols decreases health performance in sheep more than those in goat (Correddu et al., 2020). Since proline-rich proteins have an important role in suppressing the action of tannins present in the diet, protein-tannin complexes are non-functional, and, consequently, protein digestion and dry matter intake are improved (Lamy et al., *2011).* Moreover, a relationship between the concentration of phenols in the diet and dry matter intake in sheep and goats has been reported. High levels of phenols in the diet contribute to decreasing dry matter intake of sheep, whereas the fluctuation of phenols in the diet does not affect the dry matter intake in goats (Correddu et al., 2020).

Milk yield and composition

Giving dairy goats feed supplemented with BEB did not influence milk production and composition throughout the experimental period. The presence of polyphenols in the byproducts has a negligible impact on the quantity and quality of milk produced by small ruminants including sheep and goats (Correddu et al., 2020). Exhausted myrtle berries, extruded linseed, and grape seeds have been used to supplement dairy ewes' diets, and the byproduct had no effect on the quantity or quality of milk produced (Nudda et al., 2015; Nudda et al., 2017). Similarly, pomegranate seed pulp introduced to the diet had no consequence on the milk yield or composition in dairy goats, except for the milk fat content (Modaresi et al., 2011). According to research on the link between milk production and polyphenol consumption in sheep, goats, and other small ruminants, high concentrations of polyphenols can impede milk synthesis. In contrast, small ruminants fed low amounts of polyphenols tended to yield more milk (Correddu et al., 2020).

Hematological and biochemical profiles

Hematological and biochemistry profiles were considered for analyzing the impact of BEB on the immune response in dairy goats. Although the values obtained for some parameters, including RBC, HGB, HCT, MCV, and MCH, were significantly lower in the goats fed with the supplemented diet, they remained within the normal ranges (Aiello and Moses, 2022). In the present study, the supplemented diet did not affect hematological parameters since there was no difference between the values measured on day 45 and day 0. The animals were healthy without anemia or abnormal RBC synthesis. The normal range of HGB in RBCs was associated with normal amounts of iron and vitamin B12, which are essential for erythropoiesis (Soul et al., 2019).

The supplemented diet did also not influence biochemical parameters. The values for these parameters were within the reference interval. SGPT is a liver enzyme typically used to determine the function of the liver (Otter, 2013). In serum derived from goats, given the BEB supplementation, SGPT levels on day 45 were similar to those measured on day 0. Moreover, the goats fed with the basal diet had higher initial SGPT levels.

Conclusion

The supplementation with 10% BEB of the dairy goat diet did not influence growth performance, milk production, and hematological profiles. No dairy goat showed signs of clinical problems in the present study; however, milk yield derived from the goats fed BEB tended to be low. Although this byproduct is not commonly used to feed ruminants such as goats since it is a local byproduct from the extractive industry, it might be safe to use up to 10% BEB to feed dairy goats. The present study is a pilot study that provides hopeful basic information prior to considering using of BEB in dairy goats or ruminants. Indeed, the best way to reduce agricultural and industrial waste products might be to use them as feed additives in ruminants.

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