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The Effect of Pistachio Shell, Pomegranate Hull, and Olive Pulp Feeding on Milk Yield, Milk Quality, and Some Biochemical Blood Parameters in Sheep

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Abstract: This study was carried out to determine the effect of different industrial by-products (pistachio, pomegranate, and olive) as alternative feed sources for sheep. Fifty-two Awassi sheep aged 3 and 4 years were divided into four groups (n=13 per group) concerning age, birth type, milk yield, and lactation period: basal diet without byproducts (CON) and basal diet added with either pistachio shell (PIS), pomegranate hull (POM), or olive pulp (OP). By-products were mixed with the total ration at a rate of 5% and given in the morning and evening feedings. The feeding experiment was continued for 60 days. Milk yield, milk quality, feed consumption, and biochemical parameters such as urea, creatine, triglyceride, total bilirubin, and albumin were determined at 30-day intervals from the beginning of the study. Tukey multiple comparison test was used to compare the research groups. There was no treatment effect on feed consumption. The highest milk yield was measured in sheep fed the POM diet in all periods (the first, second, and third-period means were 1143±111, 967±127, and 785±112 gr, respectively). Milk yield for other groups was similar. At the end of the study, the fat ratio in the CON, PIS, POM, and OP groups were determined to be 6.11±0.30%, 6.25±0.36%, 5.61±0.42%, and 5.97±0.48%, respectively. Protein values were determined as 6.34±0.16%, 6.26%±0.27%, 6.06%±0.23%, and 6.39±0.19% in the same order. There was no statistically significant difference between CON, PIS, POM, and OP groups regarding biochemical parameters. In conclusion, sheep ration can contain PIS, POM, and OP up to 5% as alternative feed sources.
Keywords: *Food waste, Olive pulp, Pistachio shell, Pomegranate hull, Sheep milk quality.*

Koyunlarda Fıstık Kabuğu, Nar Kabuğu ve Zeytin Pirinası ile Beslemenin Süt Verimi, Süt Kalitesi ve Bazı Kan Biyokimyasal Parametreleri Üzerine Etkisi

Özet: Bu çalışma, farklı endüstriyel yan ürünlerin (fıstık, nar ve zeytin) koyunlarda alternatif yem kaynakları olarak etkisini belirlemek amacıyla yapılmıştır. Araştırmada 3 ve 4 yaşlı 52 baş (her grup için n=13) İvesi ırkı koyun ilave yan ürün içermeyen bazal diyet (CON), fıstık kabuğu (PIS), nar kabuğu (POM) ve zeytin pirinası (OP) içeren rasyonlarla beslendi. Yan ürünler toplam rasyona %5 oranında karıştırılarak sabah ve akşam yemlemesinde verilmiştir. Yem denemesine 60 gün boyunca devam edilmiştir. Süt verimi, süt kalitesi, yem tüketimi ve üre, kreatin, trigliserit, total bilirubin, albümin gibi biyokimyasal parametreler çalışmanın başlangıcından itibaren 30 günlük aralıklarla belirlenmiştir. Araştırma gruplarının karşılaştırılmasında Tukey çoklu karşılaştırma testi kullanılmıştır. Yem tüketimi bakımından gruplar arasında önemli bir farklılık oluşmamıştır. Süt verimi bakımından en yüksek değerler POM grubunda tespit edilmiştir (birinci, ikinci ve üçüncü periyotta sırasıyla 1143±111, 967±127 ve 785±112 gr). Süt verimi bakımından gruplarda birbirine benzer değerler saptanmıştır. Çalışma sonunda CON, PIS, POM ve OP gruplarındaki yağ oranı sırasıyla %6.11±0.30, %6.25±0.36, %5.61±0.42 ve %5.97±0.48 olarak belirlendi. Protein değerleri aynı sırayla %6.34±0.16, %6.26±0.27, %6.06±0.23 ve %6.39±0.19 olarak belirlendi. Biyokimyasal parametreler bakımından CON, PIS, POM ve OP grupları arasında istatistiksel olarak anlamlı bir fark bulunmadı. Sonuç olarak, koyun rasyonları alternatif yem kaynakları olarak %5'e kadar PIS, POM ve OP içerebilir.
Anahtar Kelimeler: *Fıstık kabuğu, Gıda atığı, Koyun süt kalitesi, Nar kabuğu, Zeytin pirinası.*

Introduction

Milk yield and composition in sheep are mainly determined by various factors, such as sheep breed, lactation stage, milking system, and feeding (Inostroza et al., 2020). Nutrition level, which refers

to energy or feed intake level, is the main factor affecting milk yield and quality in sheep (Tzamaloukas et al., 2021). There is a positive relationship between milk yield and feed consumption (Kaufman et al., 2018). A balance must be maintained between the applications that would increase milk yield and reduce its content, which can be achieved by the optimal selection, ration, and herd management (Caja and Bocquier, 2000).

The rapid growth of the world population and the rise in living standards necessitate the large-scale production of high-quality animal-derived nutrients (Xie and Xu, 2019). In addition to improving the care and feeding of animals and their genetic structure, it is essential to identify products with the potential to be used as feed additives (Reda et al., 2021).

Olive, pomegranate, and pistachio production in the Southeast Anatolia region of Turkey is increasing every year. According to TUIK statistics, 240,000 tons of pistachios were produced in Turkey in 2018 (TUIK, 2018). According to the Ministry of Agriculture statistics, 52% of Turkey's pistachio production takes place in Şanlıurfa, which corresponds to approximately 70,000 tons, but when the average of the last five years is considered, the annual production is 38-42,000 tons (TUIK, 2015). The hull accounts for approximately 48% of the total weight of the pomegranate produced in this region, whereas the fruit, which is the edible part, accounts for 52%. Pomegranate hull is more valuable than its juice in ruminant feed (Sarıca, 2011), and feeds such as pomegranate hull will be considered as an alternative supplement if animal feeding becomes difficult and feed sources become scarce. The number of olive trees in the Şanlıurfa province is increasing gradually. According to the 2018 data, 4,599 tons of olives from 1,585,994 trees were used for olive oil production, of which 70%-80% were olive pulp (TUIK, 2018). Raising awareness for transforming of these valuable plant parts, which are currently treated as agricultural waste, into products that will contribute to the country's economy is a current issue. In Turkey, the roughage problem appears from time to time during dry climatic periods. Therefore, it is necessary to determine the possibilities of using alternative products to wheat straw in animal production.

This study aimed to determine the possibility of using agricultural wastes obtained from pistachio, pomegranate, and olive fruits, which are widely produced in agricultural activities in the Southeastern Anatolia region, as a source of roughage for sheep. In addition, the effects of soft pistachio shell, pomegranate hull, and olive pulp on animal products and animal health were evaluated comparatively.

Materials and Methods

Animals: Fifty-two sheep of the Awassi breed aged 3 and 4 years that gave birth at least twice were used as animal material. All the sheep used in the study gave birth to a singleton lamb. The average live weight of sheep in CON (Control), PIS (Pistachio shell), POM (Pomegranate hull), and OP (Olive pulp) groups are 64.28±2.17, 63.89±1.48, 63.78±2.72, and 64.17±1.69 kg, respectively. The sheep used in the study were generally on the 75th day of lactation (days in milk: 75.25±1.06). They were divided into four groups (CON, PIS, POM, and OP) concerning age, birth type, milk yield, and lactation period. The lambs were separated from their mothers and fed by hand in the evening before the control days. The study was approved by the Harran University Animal Experiments Local Ethics Committee with Decision No. 2021-001/01.

Rations: Soft pistachio shell, pomegranate hull, and olive pulp used in the study were dried in a closed environment and ground in a feed mill machine. It was added to the daily ration and given to the sheep divided into four groups. The rations issued to sheep during the study included (1) a control diet without additional byproducts (CON), (2) PIS, (3) POM, and (4) OP. The rate of by-products to be included in the diet was 5 percent. A two-week feed habituation period was applied to the sheep. Feed consumption for groups was calculated as total mixed ration consumption. The entire ration was given to the sheep in two meals, at 6:00 a.m. and 6:00 p.m. The remaining amounts of feed were collected, weighed, and recorded daily before evening feeding. During the study, animals were provided with water and feed *ad libutum*. Table 1 shows the raw nutrient contents of POM, PIS, and OP used in the study, and Table 2 shows the contents of their rations and nutritional compositions.

Milk Yield: Milking was performed twice with a machine (Portable Milking System-Sezer, Turkey) at 08:00 a.m. and 08:00 p.m., and the milk amount was designated with a scale sensitive to 1 g (Yakan, 2012). The vacuum pressure of the milking machines was set to 40 kPa, the pulse rate to 120, and the pulsation ratio to 60:40. Before and after machine milking, routine practices related to milking hygiene were carried out. Milking of the control group to determine milk yield was done every 15 days from the beginning of lactation to the peak of lactation and every 30 days after the peak of lactation. With the help of interpolation from the data obtained on the control days, the daily milk yields of each sheep on days 15, 30, 45, 60, and 75 were determined. According to the data obtained, four homogeneous groups (CON, n = 13; PIS, n = 13; POM, n = 13; OP, n = 13) were formed, and the feeding trial continued

Table 1. Raw nutrient contents of Pistachio shell, Pomegranate hull, Olive pulp and Wheat straw used in the research.

Items	Pomegranate Hull	Pistachio Shell	Olive Pulp	Wheat Straw
DM (%)	81.39	76.07	31.07	92.01
CA (%)	5.51	7.07	5.10	8.04
CP (%)	3.64	6.44	6.81	3.95
CO (%)	9.75	8.78	5.96	1.22
ADF (%)	47.82	34.11	51.37	50.68
NDF (%)	56.33	36.89	69.10	79.81
ME Mcal/kg (DM)	2100	2000	2150	1025
N (mg/100g)	0.58	1.67	1.09	7.01
C (mg/100g)	42.40	44.37	46.03	0.14
H (mg/100g)	5.22	5.65	6.58	0.00
S (mg/100g)	0.00	0.00	4.86	1.5

DM: Dry Matter, CA: Crude Ash, CP: Crude Protein, CO: Crude Oil, ADF: Acid Detergent Fiber, NDF: Neutral Detergent Fiber, ME: Metabolic Energy, N: Nitrogen, C: Carbon, H: Hydrogen, S: Sulfur.

Table 2. Contents and nutrient compositions of the rations used in the research.

Items	Diets (%)			
Feed [(g/kg) DM]	**CON**	**POM**	**PIS**	**OP**
Concentrated Feed	62	61	63	66
Alfalfa	33	34	32	29
Wheat Straw	5	-	-	-
Pomegranate Hull	-	5	-	-
Pistachio Shell	-	-	5	-
Olive Pulp	-	-	-	5
Total	100	100	100	100
	Analyzed Values (%)			
DM	94.75	94.59	94.07	92.14
CP	15.51	15.61	15.76	15.52
CS	22.67	22.04	22.93	21.00
CO	5.60	5.68	5.93	5.87
ME (Mcal/kg DM)	2253.76	2285.29	2280.32	2259.16

CON: Conrol, POM: Pomegranate Hull, PIS: Pistachio Shell, OP: Olive Pulp, Concentrated Feed: CP: %18, CS: %10, Ash: %10, CO: %3, Phosphorus: %0.5, Sodium: % 0.2, Vitamine A (IU/Kg): 5000, Vitamine D3 (IU/Kg): 700, Vitamine E (IU/Kg): 30 mg:, DM: Dry Matter, CP: Crude Protein, CS: Crude Cellulose, CO: Crude Oil, ME: Metabolic Energy.

Table 3. Milk yield and milk quality characteristics in sheep during the research period (n=13 for each group).

Traits	Period	Diets (X±SEM)				P Value
		CON	PIS	POM	OP	
Milk Yield (g/d)	1	1140±94	1145±99	1143±111	1142±137	0.99
	2	858±122	941±121	967±127	801±108	0.75
	3	748±102	764±134	785±112	631±146	0.82
Daily Feed Intake (g/d)	1	2.43±0.07	2.58±0.11	2.52±0.11	2.48 ±0.07	-
	2	2.48±0.03	2.56±0.05	2.54±0.05	2.51 ±0.03	-
	3	2.50±0.01	2.53±0.01	2.60±0.01	2.54 ±0.01	-
Fat (%)	1	4.75±0.20	4.56±0.25	4.67±0.30	4.73±0.17	0.94
	2	6.70±0.18	6.86±0.45	6.06±0.33	6.44±0.32	0.36
	3	6.11±0.30	6.25±0.36	5.61±0.42	5.97±0.48	0.72
Protein (%)	1	5.35±0.12	5.21±0.09	5.15±0.15	5.39±0.13	0.53
	2	6.38±0.21	6.23±0.21	6.04±0.24	6.32±0.17	0.70
	3	6.34±0.16	6.26±0.27	6.06±0.23	6.39±0.19	0.73
Lactose (%)	1	5.10±0.07	5.23±0.06	5.23±0.04	5.01±0.07	0.05
	2	4.54±0.16	4.36±0.18	4.70±0.11	4.31±0.18	0.34
	3	4.41±0.21	4.44±0.16	4.50±0.10	4.02±0.31	0.38
Dry Matter (%)	1	16.2±0.2	16.1±0.3	16.1±0.3	16.2±0.3	0.96
	2	18.7±0.2	18.5±0.7	17.9±0.5	18.1±0.5	0.70
	3	17.9±0.5	18.9±0.5	17.2±0.6	17.4±0.8	0.75
Fat Free Dry Matter (%)	1	11.4±0.1	11.4±0.1	11.4±0.2	11.4±0.2	0.97
	2	11.9±0.1	11.6±0.3	11.7±0.2	11.6±0.2	0.75
	3	11.7±0.2	11.7±0.2	11.5±0.3	11.3±0.4	0.76
Urea	1	16.2±1.1	12.9±1.6	16.6±1.3	16.1±1.9	0.30
	2	23.6±0.9	23.6±2.0	21.6±1.3	23.9±1.9	0.73
	3	22.0±1.2	23.1±2.7	20.8±1.3	20.9±2.4	0.83
Somatic Cell Count x10^3 Cell/ml	1	317±59	324±57	319±66	323±84	1.00
	2	506±91	565±127	434±63	473±108	0.81
	3	560±93	602±129	478±65	554±128	0.87
pH	1	5.79±0.02	5.75±0.03	5.79±0.01	5.74±0.02	0.44
	2	5.80±0.03	5.89±0.05	5.89±0.04	5.97±0.06	0.13
	3	5.86±0.04	5.88±0.04	5.91±0.04	6.01±0.08	0.21
L*	1	72.0±0.5	71.9±0.4	70.9±0.8	72.4±0.5	0.24
	2	72.7±0.3	72.3±0.5	71.8±0.6	73.3±0.4	0.18
	3	73.4±0.2	73.1±0.4	72.9±0.4	72.9±0.5	0.79
a*	1	-8.63±0.14	-8.85±0.16	-8.98±0.18	-8.29±0.22	0.05
	2	-8.25±0.15	-8.00±0.25	-8.25±0.27	-7.79±0.19	0.42
	3	-7.76±0.17	-7.38±0.21	-7.40±0.13	-7.29±0.15	0.23
b*	1	5.11±0.23	4.49±0.32	4.79±0.39	5.66±0.22	0.05
	2	5.47±0.14	5.08±0.40	5.56±0.48	6.01±0.36	0.38
	3	5.76±0.22	5.58±0.24	6.02±0.40	5.99±0.36	0.74

-: Statistical analysis was not applied because of group feeding. CON: Control, PIS: Pistachio Shell, POM: Pomegranate Hull, OP: Olive Pulp, 1: 1st Period, 2: 2nd Period, 3: 3rd Period.

Table 4. Biochemical parameters determined in sheep during the research period (n=13 for each group).

Parameters	Period	Diets (X±SEM)				P Value
		CON	PIS	POM	OP	
Urea (mg/dL)	1	27.7±2.3	27.1±4.1	28.4±2.1	28.4±1.6	0.98
	2	38.5±1.6	42.6±4.2	41.1±2.2	44.5±3.5	0.56
	3	37.5±2.1	41.8±5.8	40.7±2.5	44.2±4.9	0.72
Creatinine (mg/dL)	1	0.550±0.010	0.610±0.040	0.560±0.010	0.620±0.060	0.54
	2	0.590±0.010	0.670±0.070	0.590±0.010	0.620±0.040	0.51
	3	0.650±0.010	0.770±0.090	0.640±0.010	0.690±0.040	0.34
Triglyceride (mg/dL)	1	20.5±1.7	23.2±0.6	21.2±1.5	20.9±1.4	0.52
	2	13.2±0.9	15.2± 0.8	14.2±1.3	17.9±3.3	0.33
	3	13.6±1.0	13.8±1.6	13.9±1.4	17.0±2.9	0.52
Total protein (g/dL)	1	7.43±0.13	7.04±0.15	7.33±0.14	7.50±0.18	0.48
	2	6.97±0.13	6.66±0.26	6.82±0.24	6.94±0.19	0.81
	3	7.66±0.12	7.51±0.11	7.68±0.17	7.59±0.12	0.86
Total bilirubin (g/dL)	1	0.140±0.000	0.150±0.000	0.18±0.010	0.160±0.010	0.96
	2	0.090±0.000	0.110±0.000	0.10±0.000	0.100±0.000	0.99
	3	0.050±0.000	0.050±0.000	0.04±0.000	0.030±0.000	0.86
Low density lipoprotein (mg/dL)	1	34.1±4.0	37.2±2.8	31.1±4.7	32.6±4.1	0.73
	2	26.7±1.6	22.0±1.3	25.4±2.5	22.8±1.6	0.21
	3	9.93±1.5	7.39±1.5	11.57±2.3	8.86±1.4	0.38
Lactate dehydrogenase (U/L)	1	426±16	426±16	408±18	447±20	0.69
	2	534±26	561±20	567±27	612±20	0.12
	3	577±21	618±17	592±46	587±34	0.29
Cholesterol (mg/dL)	1	58.3±2.4	61.2±3.7	62.6±3.4	65.6±3.8	0.82
	2	70.1±2.9	65.8±3.1	68.2±3.5	66.8±3.6	0.35
	3	70.2±3.0	70.7±3.1	74.2±4.4	72.8±3.9	0.35
High density lipoprotein (mg/dL)	1	51.9±3.4	52.1±3.8	51.6±2.9	53.8±3.1	0.72
	2	40.7±2.0	40.8±2.5	40.0±1.6	40.4±2.2	0.46
	3	57.6±3.0	60.5±2.9	60.6±2.7	60.5±3.2	0.40
Gamma glutamyl transferase (U/L)	1	72.5±2.7	66.2±3.4	65.3±6.1	64.8±7.8	0.77
	2	59.2±2.1	58.2±3.2	59.9±3.5	64.6±3.3	0.74
	3	56.2±2.2	57.3±2.5	60.9±3.0	61.6±2.8	0.12
Creatine kinase (mg/dL)	1	120±8.73	132±12	132±9.	130±10	0.75
	2	219±29.34	258±28	244±17	240±24	0.92
	3	303±19.79	335±32	372±40	273±23	0.59
Aspartate transaminase (U/L)	1	95.9±3.3	97.0±4.5	91.0±5.1	98.0±4.6	0.47
	2	108.8±3.4	100.4±4.5	92.8±5.5	99.8±4.8	0.14
	3	121.9±5.6	121.6±5.2	108.6±6.2	115.0±5.4	0.82
Alanine aminotransferase (U/L)	1	18.5±1.8	20.5±1.7	20.4±1.9	20.8±2.0	0.18
	2	28.7±2.2	26.2±1.7	24.2±1.8	27.5±1.4	0.72
	3	30.7±2.7	26.7±1.8	26.4±1.4	28.8±1.5	0.81
Albumine (g/dL)	1	2.26±0.05	2.30±0.06	2.34±0.04	2.34±0.07	0.47
	2	2.40±0.03	2.43±0.04	2.40±0.06	2.39±0.05	0.16
	3	2.65±0.03	2.72±0.04	2.70±0.04	2.64±0.06	0.20

CON: Control, PIS: Pistachio Shell, POM: Pomegranate Hull, OP: Olive Pulp, 1: 1st Period, 2: 2nd Period, 3: 3rd Period.

for 60 days. The beginning of the study (first period), second period, and third period corresponded to the 75th day of lactation, 105th day of lactation, and 145th day of lactation, respectively.

Milk Quality: Milk quality parameters were dry matter, fat, lactose, urea, protein contents, and the number of somatic cells in milk. Microtab II chemical tablet, which does not affect the structure of milk, was added to these samples and sent to Şanlıurfa Raw Milk Analysis Laboratory in a cold chain the next day. Milk components (dry matter, fat, lactose, protein, and urea) and somatic cell count were determined using a Combi Milk Analyzer (Bentley, USA). A pH value was determined using a portable pH meter (Metler Toledo, Spain) immediately after morning milking on control days. 25 ml of milk samples were collected during morning milking on the control days and transported in a cold chain to the Laboratory of the Department of Genetics at Harran University Faculty of Veterinary Medicine to determine the color characteristics. Each of these samples was transferred to clean and transparent petri dishes, and color characteristics were determined with a portable color device (Colour Lite, Germany) (Kahraman and Yüceer Özkul, 2020).

Biochemical Analysis: Blood samples taken from the V. jugularis of the sheep before morning feeding were centrifuged at 4000 rpm for 15 minutes. Serum was separated and stored at -20 °C until analysis. Serum samples after this procedure are sent to the analysis laboratory (Yaşamlab, Adana/Turkey) in a cold chain. Biochemical analyzes were carried out on the laboratory's Abbott - Architect Ci8200 device. Architect ci8200 is an integrated system with an autosampler to provide clinical biochemistry tests.

Statistical Analysis: The data were analyzed using Levene and Shapiro–Wilk tests for equality of variances and normality assumption (P>0.05), respectively (SPSS 24.0, SPSS Inc., NY, USA). The data (milk yield, milk quality, and biochemical parameters) were then analyzed using a General Linear Model and a Tukey HSD multiple comparison test for group mean comparisons. The data were presented as mean and standard error (X±SE). The significant level for all tests was evaluated as P<0.05.

Results

The values of milk yield, feed consumption, and milk quality characteristics determined in sheep during the study are shown in Table 3. The findings obtained from the study show the highest milk yield and feed consumption in the POM group, the highest milk fat ratio in the PIS group, and the highest protein content in the OP group. According to repeated measurements and variance analysis results, the effect of the groups on milk yield and quality was not statistically significant (P>0.05). The biochemical values determined from sheep serums are shown in Table 4. There was no statistically significant difference among the study groups in terms of biochemical values (P>0.05).

Discussion

Feed costs constitute approximately 70% of the production cost of raising livestock. In addition to increasing the amount and quality of the feed sources, using cheaper alternative feed sources are very important for economical animal breeding. Feeding is the most critical factor in determining milk yield and quality in farm animals raised for milk production (Ramírez-Rivera et al., 2019). Milk yield and content are affected by factors such as the amount and quality of roughage in the diet, roughage/concentrated feed ratio, particle size, amount and type of fat added to the ration, protein source, and carbohydrate source of the ration (Ergül et al., 2019). The present study evaluated the potential of using pistachio shells, pomegranate hull and olive pulp as alternatives to wheat straw in sheep rations. Although the highest values in terms of milk yield were detected in the POM group, similar values were found in the other groups (P>0.05). Cooper and Owen-Smith (1985) stated that feeds containing high levels of condensed tannin, such as POM, cause significant taste problems. However, at the end of the trial, it was observed that all of the adverse effects had been minimized, the performance values had approached each other, and there was no significant difference among the groups in terms of performance values, such as feed consumption and milk yield. On the other hand, adding POM to the ration at different rates can produce promising results in terms of milk yield.

Although there was no difference among the groups at the beginning of the trial and in the first month, the highest feed consumption was observed in the POM group. In contrast, the lowest feed consumption was observed in the CON group in the second month. The positive effects of POM and PIS used in the study on hay consumption are evident in Table 3. According to Villalba and Provenza (2000), if a low-quality feed is associated with a powerful nutrient, voluntary feed consumption of in sheep increases. Norouzian and Ghiasi (2012) showed in their study that the pistachio shell, which accounts for 30% of the roughage, had no adverse effects. Pistachio byproducts did not cause a significant change in performance values as well. Reed (1995) stated that POM, which contains high tannins, reduces feed consumption and protein digestibility due to its negative effect on digestion and

palatability. He also stated that high doses of the compounds in the POM could cause toxicity. In the present study, the positive effect on feed consumption and milk yield may be due to the increase in bypass protein in the rumen due to the tannin effect of the POM used in the study. In light of the data obtained, it was observed that OP, PIS, and POM added to the hay at a rate of 5% increased feed consumption, thus improving in the taste of the ration.

The highest fat content was determined in the PIS group in the second period, and the highest protein content was determined in the OP group in the third period (Table 3). The effect of diet on fat yield from sheep milk has been studied by many researchers (Angeles-Hernandez et al., 2020; Mohapatra et al., 2019). The fat content of milk increases with the addition of roughage and preserved oil used in the ration (Ergül et al., 2019). However, genetic, and nutritional interactions are influential in determining sheep milk protein. While milk protein synthesis, shaped under the control of many genetic mechanisms, is less affected by different ration practices, the nonprotein nitrogen fraction of milk is greatly affected by nutritional factors (Nudda et al., 2020). The findings obtained within the scope of the study are partially similar to this situation.

The lowest values in terms of somatic cell count (SCC) were obtained from POM and OP, and the lowest values in terms of urea amount were obtained from sheep in the PIS and POM groups (Table 3). Milk urea concentration is an indicator of protein metabolism associated with adverse effects on reproductive performance and immunity (Utama et al., 2018). At the end of the study, the SCC value tended to increase in all groups. This change in SCC value occurred under literature reports (Daş et al., 2022; Kahraman and Yüceer Özkul, 2020). Somatic cells consist of mammary epithelial cells, bacteria, and immune cells (Paschino et al., 2019). High SCC levels affect milk quality and indicate mammary gland inflammation (Podhorecká et al., 2021). The change in these parameters, which are used as primary indicators in evaluating of animal health, may be due to the bioactive components (flavonoids, polyphenols, anthocyanins, and tannins) in pistachio, pomegranate, and olive wastes. Because of these properties, PIS, POM, and OP can be recommended as measures to prevent increasing SCC values in the last period of lactation. The SCC values obtained from the study were within the acceptable range for healthy sheep milk (Daş et al., 2022; Kahraman and Yüceer Özkul, 2020).

Using pistachio byproducts at a dry matter ratio of approximately 50% in the diets of sheep does not affect blood metabolites (Ghasemi et al., 2012). Similarly, Rezaeenia et al. (2012) reported that using 15% PIS silage in the diet of early lactation dairy cows did not affect blood glucose and cholesterol. Gholizadeh et al. (2010) reported that no changes were observed in the concentration of blood metabolites (cholesterol, glucose, triglyceride, and blood urea nitrogen) in dairy cows when 10% pistachio shell was used in diets. In addition, it has been reported that the use of pistachio byproducts in the diet of sheep reduces blood urea nitrogen concentrations without affecting other blood metabolites (Ghaffari et al., 2014). Similar results have been reported for male calves in the growing period (Shakeri et al., 2013).

Oliveira et al. (2010) found that while the addition of different amounts of pomegranate extract to the ration of Holstein's calves did not affect the feed consumption and live weight gain of the calves in the first 30 days of age, the dry matter consumption and live weight gains of the calves decreased after 30 days of age in proportion to the increase in the amount of added pomegranate extract. Shabtay et al. (2008) stated that adding fresh pomegranate hull as a feed ingredient to the ration of Holstein Friesian fattening calves significantly increased feed consumption with live weight gain. Modarresi et al. (2010) reported that the addition of 6% or 12% pomegranate hull to the ration did not significantly affect the dry matter consumption and daily live weight gain of goats, but the milk yield decreased considerably with the increase in the level of pomegranate pulp added to the ration. In addition, it is stated that with the addition of 6% and 12% pomegranate pulp to the ration, the milk fat level increased by up to 8% and 15%, respectively, but the milk fat yield and milk protein level were not significantly affected. It was also determined that adding pomegranate hull to the ration did not affect blood glucose, cholesterol, urea, triglyceride, and lipoprotein levels.

Razzaghi et al. (2015) reported that pomegranate and pistachio byproducts did not affect milk yield, protein, and fat yield in dairy Saanen goats and positively changed the fat and protein ratio. Other studies have also reported the potential use of these byproducts as part of small ruminant diets (Abbeddou et al., 2011, Sedighi-Vasegh et al., 2015). Decreases in milk yield and milk protein content were observed in Awassi sheep fed with olive pomace-mixed rations (Abbeddou et al., 2015). The differences observed in milk yield and quality were because the rations were isoenergetic and not isonitrogenous (Abbeddou et al., 2011, Sedighi-Vasegh et al., 2015). It was determined that the PIS, POM, and OP used in the research did not harm the yield performance (feed intake, milk yield, and milk components) and health parameters of the

sheep. In addition, pistachio, pomegranate, and olive wastes used instead of straw in the research are valued as garbage. These fruit wastes constitute a significant environmental problem for the production enterprises. The use of these products, which are more valuable in terms of content (Table 1), although they have a lower economic value, can be evaluated to reduce feed costs.

Conclusion

The present study reveals that the PIS, POM, and OP can be considered as alternative low-cost feed sources without causing a significant decline in milk yield and health parameters in sheep. Although this study demonstrates the biological potential of feed additives, large-scale studies with more significant numbers of individuals and groups are required to establish an actual cause–effect relationship.

Conflict of Interest

The authors stated that they did not have anyreal, potential or perceived conflict of interest.

Ethical Approval

This study was approved by the Harran University Animal Experiments Local Ethics Committee (04.02.2021, 2021/001/01 Number Ethics Committee Decision). In addition, the authors declared that Research and Publication Ethical rules were followed.

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