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Using rose pulp silage instead of sugar beet pulp silage in lambs fed with total mixed ration

Kadir Emre BUĞDAYCI[1,*], Mustafa Numan OĞUZ[1], Hale SEÇİLMİŞ CANBAY[2], Hıdır GÜMÜŞ[1], Fatma KARAKAŞ OĞUZ[1]

[1]Department of Animal Nutrition and Nutritional Diseases, Faculty of Veterinary Medicine, Burdur Mehmet Akif Ersoy University, Burdur, Turkey

[2]Department of Chemistry, Faculty of Arts and Sciences, Burdur Mehmet Akif Ersoy University, Burdur, Turkey

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Abstract: The aim of this study was to determine the effects of using rose pulp (*Rosa damacena*) silage instead of sugar beet pulp silage on fattening performance, carcass yield, and some ruminal fluid parameters in lambs fed with total mixed ration. For this purpose, a total of 16 (average 30 ± 5 kg) 6-month-old Pırlak lambs, 8 in each group, were randomly divided into two groups. Total mixed rations were formulated by using concentrate, wheat straw and rose pulp silage (RPS) (Group 1) or sugar beet pulp silage (SBPS) (Group 2) in the experiment. Due to the low dry matter content of rose pulp, 7% wheat bran was added to its silage (RPS). The physical and chemical properties of both silages were evaluated, and rations were formulated as isocaloric and isonitrogenic. The study lasted 8 weeks after 2 weeks of the animals' adaptation to the ration. Live weight, live weight gain, feed consumption, feed conversion ratio, hot–cold carcass yield and ruminal parameters such as volatile fatty acids, protozoan number, pH, and ammonia nitrogen concentration were measured in the experiment. It was determined that the acetic acid level (12.4% DM) of RPS was approximately 6 times higher than SBPS, and the butyric acid level (3.83% DM) was 3 times higher. At the end of the study, it was determined that the difference between the performance parameters of both groups was not significant. Apart from acetic and butyric acid, rumen fluid parameters were not affected by the usage of RPS in the ration. It was concluded that the rose pulp silage consisting of wheat bran (7%) can be used as an alternative silage source to feed small ruminants instead of sugar beet pulp silage without any adverse effects.

Key words: Rose (*Rosa damascena*) pulp, lamb fattening, rumen parameters, silage

1. Introduction

Rose (*Rosa damascena*.), which is one of the most cultivated ornamental plants in the world and known as the queen of flowers, is the plant genus where the family Rosaceae derived its name [1]. Rose flowers are harvested and processed for oil production in June during the hot and dry season of the year in the Western part of Mediterranean Türkiye. 18,020 tons of rose flowers were harvested from 41046 decares of rose flowers planted in 2021 [2]. To obtain 1 kg of rose oil, approximately 3750 kg of rose flowers must be processed, and to obtain 1 kg of rose concrete, approximately 350 kg of rose flowers must be processed [3]. Rose pulp is a semiprocessed material obtained after the distillation of flowers for rose oil and rose concrete. The processing technologies of rose flowers differ according to the technology of the factories, and the steam distillation method is one of the preferred methods. After oil is obtained from rose flowers, the pulp is usually discharged from the boilers using pressurized water or by different methods. Rose pulp is a moist by-product of the rose oil industry, which is released as a wet processing product. The dry matter content of the pulp obtained can vary between 7.49% and 15.88%.

The amount of roughage produced in the Mediterranean region, especially in the hot summer months, cannot meet the needs of the ruminants. Because of the lack of forage, silage of sugar beet pulp, which has an excellent digestibility compared to some other by-products such as apple pomace and pumpkin pulp [4], is one of the most commonly used by-product silage. On the other hand, sugar beet pulp silage cannot meet the need and has to be supplied from the surrounding regions.

It is known that if the dry matter of the material to be silaged is low, fermentation is adversely affected. McDonald et al. [5] suggest that the dry matter content of the raw material to be silage should be 25%–30%. At this point, it is possible to make silage of rose pulp only if the dry matter content is increased (such as adding wheat bran). Baydar [6] reported that nearly 30 thousand tons of rose pulp is produced in rose oil factories every year,

* Correspondence: kadiremrebugdayci@hotmail.com

but that rose pulp is not economically utilized although more than 80% of it is organic matter. As a wet processing product, rose pulp has the potential to close this gap as an alternative to silage.

Many studies have been carried out on the usability of silages obtained from by-products in ruminates. Studies reported that diets containing pomegranate pulp silage [7] and Napier grass and pineapple by-product silages [8] did not adversely affect the fattening performance of lambs. Moreover, Massaro Junior et al. [9] reported that adding up to 30% of grape pomace silage to lamb rations did not have a negative effect on performance, carcass yield, and meat quality. It has also been reported that high levels of tassel flower silage [10] in the rations of lambs improved their live weight and carcass yield. Guzman et al. [11] reported that mango by-product silage, with its fast fermentable carbohydrate content, has high rumen degradability. It was reported that Mentha pulegium by-product with waste palm silage (20%) added to ram rations did not adversely affect feed consumption and digestibility of NDF [12]. It is seen that these alternative silage sources were able to meet some of the dietary dry matter needs of small ruminants. The aim of this study was to determine the effects of using rose pulp (*Rosa damacena*) silage instead of sugar beet pulp silage on fattening performance, carcass yield, and some ruminal fluid parameters in lambs fed with total mixed ration.

2. Materials and methods

The research was conducted with the permission of Burdur Mehmet Akilf Ersoy University, Experimental Animals Ethics Committee (Approval no: 2015-20-131). It was carried out in XXX, Türkiye with coordinates of 37°68′27″ N and 30°31′81″ E.

2.1. Animals used

Pırlak lambs, common breeds in the Western Mediterranean and Aegean regions of Türkiye, were used in the study. According to the power analysis with GPower version 3.1.9.7, the sample size was found to be 7 for each group. In the study, 6-month-old lambs (average 30 ± 5 kg live weight) were used, and 2 equal groups of 8 lambs with similar body weights were formed. The study lasted for 8 weeks (56 days), following a 2-week adaptation period.

2.2. Silages used in the research and procedure

After the distillation procedure, the rose pulp from the boiler was stacked to reduce the water content. In order to increase the dry matter content of the pulp, wheat bran was added up to 7% of its fresh weight during the packaging of the pulp. Wheat bran was preferred due to its high water holding capacity, ease of application during packaging and nutrient content. The sugar beet pulp silage used in the research was created by packaging sugar beet pulp without any additions. For chemical analysis of silages, 25 g of samples was mixed with 100 mL of distilled water (20 min) and the pH was measured from the filtered filtrate. Physical properties of the samples such as odor, color, and texture were analyzed according to DLG's silage evaluation key [13].

For fatty acid analysis, fat was first extracted from the silage samples and derivatized using 1.5 M methanolic HCl. HP - 88 (100 mm × 0.250 mm, 0.20 µm) column was used for fatty acids analysis. Fatty acid compositions of the silage samples were determined by using an HS/GCMS device (Agilent 5975C CN12410059, Agilent 7890A GC CN12451017). The initial temperature of the column was set at 60 °C. One minute later, it was increased to 175 °C with an increase of 13 °C/min. Thereafter, it was increased to 215 °C in a systematic increase of 4 °C. This temperature was maintained for 35 min. The temperature of the injector and detector was set at 250 °C [14]. Lactic acid levels of the silage samples were determined by using HPLC (Agilent 7697A Headspace HT12440002). For the chromatographic separation flow rate of the device, 1 mL/min. ODC – 4 (250 mm × 4.6 mm, 5 µm) column was used. pH was adjusted to 3 with orthophosphoric acid in the mobile phase. After the baseline was stabilized, sample injections were made [15]. NH_3 – N / Total N of silages was fixed by using a Kjeldahl distillation device (Gerhardt Vapodest, VAP001217). For this purpose, 10 mL of the silage liquid was distilled with NaOH during the DLG scoring process, and the amount of N was determined by calculation [16]. Dry matter (DM), crude protein (CP), crude ash (CA), and ether extract (EE) contents of silages used in group rations and TMRs were determined according to AOAC [17]. Crude fiber (CF) and acid detergent fiber- neutral detergent fiber (ADF – NDF) contents were determined according to Crampton and Maynard [18] and Goering and Van Soest [19], respectively. The Flieg score of silage samples was calculated by using pH and dry matter values [13], and their metabolizable energy levels were calculated by using crude cellulose and ADF values [20]. Formulas of Flieg and Metabolizable energy, used in the present study were as follows:

Flieg score: 205 + (2 × DM%) – (40 × pH)

ME - 1 = 3309.5 – 35.64 × CF (kcal/kg DM)

ME - 2 = 3464.7 – 58.10 × ADF + 27.99 × CF (kcal/kg DM)

ME - 3 = 239 × (14.70 – 0.150 × ADF) (kcal/kg DM)

The total mixed rations (TMR) of the study groups were composed of rose pulp silage (Group 1) or sugar beet pulp silage (Group 2) and concentrate and wheat straw [21] (Table 1). Group rations were evaluated to be isocaloric and isonutrogenic. The rations were weighed daily and prepared in a way that increased the feed for the animals by 10%. Clean and cool water was constantly placed in front of the lambs ad libitum.

Table 1. Composition of total mixed rations of experimental groups.

Ingredients, %	Total mixed rations [A]	
	Group 1	Group 2
Wheat straw	0.35	0.3
RPS [B]	3	-
SBPS [C]	-	3
Barley	0.2	0.08
Wheat bran	-	0.24
Corn	0.15	0.1
Vegetable oil	0.035	0.035
Sunflower meal, 36%	0.18	0.085
Soybean meal, solvent, 49%	0.05	0.08
Limestone	0.016	0.026
Salt	0.005	0.005
Vitamin-mineral premix [D]	0.003	0.003
Calculated composition		
Dry matter [E] (kg)	1.29	1.31
Metabolizable energy [F] (kcal/kg DM)	2650	2590
Crude protein (g/kg)	147.16	144.87
Calcium (Ca) (g/kg)	5.13	7.66
Phosphorus (P) (g/kg)	2.49	3.74
Calcium/Phosphorus (Ca/P)	2.06	2.05

[A] Group 1: The group that consume rose pulp silage, Group 2: The group that consume sugar beet pulp silage. [B] RPS: Rose pulp silage (containing 7% wheat bran by weight of the pulp). [C] SBPS: Sugar beet pulp silage. [D] Each kg contained 50.000 mg Mn, 50.000 mg Fe, 50.000 mg Zn, 10.000 mg Cu, 150 mg Co, 150 mg Se, 800 mg I, 8,000,000 IU vitamin A, 2,000,000 IU vitamin D3, 20.000 mg vitamin E. [E] Calculated amount of daily dry matter need per lamb. [F] Calculated according to NRC [21].

2.3. Determination of body weight, body weight gain, and feed consumption

The groups were individually weighed every 2 weeks (2nd, 4th, 6th, and 8th weeks) on 2 consecutive days (at the same hour) during the study. Live weights of lambs were recorded as the average of the 2-day weighing. Body weight gains (2 weeks) were calculated by subtracting these averages from the previous weighing averages. The daily body weight gains in the relevant periods were calculated by dividing the average body weight gains by fourteen. TMR consumption of the groups was determined by subtracting the remaining feed of the previous day from the daily prepared group feed. TMR that was not consumed was not given again to the animals. Average daily TMR consumption per animal was calculated by dividing the daily TMR consumption of the groups by the number of animals in the group. The groups' feed conversion ratio was determined by calculating the ration (TMR) consumed on a dry matter basis for 1 kg live weight gain (kg consumed ration/kg live weight gain).

At the end of the experiment, all group animals that were not excluded from the study for any reason until the end of the study were slaughtered. The weight of the hot carcass was determined by separating the head, feet, and visceral organs from the carcass, and the cold carcass weight was determined by weighing after holding at +4 °C for 24 h. Carcass yields were calculated by proportioning them to body weight. Rumen fluid samples were taken (2 × 100 mL) from each animal during the slaughtering process.

2.4. Determination of rumen fluid parameters

Volatile fatty acids of rumen fluids were taken from rumen determined by gas chromatography (Agilent 5975C CN12410059, Agilent 7890A GC CN12451017). To do this,

the samples taken for analysis were prepared with innering standard (4 – Methylvalerianic acid and formic acid 1: 101) within 1 h. Rumen fluids fixed by adding phosphoric acid (–20 °C) were dissolved, centrifuged (4000 rpm), and the clear supernatant part was injected into the device [22]. The pH values of the rumen fluids were determined using a pH meter; the amount of ammonia nitrogen was determined spectrophotometrically (UV – 1601 Shimadzu, Seri No: A1075 – 3501646) through the indophenol blue method reported by McCullough [23]. Rumen fluid samples (3–4 drops of 98% sulfuric acid added) were stored at –20 °C. Samples were thawed at +4 °C before analysis. The NH_3 – N concentration was determined using a spectrophotometer (UV – 1208, Shimadzu) at a wavelength of 546 nm. The number of protozoa was determined by using Fuchs–Rosenthal Lam (16 × 16 squares, 0.0625 mm^2 area, 0.200 mm depth) and light microscope [24]. To do this, 0.1 mL of rumen fluid was taken and 0.9 mL of MFS solution (Composition: 100 mL of formaldehyde solution (30%), 900 mL of distilled water, 0.6 g methylgreen, 8 g NaCl) was added. Counting was performed after the prepared samples were placed under the microscope by dropping them onto the lambs.

2.5. Blood parameters

At the end of the experiment, blood samples were taken from Vena Jugularis in all animals. Hematological parameters [white blood cell (WBC), lymphocyte (LYM), monocytes (MID), granulocyte (GRA), red blood cell (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDWc), platelet count (PLT), procalcitonin (PCT), mean platelet volume (MPV), latelet distribution width (PDWc)] were determined using Abacus Junior Vet Hematology Analyzer (Diatron MI PLC. Hungary). Biochemical blood parameters (albumin, total protein, uric acid, aspartate aminotransferase (AST/GOT), alanine aminptransferase (ALT/GPT), glucose, cholesterol, and triglyceride) were analyzed using an autoanalyzer (Model: Gesan - Chem200, model: Gesan - Chem200, No: 1102422, Campobello – Italy) in sera obtained from samples centrifuged at 3000 rpm and room temperature for 5 min.

2.6. Statistical analysis

The normality of the data was checked with the Kolmogorov–Smirnov and Shapiro–Wilk tests. Since the outcomes were not normally distributed and the samples were small, a nonparametric test (Mann–Whitney U test) was used to determine whether there was a difference in the dependent variable for the 2 independent groups [25] using the SPSS package program (SPSS Inc., Chicago, IL, USA). Significance of the mean values was determined as $p < 0.05$.

3. Results

The physical evaluation results showed that the values of RPS (19.33) were numerically close to SBPS (18.66), and the pH was lower than 4.40 in both silage samples. The lactic acid, acetic acid, and butyric acid levels of RPS were determined as 27.26, 12.40, and 3.83 g/kg DM, respectively. SBPS were determined as 30.04, 1.87, and 0.51 g/kg DM, respectively (Table 2). The metabolizable energy value of RPS calculated by three different methods was found to be between 1524.39 and 2408.88 kcal/kg DM. On the other hand, the metabolizable energy levels of SBPS were calculated more close to each other and determined as average 2304.32 kcal/kg DM (Table 3). The ratio of palmitic acid among the saturated fatty acids of RPS in total fatty acids was determined at 13.30%. This value was determined at 48% in SBPS. This ratio is about 3.5 times higher than that of RPS. It was determined in this current study that the linolenic acid level of RPS was 8.63 times higher than that of SBPS. The fatty acid compositions of RPS and SBPS can be seen in Table 4.

In the second week of the study, one lamb from Group 1 was excluded from the study as a result of a foot injury. Due to this, 7 lambs from Group 1 and 8 lambs from Group 2 were slaughtered at the end of the study. During the study, a linear increase occurred in feed consumption in parallel with the increase in the live weight of the lambs (Table 5–7). This indicates that the lambs that adapted to consuming TMR containing RPS can be evaluated as similar to the lambs that consumed TMR with SBPS (Table 8). No statistical difference was found between the groups in terms of all blood parameters examined (Table 9).

The pH of the rumen fluid and the number of protozoans were formed within the desired values in both groups without statistical significance. The numerical differences of the value of rumen fluid ammonia nitrogen were also not carrying any significance in the lambs that consumed TMR containing RPS or SBPS. While the consumption of TMR containing RPS in terms of rumen volatile fatty acids significantly increased acetic and butyric acid formed in the rumen ($p < 0.05$), there was no difference in the group that consumed TMR containing SBPS at the level of propionic acid released. RPS added to the diet did not affect the level of lactic acid released in the rumen (Table 10).

4. Discussion

Due to the low dry matter content of rose pulp, 7% of its fresh weight wheat bran was added to the rose pulp in order to make silage. Similarly, for some plant species regarded as alternative silage, the dry matter content was increased [26,27]. Ergün et al. [28] define silage as fermented feeds produced as a result of storing green forages containing 30%–40% dry matter under anaerobic conditions after

Table 2. Physical and chemical evaluation results with volatile fatty acids and lactic acid values of rose pulp silage and sugar beet pulp silage.

Physical evaluations [B]	**Silages** [A]	
	RPS	**SBPS**
Odor	4.0	4.0
Smell	13.33	12.66
Color	2.0	2.0
Total physical evaluation result	19.33	18.66
Chemical evaluations [C]		
Flieg score	74.60	82.42
pH	4.36	4.04
Ammonia N/Total N (DM%)	0.01	6.83
Acetic acid (DM%)	12.40	1.87
Propionic acid (DM%)	3.88	5.67
Butyric acid (DM%)	3.83	0.51
Lactic acid (DM%)	27.26	30.04

[A] RPS: Rose pulp silage; SBPS: Sugar beet pulp silage. [B] Odor, smell, and color were calculated as the averages of the scores given by 3 different researchers according to the DLG (Deutsche Landwirtschafts-Gesellschaft) score. [C] The Flieg score was calculated using the formula "205 + (2 × DM%) – (40 × pH)", DM: Dry matter.

Table 3. Nutritional value of rose pulp silage and sugar beet pulp silage on dry matter basis, %.

	Silages [A]	
	RPS	**SBPS**
Dry matter, (%)	22.00	19.51
Crude ash, (%)	11.00	4.85
Ether extract, (%)	4.75	2.75
Crude protein, (%)	14.73	13.36
Crude fiber, (%)	25.27	28.06
Acid detergent fiber (ADF), (%)	45.57	33.62
Neutral detergent fiber (NDF), (%)	65.88	76.52
Calculated metabolizable energy values [B]		
ME - 1, (kcal/kg DM)	2408.88	2309.79
ME - 2, (kcal/kg DM)	1524.39	2296.77
ME - 3, (kcal/kg DM)	1878.58	2306.40

[A] RPS: Rose pulp silage; SBPS: Sugar beet pulp silage. [B] Metabolizable energy values were calculated by using following formulas, ME-1 = 3309.5 – 35.64 × CF; ME-2 = 3464.7 – 58.10 × ADF + 27.99 × CF; ME-3 = 239 × (14.70 – 0.150 × ADF) (ME: Metabolizable energy, ADF: Acid detergent fiber, CF: Crude fiber, DM: Dry matter).

Table 4. Fatty acid composition of rose pulp silage and sugar beet pulp silage (%).

Fatty acids, %	Silages [A]	
	RPS	**SBPS**
Octanoic acid	0.54	3.00
Nonanoic acid	0.18	0.71
Decanoic acid	0.23	1.00
Benzoic acid	0.08	0.36
Dodecanoic acid	0.44	0.98
Palmitic acid	13.31	48.12
9 - Hexadecenoic acid	0.19	1.97
Stearic acid	3.26	4.98
Oleic acid	2.98	11.20
Linoleic acid	13.32	12.07
Linolenic acid	8.64	1.00
Butanoic acid	10.192	-
Benzene	1.280	-
Pentanoic acid	4.232	-
Hexanoic acid	10.306	-
Benzenepropanoic acid	1.604	-
Phenylethyl Alcohol	2.193	-
Heneicosane	1.045	-
Acetate	8.998	-
Benzothiazole	4.677	-
1,6 – Octadiene	5.267	-
2 – Methyl – 4 – nitroresorcinol	2.699	-
Myristic acid	-	1.91
Pentadecanoic acid	-	1.97
Nonanedioic acid	-	1.20
Hexadecanoic acid	-	1.20
Eicosonoic acid	-	2.18
Pentaoxacyclopentadecane	-	1.00
4,7,10,13,16 – Pentaoxanonadecadiene	-	1.10

[A] RPS: Rose pulp silage, SBPS: Sugar beet pulp silage.

harvesting. Bastiman and Altman [29] reported that in order to minimize the risk of seepage of high moisture raw materials during the silage formation process, the dry matter content of the raw material should be more than 30% in horizontal silos and more than 35% in tower silos. However, morphological variations of different silage maize hybrids can be between 22.00% and 35.45% depending on plant characteristics [30]. Moreover, Brar et al. [31] declared that the dry matter content of maize silage could drop to 16.5% under field conditions. In line with the present study, Alvarez et al. [27] found that the average dry matter of the banana by-product silage was 20%–30%. However, the dry matter content of rose pulp silage with 7% wheat bran added was higher than broccoli by-product silage (18.1%) and artichoke by-product silage (19.0%) [32]. The desired pH levels of 3.5–4.3 for proper silage [33] and the ratios of NH_3 – N / N were less than 6.83%. This shows that RPS is suitable for the chemical properties of the silages and SBPS is suitable for their physical properties. A study which evaluated pH levels of

Table 5. Mean values of live weight (g), hot–cold carcass weight (g) and carcass yields (%) of experimental groups.

	Groups [A]	n	Mean value	Statistical Scores [B]		
				U	Z	p
Initial body weight	1	8	30621.87 ± 2118.62	32.00	0.001	1.000
	2	8	31058.75 ± 1658.78			
Live weight in the 2nd week	1	8	31565.62 ± 2256.30	26.00	–0.630	0.529
	2	8	33637.50 ± 5029.96			
Live weight in the 4th week	1	7	34950.00 ± 1854.21	24.00	–0.463	0.643
	2	8	36000.00 ± 1887.57			
Live weight in the 6th week	1	7	37567.85 ± 2048.67	24.00	–0.463	0.643
	2	8	39321.87 ± 2085.31			
Live weight in the 8th week	1	7	40670.31 ± 1934.20	25.00	–0347	0.728
	2	8	41737.50 ± 1923.88			
Hot carcass weight	1	7	17333.33 ± 1161.00	21.50	–0.756	0.450
	2	8	18125.00 ± 907.85			
Cold carcass weight	1	7	16858.32 ± 1151.78	22.00	–0.695	0.487
	2	8	17606.25 ± 890.39			
Hot carcass yield	1	7	42.37 ± 1.11	27.00	–0.116	0.908
	2	8	43.38 ± 0.63			
Cold carcass yield	1	7	42.50 ± 1.32	27.00	–0.116	0.908
	2	8	42.13 ± 0.61			

[A] 1: The group that consume rose pulp silage, 2: The group that consume sugar beet pulp silage. [B] U: The score of the Mann–Whitney U test; Z: Z score of the Mann–Whitney U test; p: Significance value ($p < 0.05$).

Table 6. Mean values of daily live weight gain (g) of experimental groups.

Period	Groups [A]	n	Average value	Statistical scores [B]		
				U	Z	p
1st two weeks	1	8	67.41 ± 47.10	17.00	–1.575	0.115
	2	8	184.19 ± 41.84			
2nd two weeks	1	7	142.09 ± 23.63	18.00	–1.157	0.281
	2	8	168.75 ± 26.68			
3rd two weeks	1	7	186. 98 ± 39.49	17.50	–1.217	0.223
	2	8	237.27 ± 34.94			
4th two weeks	1	7	221.60 ± 39.94	12.00	–1.853	0.064
	2	8	172.54 ± 18.92			
Mean (0–8th weeks)	1	29	151.52 ± 21.65	353.00	–1.603	0.109
	2	32	190.69 ± 15.89			

[A] 1: The group that consume rose pulp silage, 2: The group that consume sugar beet pulp silage. [B] U: The score of the Mann–Whitney U test; Z: Z score of the Mann–Whitney U test; p: Significance value ($p < 0.05$).

Table 7. Total mixed ration consumption of experimental groups (g).

Period	Group 1 [A]	Group 2 [B]
1st two weeks	981.12	979.29
2nd two weeks	1112.74	993.69
3rd two weeks	1274.19	1160.51
4th two weeks	1347.10	1214.30
Mean (0–8th weeks)	1178.78	1086.95

[A] Group 1: The group that consume rose pulp silage. [B] Group 2: The group that consume sugar beet pulp silage.

Table 8. Feed conversion ratio of experimental groups (kg consumption of total mixed ration on dry matter basis)/kg live weight gain).

Period	Group 1 [A]	Group 2 [B]
1st two weeks	14.55	5.31
2nd two weeks	7.83	5.88
3rd two weeks	6.81	4.89
4th two weeks	6.07	7.03
Mean (0–8th weeks)	7.78	5.70

[A] Group 1: The group that consume rose pulp silage. [B] Group 2: The group that consume sugar beet pulp silage.

an alternative silage (sesame) and usual silages (corn and millet) revealed similar results with the present study [34]. In addition, it was stated that the pH levels of artichoke silage and artichoke plant stubble silage were 4.20 and 4.55, respectively [32]. Soltani Nezhad et al. [35] reported that the NH3-N / N ratio of pistachio by product silage was 5.3 and the pH was 4.1.

In line with this present study, Monllor et al. [36] reported that the NH3 – N/N ratios of artichoke plant silage (0.27) and common reed silage (0.69) were similar to rose pulp silage. On the other hand, Alvarez et al. [27] found that the NH3-N levels of green banana silage and green banana bunch silage were 25.61 and 9.76, respectively.

The metabolizable energy level of rose pulp silage appears to be very close when compared to some alternative silage such as amaranth plant [37], potato–wheat straw [38], and pistachio by-products [35]. The nutritional value of RPS containing wheat bran appears to be similar to common reed (*Phragmites australis*) silage with molasses [39] or citrus pulp silage without any additives [40]. The acetic acid and butyric acid levels of rose pulp silage were similar to those of artichoke (13.1 g/kg DM) [41] and green banana (2.21 g/kg DM) [27]. It can be accepted that butiric acid and propionic acid levels of rose pulp silage were similar to that of guar bean silage (5.50 and 2.67 g/kg DM) [42]. However, lactic acid, acetic acid, and propionic acid levels of green banana bunch silage were reported as 0.73, 2.24, and 0.44, respectively [27]. These values were very low compared to rose pulp silage. The reason why the butyric acid level in rose pulp silage is as high as in green banana silage may be due to its high moisture content, as in green banana silage, despite the increased dry matter content. Megias et al. [43] reported that the palatable and sweet-smelling silage is related to its lactic acid content, which encourages feed consumption. In the present study, the lactic acid content of rose pulp silage was determined as 27.26% DM, and this value was 27 times higher than green banana silage and green banana bunch silage.

As for the fattening performance of the lambs, the feed conversion ratio of the lambs that consumed RPS was similar to that of Caparra et al. [44], who revealed that the feed conversion ratio of the lambs was similarly affected by the rations containing olive oil by-product, orange pulp silage, and wheat straw, which are the traditional rations of lambs. Souza et al. [45] found that feed consumption, feed conversion ratio, body weight, and body weight gain of sheep that were fed with rations containing sisal (*Agave sisalona*) silage were not affected compared to the control group. On the other hand, it was reported that the body weight gain increased in lambs fed with orange pulp silage [46]. This difference could be caused by the composition of the raw materials of silages and the age of the animals. Gusha et al. [26] declared that 22 kg live-weight goats consumed 0.81 kg DM silage per day containing various cactus species together with legume hay. Soltani Nezhad et al. [35] found that body weight and body weight gain increased significantly in lambs fed a ration containing 21% pistachio by-product silage compared to the control group. It was also revealed that potato–wheat straw silage, in which 100, 200, or 300 g/kg DM was added to the lamb ration, did not affect the increase in live weight but increased feed conversion ratio linearly [38]. Papi et al. [41] reported that artichoke silage substituted at the level of 50, 100, 150, and 200 g/kg DM for corn silage did not affect the daily body weight gain and feed conversion ratio in lambs. Hatami et al. [47] found that 80 g/kg of pomegranate pulp added to lamb rations did not have a negative effect on dry matter consumption, live weight gain, or feed conversion ratio. The feed conversion ratios of the RPS and SBPS consumed groups were determined as 6.07 and 7.03, respectively, in the 4th two weeks of the study. This indicates that the adaptation of the rumen flora to the rose pulp silage reached the highest level in the period from the beginning of the study. In the present

Table 9. Biochemical blood parameters and hematological parameters of experimental groups.

Biochemical blood parameters	Group [A]	n	Average value	Statistical scores [B]		
				U	Z	p
Albumin (g/dL)	1	7	2.07 ± 0.11	27.00	–0.116	0.908
	2	8	2. 07 ± 0.09			
Total protein (g/dL)	1	7	5.91 ± 0.22	24.00	–0.465	0.642
	2	8	5.77 ± 0.19			
Uric acid (mg/dL)	1	7	2.61 ± 1.67	28.00	0	1.000
	2	8	1.41 ± 0.45			
Aspartate Aminotransferase (AST/GOT) (U/I)	1	7	110.05 ± 9.54	24.00	–0.463	0.643
	2	8	107.12 ± 11.28			
Alanine Aminotransferase (ALT/GPT) (U/I)	1	7	20.85 ± 3.39	17.00	–1.281	0.200
	2	8	14.87 ± 1.64			
Glucose (mg/dL)	1	7	59.28 ± 3.46	22.50	–0.638	0.523
	2	8	56.62 ± 3.30			
Cholesterol (mg/dL)	1	7	13.00 ± 4.91	18.50	–0.104	0.269
	2	8	13.03 ± 4.60			
Triglyceride (mg/dL)	1	7	8.59 ± 3.25	24.50	–0.407	0.684
	2	8	11.80 ± 4.17			
Hematological parameters						
White blood cell (WBC) (10^9/L)	1	7	14.58 ± 4.29	15.00	–1.504	0.132
	2	8	11.51 ± 2.10			
Lymphocyte (LYM) (10^9/L)	1	7	6.12 ± 0.59	16.00	–1.389	0.165
	2	8	4.93 ± 0.72			
Monocytes (MID) (10^9/L)	1	7	0.07 ± 0.01	15.00	–1.517	0.129
	2	8	0.05 ± 0.01			
Granulocyte (GRA) (10^9/L)	1	7	8.37 ± 1.59	20.00	–0.926	0.355
	2	8	6.51 ± 1.83			
Red blood cell (RBC) (10^{12}/L)	1	7	10.07 ± 0.57	24.00	–0.463	0.643
	2	8	10.08 ± 0.31			
Hemoglobin (HGB) (g/dL)	1	7	9.64 ± 0.53	23.00	–0.581	0.561
	2	8	10.17 ± 0.28			
Hematocrit (HCT) (%)	1	7	26.04 ± 1.51	24.00	–0.463	0.643
	2	8	26.66 ± 0.79			
Mean corpuscular volume (MCV) (fl)	1	7	25.85 ± 0.98	22.50	–0.648	0.517
	2	8	26.62 ± 0.62			
Mean corpuscular hemoglobin (MCH) (pg)	1	7	9.58 ± 0.23	15.00	–0.153	0.130
	2	8	10.12 ± 0.20			
Mean corpuscular hem. concentration (MCHC) (g/dL)	1	7	37.14 ± 0.87	20.50	–0.869	0.385
	2	8	38.22 ± 0.57			
Red cell distribution width (RDWc) (%)	1	7	27.75 ± 1.17	23.00	–0.579	0.563
	2	8	26.67 ± 0.58			
Platelet count (PLT) (%)	1	7	611.28 ± 98.61	24.00	–0.463	0.643
	2	8	674.25 ± 31.44			

Table 9. (Continued).

Procalcitonin (PCT) (%)	1	7	0.35 ± 0.05	25.00	–0.348	0.728
	2	8	0.39 ± 0.02			
Mean platelet volume (MPV) (fl)	1	7	5.85 ± 0.07	25.50	–0.293	0.769
	2	8	5.86 ± 0.13			
Platelet distribution width (PDWc) (%)	1	7	31.31 ± 0.88	24.00	–0.552	0.581
	2	8	30.56 ± 0.85			

[A] 1: The group that consume rose pulp silage, 2: The group that consume sugar beet pulp silage. B U: The score of the Mann–Whitney U test; Z: Z score of the Mann–Whitney U test; P: Significance value ($p < 0.05$).

Table 10. Ruminal fluid parameters of experimental groups.

Ruminal fluid parameters	**Group** [A]	**n**	**Average value**	**Statistical scores** [B]		
				U	**Z**	**p**
Acetic acid (mmol/L)	1	7	53.96 ± 3.24	10.00	–2.083	0.037
	2	8	41.33 ± 3.06			
Propiyonic acid (mmol/L)	1	7	12.72 ± 0.77	19.00	–1.042	0.298
	2	8	11.35 ± 0.83			
Butyric acid (mmol/L)	1	7	23.72 ± 2.24	11.00	–1.967	0.049
	2	8	17.21 ± 1.81			
Lactic acid (mmol/L)	1	7	240.57 ± 54.26	15.00	–1.504	0.132
	2	8	215.45 ± 76.17			
Protozoa number ($\times 10^3$/mL)	1	7	541 ± 117337	19.00	–1.042	0.298
	2	8	782 ± 169430			
pH	1	7	6.38 ± 0.09	20.00	–0.926	0.355
	2	8	6.54 ± 0.05			
NH_3-N (mmol/L)	1	7	4.61 ± 0.61	21.00	–0.811	0.417
	2	8	4.0 ± 0.25			

[A] U: The score of the Mann–Whitney U test, Z: Z score of the Mann–Whitney U test, p: Statistical significance value ($p < 0.05$). [B] U: The score of the Mann–Whitney U test; Z: Z score of the Mann–Whitney U test; p: Significance value ($p < 0.05$).

study, the groups were formed from lambs fed under farm conditions that had never consumed rose pulp silage before. In commercial farm conditions, it can be stated that the longer the lambs are fed with TMR containing rose pulp silage, the higher the feed conversion ratio will be. Ergün et al. [48] reported that the digestibility of crude cellulose increased due to the adaptation of the rumen flora to the consumed ration. Regarding TMRs containing both silages, it can be concluded that TMR containing RPS is more advantageous than TMR containing SBPS in terms of the metabolizable energy requirement of lambs. This is because TMR containing RPS increases ruminal acetic acid. Gado et al. [46] reported that orange pulp silage added to lamb rations did not change rumen total volatile fatty acids compared to the control group. There was no difference between the groups in terms of rumen pH, protozoa number, and ammonia nitrogen released in the rumen. Studies show that there is a similar relationship between rumen pH and the number of protozoa. It is also accepted that as the acidity level of rumen increased the number of protozoa decreased [49,50]. In the study, rumen pH values of the groups that consumed TMR containing RPS and SBPS were determined as 6.38 and 6.54, respectively, and they were evaluated to be within normal limits [48].

In terms of blood glucose and urea nitrogen levels, the present study is similar to the studies of potato–wheat straw silage (300 g/kg DM) and Jerusalem artichoke silage (200 g/kg DM) added to lamb (4–4.5 months old) rations [38,41]. However, it was reported that the addition of

polyethylene glycol to pomegranate pulp (80 g/kg DM) in lamb (4–5 months old) rations increases male blood urea nitrogen levels [47]. In addition, lambs consuming leguminous silages (red clover or alfalfa) ad libitum increased blood sugar and decreased total protein levels compared to lambs consuming grass silage [51]. The difference in blood parameters between the studies carried out with different silages may be related to the difference in the nutrient content of the silages and the amount included in the ration.

5. Conclusion

The present study showed that the rose pulp can be stored as silage by adding 7% wheat bran. The physical evaluation results of rose pulp silage were similar to sugar beet pulp silage. However, the crude ash and acetic acid levels were higher in rose pulp silage compared to sugar beet pulp. It was observed that there was no significant difference between live weight, live weight gain, carcass yield, blood parameters and, rumen fluid parameters in lambs consuming rose pulp silage or sugar beet pulp silage in the total mixed ration. After an appropriate adaptation period, it was detected that the use of rose pulp silage in lamb rations did not have a negative effect on the fattening performance. Future research should focus on new approaches that will further reduce moisture content by supporting the nutrient content of rose pulp silage.

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Conflict of interest

The authors of this research declare that there are no conflicts of interest.

Ethical approval

This research was carried out with the permission of the animal trials local ethics committee of Burdur Mehmet Akif Ersoy University with the number of 2015-20-131.

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