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The Effects of Replacement of Dried Orange Pulp with Ground Corn in Concentrate Feed on Dairy Goats' Performance, Milk Somatic Cell Counts and Blood Parameters

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A B S T R A C T

In this study orange pulp, dried in hot air, was replaced at control, 7.5, 15 and 22.5% levels (DM basis) with ground corn in the concentrate feeds of dairy goats. Considering the milk yield, average live weight and age of the animals, a total of 24 animals were used in 4 groups with 6 animals in each. Goats with 1375±330 ml milk yield, 2.45±0.17 years of age and 55.40±0.91 kg body weight were chosen for the trial. The animals were housed in individual compartments of 2x2 m during the study. In 2 weeks of adaptation, 8 weeks data collection of the trial, feed and water were provided *ad libitum*. Orange pulp utilisation increased dry matter intake, did not change milk yield and feed conversion rates, and negatively affected the body weight changes. Somatic cell counts were found to be lower in the control group in the middle of the study. Blood glucose and cholesterol levels were reduced, NEFA and BHB increased due to the treatments.

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Introduction

Feeding expenses cover 70% of the total costs in animal production. Increasing costs in the feedstuff production make animal nutrition harder day-by-day. Therefore, the search for alternative feed materials steams ahead. By-products and wastes from many areas of food industry and plant production are the most common factors in minimizing the ration costs. Citrus pulp is one of these alternatives in temperate regions. In Türkiye, citrus production is about 4 million tons (Erdem et al., 2019) and 195.500 tons were processed into juice MEYED, 2019). After this process, citrus pulps occur as food industry wastes 50-60% amount of the fruits (Erdem et al., 2019). 195.500 tons of citrus fruits were processed Depending on source and breeding conditions, this material's nutritional composition, as dried, is close to barley and corn, and has a very high potential for use in animal feeding (Bampidis and Robinson, 2006). Dried orange pulps contain approximately 92.67% dry matter; 1584 kcal/kg ME, 89% organic matter, 3.15% crude protein, 20.44% ether extract, 3.40% ADF, 35.52% NDF and 3.44% NPN matters (Filik and Kutlu, 2018). Both citrus pulp is an alternative in animal nutrition, and the aromatic substances in it also positively affect feed consumption (Ralphs et al., 1995; Hof, 2000; Sterk, 2008; Şahan and Kutay, 2019). Although, there are approximately 9000 taste buds on the human tongue, these values are 15000 in pigs and goats, 17000 in rabbits and around 25000 in calves (Hof, 2000). These figures can be considered as an indicator of how important the taste of the feed is on the feed consumption of mammals.

In livestock industry, citrus pulp is generally used as fresh in short periods or as ensiled by increasing dry matter in long periods. However, it is convenient to spoil because of the high sugar and water content. On the other hand, transportation of fresh pulps to animal farms is another handicap. Also, efflux of juice during transportation threatens environmental health and traffic safety and will be punished according to Turkish Penal Code Highway

Law (Anonymous, 2022). To eliminate these hitches and to prevent the loss of nutrients, drying citrus pulps become necessary.

In the current study, the effects of replacing hot air-dried orange pulp with corn at different levels on performance and milk components in dairy goats were investigated.

Materials and Methods

Ethical Statement

This study was conducted by the approval of the Local Ethics Board for Animal Experiments of Çukurova University (ÇÜHADYEK, Research Code: ÇÜ-HADYEK-2022/2), Adana, Türkiye.

Animals, Trial Groups and Feeds

The study was carried out on Saanen dairy goats in Çukurova University Faculty of Agriculture Research and Application Farm. Considering the milk yield, average live weight and age of the animals, a total of 24 animals were used in 4 groups with 6 animals in each. Goats with 1375±330 ml milk yield, 2.45±0.17 years of age and 55.40±0.91 kg body weight were chosen for the trial. The animals were housed in individual compartments of 2x2 m during the study. In 2 weeks of adaptation, 8 weeks data collection of the trial, feed and water were provided *ad libitum*. Hot air-dried orange pulp was obtained from a private company in Adana, and feeds containing dried pulp were produced in a private company in Mersin. Alfalfa hay chopped 3-5 cm and corn silage used as roughage were obtained from Çukurova University Faculty of Agriculture. Concentrate feed and forage rate was 40:60 in dry matter basis. The feedstuff composition and nutrient contents of the feeds used in the study are given in Tables 1 and 2. The levels of replacement were determined by a literature survey for the energy supply of citrus pulps and the animals' reaction to the taste of citrus pulp.

Performance Measurements

The feed consumptions of the animals were determined by subtracting the remaining feeds from the given twice a day, and the live weight changes were determined cumulatively by subtracting the live weights of the weeks from the trial beginning weights. Feed conversion rates were calculated weekly by dividing the cumulative dry matter consumptions with the cumulative milk yields. Milking was done in the early morning once a day and milk yields were determined twice a week. Milk somatic cell counts were done with DeLaval Somatic Cell Counter (DCC) on the days when milk yields were measured. Glucose, cholesterol, non-esterified fatty acids (NEFA) and β-Hydroxybutyric acid (BHB) were also measured by using ELISA Plate Reader (Epoch Microplate Spectrophotometer) from bloods taken from the *vena jugularis* of the animal at the 1st, 4th and 8th weeks of the trial (Şahan and Kutay, 2019).

Statistical Analysis

Data obtained from the trial was evaluated using the SAS package software (SAS, 2004). Variance analysis of the data was conducted according to Randomized Parcels Experiment Design on the General Linear Model (PROC GLM). Duncan test was used for the multiple comparisons of the averages (Bek & Efe, 1995).

Results and Discussion

Performance Findings

Dry matter consumption of animals during the experiment is given in Table 3. It was observed that the use of dried orange pulp instead of dried ground corn in the ration quadratically increased the weekly dry matter consumption of the animals in the group that received 15% pulp in the 1st week, and decreased it in the group that received 22.5% pulp. While no significant difference was observed in dry matter consumption in the 2nd week of the experiment; a linear increase was detected compared to the control group at 3rd, 4th, 5th, 6th and 7th weeks, and a quadratic effect was observed between groups in the last week.

A general increase in dry matter consumption can be attributed to the aromatic properties of dried orange pulp in the ration. Because while poultry give more importance to visuality in feed selection; ruminants pay attention to the characteristics of the feeds such as taste and smell. The positive effect of feed taste on feed consumption has been previously stated by other researchers (Ralphs et al.1995; Hof, 2000; Sterk, 2008). The fact that the dry matter consumption in the group that received 22.5% orange pulp in the last week was higher than the control group but lower than the other treatment groups can be attributed to the fact that the aromatic components in the orange pulp may cause a feeling of boredom in the animals. Indeed, Oni et al. (2008) similarly found that an increase in orange pulp in the ration reduces feed consumption after a point. Kutlu and Çelik (2018) also stated that long-term and excessive consumption of barley, wheat, soybean and milling industry by-products can cause boredom in animals.

The live weight changes of the animals on a weekly basis during the study are given in Table 4. It was determined that the treatments had a negative effect on the live weight changes of the animals in general, especially the difference between the first 2 weeks and the 4th and 5th weeks was statistically significant ($P<0.05$).

Although the dry matter consumption of the groups fed dried orange pulp were found to be higher, it is observed that milk yields and live weight changes decreased. However, with the increase in feed consumption, one or both of these parameters are expected to improve. Despite the treatments increased dry matter consumption, the negative effect on live weight change brings to mind that there was a problem in the metabolism of feeds. It has been stated that high amount of citrus pulp utilisation instead of corn in the diet reduces the production of propionic acid in the rumen (Ferrari et al., 2016) and increases the excretion of nitrogen in the feces (O'Connor et al., 2018). In this study, it is thought that the use of dried orange pulp reduced the production of propionic acid in the rumen and negatively affected the live weight change by reducing the rate of glucose transferred from the liver to the blood. At the same time, it comes to mind that it showed a similar effect by increasing the excretion of nitrogen with feces.

The effects of replacing dried orange pulp with different levels of ground corn on milk yield in dairy goats are given in Table 5. It was determined that the use of dried orange pulp at different levels instead of ground corn in the ration did not have any significant effect on the milk yield of the animals throughout the experiment ($P>0.05$).

Table 1. The composition and nutrient content of the concentrate feeds used in the experiment (Dry matter basis)

Feedstuffs	Control	7.5% Pulp	15% Pulp	22.5 Pulp
Barley	13.60	13.50	13.70	13.60
Ground corn	40.80	27.00	13.70	-
Dried orange pulp	-	13.50	27.40	40.90
Sunflower meal, 27% CP	4.20	4.10	4.20	4.20
Soybean meal, 44% CP	13.60	13.50	13.70	13.60
Cotton seed meal	12.90	12.80	13.00	12.90
Marble powder	1.50	1.40	1.50	1.50
Salt	0.70	0.70	0.70	0.70
Vibrotal	2.70	2.70	2.70	2.70
Urea	0.60	0.60	0.60	0.60
Vitamin-mineral mixture*	0.10	0.10	0.10	0.10
Nutrient content (%)				
Dry matter	90.43	89.94	90.34	90.09
ME (Kcal/kg) (MAFF, 1976)	2550	2330	2100	1890
Crude protein	19.28	19.32	19.17	19.33
Starch	43.50	33.78	24.60	14.94
Sugar	3.13	5.88	8.76	11.52
Ether extract	2.33	2.36	2.29	2.31
Ash	7.48	8.02	8.13	8.11
Crude fiber	22.53	22.57	22.60	22.59
ADF	14.17	14.06	14.19	14.11
NDF	24.22	24.09	24.16	24.19

* Per kg of vitamin–mineral mixture contains 50,000 mg of manganese sulphate, 50,000 mg of iron sulphate, 50,000 mg of zinc sulphate, 10,000 mg of copper sulphate, 150 mg of cobalt, 800 mg of iodine, 150 mg of Se, 150,000 mg of niacin, 15,000,000 IU of vitamin A, 3,000,000 IU of Vitamin D3 and 30,000 mg of Vitamin E.

Table 2. Nutrient content of dried orange pulp, alfalfa hay and corn silage used in trial rations (%)

Feed materials	Dry matter	Ash	Crude protein	Ether extract	Crude fiber	ADF	NDF
Dried orange pulp	89.77	4.22	5.77	1.13	12.13	16.89	18.06
Alfalfa hay	93.15	10.34	16.94	2.19	43.93	34.24	57.23
Corn silage	27.03	5.92	7.45	2.51	36.32	34.20	51.81

Table 3. Dry matter consumption of animals in the experiment

Weekly dry matter consumption (g)	Ground corn-dried orange pulp replacement levels				SED	Effects (P)		
	Control	7.5%	15%	22.5%		L	Q	C
1st Week	1774.58ab	1776.23ab	1825.73a	1706.93b	14.87	0.262	0.057*	0.120
2nd Week	1970.93	1968.45	2004.75	1982.48	12.58	0.535	0.968	0.397
3rd Week	1928.03b	2006.40a	1997.33ab	2020.43a	11.75	0.019*	0.253	0.269
4th Week	2179.65b	2367.75a	2347.13a	2369.40a	23.72	0.018*	0.096	0.250
5th Week	2104.58b	2332.28a	2351.25a	2360.33a	29.97	0.008*	0.083	0.467
6th Week	2134.28b	2374.35a	2374.35a	2407.35a	26.85	0.006*	0.098	0.319
7th Week	2088.08b	2245.65ab	2281.13ab	2376.00a	36.88	0.013*	0.675	0.588
8th Week	2217.60b	2371.88a	2379.30a	2281.95ab	26.08	0.400	0.026*	0.859

a. b. c: Significant effect on group averages indicated by different letters (P<0.05). SED: Standard error of difference between group averages. L: linear effect, Q: Quadratic effect, C: Cubic effect, *: P<0.05, **: P<0.01

Table 4. Body weight changes of the animals in the experiment

Weekly body weight chages (kg)	Ground corn-dried orange pulp replacement levels				SED	Effects (P)		
	Control	7.5%	15%	22.5%		L	Q	C
Initial body weight	56.72	54.68	54.94	55.24	1.465	0.754	0.695	0.865
Body weight change 1	-1.12a	-3.08ab	-5.90b	-5.86b	0.462	0.001**	0.562	0.820
Body weight change 2	-1.67a	-2.88ab	-5.42b	-4.58ab	0.516	0.036*	0.594	0.680
Body weight change 3	1.02	-0.20	-1.11	-1.63	0.610	0.120	0.780	0.989
Body weight change 4	0.13a	-2.14ab	-3.75b	-3.08ab	0.563	0.037*	0.205	0.752
Body weight change 5	0.61a	-0.58ab	-3.20b	-2.91b	0.563	0.017*	0.517	0.400
Body weight change 6	2.04	0.49	-1.82	-0.48	0.664	0.113	0.289	0.467
Body weight change 7	2.42	1.27	-1.18	0.40	0.656	0.163	0.310	0.374

a. b. c: Significant effect on group averages indicated by different letters (P<0.05). SED: Standard error of difference between group averages. L: linear effect, Q: Quadratic effect, C: Cubic effect, *: P<0.05, **: P<0.01

Table 5. Milk yield of the animals in the experiment

Weekly milk yield (ml)	Ground corn-dried orange pulp replacement levels				SED	Effects (P)		
	Control	7.5%	15%	22.5%		L	Q	C
1st Week	1175.00	1066.67	1258.33	1250.00	78.02	0.557	0.752	0.482
2nd Week	1337.50	1129.17	1445.83	1429.17	79.71	0.416	0.555	0.243
3rd Week	1454.17	1316.67	1525.00	1658.33	82.28	0.278	0.420	0.574
4th Week	1333.33	1225.00	1391.67	1650.00	82.95	0.148	0.282	0.807
5th Week	1487.50	1295.83	1341.67	1583.33	95.86	0.702	0.272	0.962
6th Week	1175.00	1208.33	1183.33	1416.67	88.18	0.385	0.577	0.692
7th Week	1116.67	1000.00	1000.00	1300.00	89.19	0.499	0.257	0.821
8th Week	1229.17	1083.33	1141.67	1270.83	103.29	0.845	0.513	0.887

a. b. c: Significant effect on group averages indicated by different letters (P<0.05). SED: Standard error of difference between group averages. L: linear effect, Q: Quadratic effect, C: Cubic effect, *: P<0.05, **: P<0.01

Table 6. Feed conversion rates of the animals in the experiment

Weekly feed conversion rates	Ground corn-dried orange pulp replacement levels				SED	Effects (P)		
	Control	7.5%	15%	22.5%		L	Q	C
1st Week	2.21	2.81	2.25	2.27	0.18	0.819	0.440	0.305
2nd Week	2.25	2.84	2.14	2.21	0.18	0.609	0.462	0.205
3rd Week	2.07	2.53	1.97	1.84	0.16	0.389	0.361	0.321
4th Week	2.50	3.23	2.56	2.21	0.19	0.380	0.176	0.336
5th Week	2.25	3.40	2.65	2.32	0.27	0.831	0.190	0.348
6th Week	2.84	3.82	3.04	2.64	0.31	0.618	0.271	0.439
7th Week	3.29	4.60	3.51	2.98	0.43	0.606	0.293	0.447
8th Week	3.02	4.77	3.51	3.10	0.50	0.821	0.293	0.397

a. b. c: Significant effect on group averages indicated by different letters (P<0.05). SED: Standard error of difference between group averages. L: linear effect, Q: Quadratic effect, C: Cubic effect, *: P<0.05, **: P<0.01

Table 7. Milk somatic cell counts of the animals in the experiment

Milk somatic cell count (cell/ml)	Ground corn-dried orange pulp replacement levels				SED	Effects (P)		
	Control	7.5%	15%	22.5%		L	Q	C
1st Week	130.50	176.17	83.92	147.42	18.40	0.804	0.811	0.090
2nd Week	124.92	168.67	103.67	154.08	13.76	0.857	0.905	0.084
3rd Week	96.58^{b}	149.50^{a}	108.67^{ab}	108.08^{ab}	11.50	0.055*	0.692	0.059
4th Week	86.33^{b}	145.92^{ab}	107.67^{ab}	170.25^{a}	10.11	0.029*	0.942	0.040*
5th Week	72.42^{b}	115.75^{ab}	100.00^{ab}	141.58^{a}	8.30	0.018*	0.959	0.132
6th Week	76.25^{b}	107.92^{ab}	89.67^{ab}	116.42^{a}	5.20	0.040*	0.815	0.055*
7th Week	83.50	117.08	94.67	120.83	5.89	0.105	0.756	0.061
8th Week	83.92	115.42	100.50	113.58	6.37	0.208	0.478	0.206

a. b. c: Significant effect on group averages indicated by different letters (P<0.05). SED: Standard error of difference between group averages. L: linear effect, Q: Quadratic effect, C: Cubic effect, *: P<0.05, **: P<0.01

Table 8. Blood glucose levels of the animals in the experiment

Blood glucose (mg/dl)	Ground corn-dried orange pulp replacement levels				SED	Effects (P)		
	Control	7.5%	15%	22.5%		L	Q	C
1st week	64.78	67.73	64.17	65.72	0.88	0.923	0.695	0.154
4th week	65.35^{a}	62.05^{ab}	56.82^{c}	58.80^{bc}	0.62	0.000**	0.045*	0.114
8th week	69.10^{a}	63.68^{b}	58.13^{c}	60.78^{bc}	0.66	0.000**	0.006**	0.1708

a. b. c: Significant effect on group averages indicated by different letters (P<0.05). SED: Standard error of difference between group averages. L: linear effect, Q: Quadratic effect, C: Cubic effect, *: P<0.05, **: P<0.01

Table 9. Blood cholesterol levels of the animals in the experiment

Blood cholesterol (mg/dl)	Ground corn-dried orange pulp replacement levels				SED	Effects (P)		
	Control	7.5%	15%	22.5%		L	Q	C
1st week	121.98	123.43	122.75	127.52	1.98	0.378	0.679	0.672
4th week	129.97^{a}	125.25^{a}	116.98^{b}	117.85^{b}	1.02	<.0001**	0.185	0.178
8th week	193.43^{a}	161.83^{b}	144.92^{c}	132.48^{c}	2.75	<.0001**	0.097	0.683

a. b. c: Significant effect on group averages indicated by different letters (P<0.05). SED: Standard error of difference between group averages. L: linear effect, Q: Quadratic effect, C: Cubic effect, *: P<0.05, **: P<0.01

Table 10. Blood NEFA levels of the animals in the experiment

Blood NEFA (mg/dl)	Ground corn-dried orange pulp replacement levels				SED	Effects (P)		
	Control	7.5%	15%	22.5%		L	Q	C
1st week	0.65	0.66	0.69	0.68	0.02	0.498	0.746	0.797
4th week	0.69[b]	0.75[ab]	0.83[a]	0.86[a]	0.09	0.024*	0.740	0.746
8th week	0.62[b]	0.64[ab]	0.74[a]	0.72[ab]	0.02	0.018*	0.514	0.177

a. b. c: Significant effect on group averages indicated by different letters (P<0.05). SED: Standard error of difference between group averages. L: linear effect, Q: Quadratic effect, C: Cubic effect, *: P<0.05, **: P<0.01

Table 11. Blood BHB levels of the animals in the experiment

BHB (mg/dl)	Ground corn-dried orange pulp replacement levels				SED	Effects (P)		
	Control	7.5%	15%	22.5%		L	Q	C
1st week	0.35	0.38	0.38	0.38	0.01	0.516	0.613	0.865
4th week	0.37[b]	0.44[b]	0.50[ab]	0.61[a]	0.02	0.002**	0.699	0.753
8th week	0.36[b]	0.45[ab]	0.57[a]	0.52[a]	0.02	0.004**	0.070	0.293

a. b. c: Significant effect on group averages indicated by different letters (P<0.05). SED: Standard error of difference between group averages. L: linear effect, Q: Quadratic effect, C: Cubic effect, *: P<0.05, **: P<0.01

It has also been reported by previous researchers that the use of citrus pulp in the diets of dairy animals does not significantly affect milk yield (Belibasakis and Tsirgogianni, 1996; Volanis et al., 2004). On the other hand, Peixoto et al. (2015) reported that the use of citrus pulp did not affect volatile fatty acids production or other rumen dynamics. In this case, it is thought that volatile fatty acids, which play an active role in shaping milk yield, are not sufficiently released in the rumen and sufficient resources cannot be sent to the liver to raise blood glucose levels. The low level of volatile fatty acid production in the rumen may cause by the orange pulp's increasing the ruminal flow rate (Fonseca et al., 2001), the suppressing of the rumen microorganisms by enteric oils in the pulp (Barrios-Urdanetat et al., 2003; Nam et al., 2006) or the rapid digestion of sugar and causing a sudden drop in pH and disrupting rumen dynamics.

The feed conversion ratios obtained from the study are given in Table 6. It was detected that the difference between the groups in all weeks in terms of feed conversion rates was statistically insignificant (P>0.05).

Although the feed consumption was high in the groups fed dried orange pulp, the lack of difference between milk yields caused the feed conversion rate to get worse. Even though orange pulp has similar amounts of energy (about 2980 kcal/kg DM) with cereals (Bampidis and Robinson, 2006), there are studies reporting that performance decreases by affecting rumen dynamics negatively or neutrally. Dried citrus pulp increases ruminal fluid flow and reduces dry matter digestion in the rumen (Fonseca et al., 2001), the use of dried citrus pulp instead of barley suppresses rumen bacteria (Barrios-Urdanetat et al., 2003), and citrus essential oils also have antimicrobial effects (Nam et al., 2006). Due to these reasons, it can be thought that a decrease in milk yield and a deterioration in feed efficiency rate occur, since enough volatile fatty acids will not be released in the rumen.

One of the quality indicators in milk is the number of somatic cells. The main cause of somatic cell count in milk is mastitis. The number of somatic cells due to this infection and the nutritional components of milk are inversely related. While the presence of mastitis reduces the milk composition, it also damages the milk secretion cells, causing deterioration of udder health, and subsequently a decrease in productivity or atrophy of the udder. Somatic cells obtained in the present study are given in Table 7. During the study, the differences between the groups in terms of somatic cell counts in the first and last two weeks were insignificant (P>0.05), while it was significant (P<0.05) in the middle of the experiment.

Due to the presence of apocrine secretion system in the mammary glands of goats, it is normal to have a high somatic cell count. Differences between the groups may be affected by the treatments as well as by other management factors. The quality of the litter got worse because of the rain and insufficient roof materials of the experimental area. It was stated that fresh lemon pulp utilisation did not affect the somatic cell count in ewes (Todaro et al., 2017), but stress factors and some vitamins may change the somatic cell count in milk. (Pulina et al., 2006).

The effects of replacement of dried orange pulp with ground corn in concentrate feeds on glucose, cholesterol, NEFA and BHB levels of blood taken from animals in the first, middle and last weeks of the current study are as follows. Throughout the study, it was observed that the blood glucose levels of the treatment groups were significantly (P<0.05) lower than the control group, and the treatments had a linear and quadratic effect in the week's bloods were taken (Table 8).

Although the dry matter consumption of the animals in the experiment was higher (P<0.05) than the control group, their milk yields were similar. On the other hand, live weight loss was observed in groups fed dried orange pulp. The main sources of blood glucose in ruminants are the volatile fatty acids released as a result of the fermentation of microorganisms in the rumen. In particular, easily fermentable sources such as starch and sugar in the diet are rapidly digestible in the rumen, increases the blood glucose level. Blood glucose is evaluated for live weight gain and milk production in dairy animals. Although the animals in the treatment groups consumed more dry matter, the milk yields were similar to the control group and the live weights have decreased. This reminds us that enough volatile fatty acids are not produced in the rumen. Production of volatile fatty acids varies depending on the composition of the diet, rumen dynamics, the number and variety of microorganisms in the rumen, and the time spent by the feed in the rumen. There are researchers who reported that citrus pulp increases the ruminal flow rate (Fonseca et al., 2001; Volanis et al., 2004). Therefore, it is thought that in the treatment groups, the feeds left the rumen quickly, and as a result, the blood glucose level decreased due to the inability to produce enough volatile fatty acids in the rumen. On the other hand, Nam et al. (2006) mentions the antimicrobial effect of enteric oils in citrus peels. These oils may have suppressed rumen microorganisms, reduced the production of volatile fatty acids, and caused a decrease in blood glucose levels.

The effect of using dried orange pulp in different levels instead of ground corn in the diets of dairy goats on blood cholesterol level is given in Table 9. It is seen that the replacement of corn with dried orange pulp at different levels significantly ($P<0.05$) reduced blood cholesterol levels.

The acetate released in the rumen by the degradation of the fibers and the pectin found in the orange pulp may have provided this effect. Pectin's degradation lasts later than other structural carbohydrates in the rumen. At the same time, it is known that citrus pulp increases the rumen flow rate and reduces the residence time of the feeds in the rumen. For these reasons, acetate formation may have been interrupted and blood cholesterol levels may have decreased in groups fed orange pulp. Consistent with the present findings, some researchers also stated that dried citrus pulp reduces cholesterol levels in dairy animals (Belibasakis and Tsirgogianni, 1996; Caparra et al., 2007). Also, Brouns et al. (2012) reported that pectin, which is a viscous fibre, can reduce the amount of cholesterol due to its physico-chemical properties such as its consistency, molecular weight, or esterification degree.

NEFA generally refer to free fatty acids in the blood. NEFA levels of blood taken from experimental animals at the 1^{st}, 4^{th} and 8^{th} weeks of the current study period are presented in Table 10. In the 4^{th} and 8^{th} weeks, it was determined that the effect of the treatment on blood NEFA levels were significant ($P<0.05$).

In general, dry matter consumption was higher in the treatment groups, milk yields were similar to the control group, but the body weight changes were shaped against the treatment groups. At this point, it is understood that the animals cannot replace the energy they lost with the consumed feed, so they enter the negative energy balance and apply to their body reserves. Blood NEFA results from the current study are similar to studies using dried citrus pulp by Cribbs et al. (2015) and Pinheiro et al. (2021).

Another negative energy indicator in dairy animals is the level of β-Hydroxybutyric acid (BHB), one of the ketone substances in the blood. The blood BHB levels obtained from the present study are listed in Table 11. As it is seen from the table, the use of dried orange pulp instead of ground corn increased the level of BHB in the blood.

Even though, orange pulp contains sugar, the fact that it is rich in pectin, which is one of the structural carbohydrates, and the degradation of these structures in the rumen is more difficult, causes the body to apply to body fat reserves due to insufficient energy supply and therefore decrease in blood glucose level. On the other hand, the lack of sufficient volatile fatty acid synthesis because of the suppression of rumen microorganisms or increasing the rumen flow rate may have contributed to this result. Similarly, other researchers found that the blood BHB level increased in animals fed with dried citrus pulp (Castro et al., 2019; Ebrahimi et al., 2020; Pinheiro et al., 2021).

Conclusion

In conclusion, it has been determined that dried pulp will encourage feed consumption due to its aromatic components. However, it has been observed that it negatively affects rumen dynamics because of increasing rumen flow rate and suppressing rumen microorganisms with its enteric oils. For this reason, it has been detected that it does not provide energy to animals as much as ground corn. In order for it to be considered as a cheap alternative in the diet, it may be recommended to keep its level lower or to use it with different energy sources that do not break down the rumen dynamics.

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Conflict of Interest

The author declared no conflict of interests.

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