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Effects of Different Olive Cake by Products on Dry Matter Intake, Nutrient Digestibility and Performance of Zel Sheep

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ABSTRACT

Toweny four similar Zel ewes (~26.51 kg body weight) from one farm were evaluated for the effects of different olive cake by products on fattening performance. The experiment consisted of three 30 days periods. Diets had 30:70 of forage: concentration ratio and contained 30, 30, 10, 9.5, 0.3, 0.1, 0.1 and 20% of dry matter of alfalfa, barely, beet pulp, wheat bran, dicalcium phosphate, vitamin premix and salt and one type of olive cake, respectively. Four different olive cake by products including crude, the exhausted, partly destoned and partly destoned exhausted olive cake were included in experimental rations. Water and mineralized salt stone were available for ewes during experiment. Ewes were housed in sheep feedlot cage and fed ad libitum, twice daily at 0900 and 2100. Live weights, feed consumptions, nutrients digestibility, growth rate and feed conversation for lambs were determined over every 30 days. All olive by products had high neutral detergent fiber (NDF, 68.9, 71.3, 50.3 & 54.3), acid detergent fiber (ADF, 51.2, 56.5, 30.5 & 36.3) and lignin (31.3, 32.3, 22.5 & 27.1%) of dry matter in crude olive cake, partly destoned olive cake, exhausted olive cake and partly destoned exhausted olive cake, respectively). There were significant differences on dry matter intake between treatments over the experiment. The animals fed with partly destoned olive cake had significantly higher dry matter intake, digestibility of DM, NDF and crude protein of ration. There were no significant differences on initial body live weight of sheep, but there were significant difference on body weight, growth rate and feed conversation between treatments over the first, second, third periods and overall the experiment. In conclusion, on the basis of our results, we can state destoned olive cake may have better nutritive value than the others olive cake by products and it has improved body weight gain, growth rate and feed conversations.

Key Words: Destoned olive cake; Screening; Lamb fattening; Zel

INTRODUCTION

Considerable quantities of olive cake by products that are suitable for feeding to livestock are generated every year in Mediterranean countries. However, due to lack of technical knowledge they are lost or under utilized, it is limited, because of the lack of information about their nutritive value. The nutritive value of this by product varies greatly with the processing system. The main factor that influenced nutritive value in ruminant is the ruminal digestible fraction of feed. Its poor digestive and metabolic utilization is probably due mainly to its high lignin content and technical process for oil extraction in which it is frequently subjected to high heat.

Appling a new system in olive oil extraction generates large amounts of a new by product, called two-stage olive cake, which includes the remainders of pulp, stones, skin and vegetable waters (Sansoucy *et al.*, 1985). This by product is often extracted and dried and the stones are partially removed. Therefore, there are different types of olive by products as crude, the exhausted, partly destoned and partly destoned exhausted olive cake for using in ruminant nutrition, but their use is limited because of their low nutritive value (Sansoucy *et al.*, 1985), high NDF and ADF (Nefzaoui, 1983), condensed tannins (Martin Garcia *et al.*, 2003), seasonality (Sansoucy *et al.*, 1985) and low degradability of cell wall component (Filya *et al.*, 2006b; Teimouri Yansari *et al.*, 2007). Teimouri Yansari *et al.* (2007) found that the DM degradation degradability parameters including soluble fraction (a; 7.83, 8.85, 11.05 & 14.40%), slowly digestible fraction (b; 24.33, 25.45, 29.80 & 31.45%), potentially degradable fraction (32.16, 34.30, 40.85 & 45.85%), fractional rate of disappearance (K_d; 2.8, 3.0, 4.1 & 4.2%/h) and effective degradability in crude, the exhausted, partly destoned and partly destoned exhausted olive cake, respectively were significantly different. The protein in different olive by products had the lowest degradable fraction and rate however, the NDF and crude protein had similar trend to DM. The results of previous experiment showed a high variation on the nutritive value of olive cakes. However, little information exists about nutrients utilization of different olive cakes by products in

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ruminants. Therefore, the present study was designed to evaluate the effects of different olive cake by products on voluntary dry matter intake, nutrient digestibility and performance of growing Zel sheep.

MATERIALS AND METHODS

Fours types of olive cake including crude olive cake, partly destoned olive cake, exhausted olive cake and partly destoned exhausted olive cake used in this experiment, were prepared from feed manufacture of Gulian province, Iran.Samples were dried at 55°C, ground through a Wiley mill (1 mm screen pore size), analyzed for DM, OM, Kjeldahl N, ether extract (AOAC, 1990), NDF, ADF (Van Soest *et al.*, 1991; using heat stable amylase & sodium sulfite) and ash at 605°C at 3 h. NFC was calculated by 100-(%CP + %NDF + %Ash + %EE) (Table I).

This experiment was carried out at the dairy barn of University of Agricultural and Bioresoure, Sari, Iran. Toweny four similar Zel ewes (BW = 26.51 ± 0.62 kg) from one farm were allotted to six replicates of a complete randomized design. The experiment consisted of three 30 days periods. Diets had 30:70 of forage: concentration ratio and contained 30, 30, 10, 9.5, 0.3, 0.1, 0.1 and 20 % of DM of alfalfa, barely, beet pulp, wheat bran, dicalcium phosphate, vitamin premix and salt and one type of olive cake, respectively. Four different olive cake by products including crude (T1), the exhausted (T2), partly destoned (T3) and partly destoned exhausted (T4) olive cake were included in experimental rations. Water and mineralized salt stone were available for ewes over experiment. Diets were formulated using the CNCPS system to supply adequate NE_m, NE_g and protein for a 27 kg ewes growing 0.200 kg day^{-1}. Ewes were housed in sheep feedlot cage and fed ad libitum, twice daily at 0900 and 2100, allowing for at least 10% orts (as-fed basis).

The body weight of ewes was taken at monthly intervals. The dry matter intake (DMI) was measured daily for all ewes over the experiment (Table II). At the end of each period, at 25 to 30 days, daily samples of TMRs and orts were collected, dried at 55°C, ground through a Wiley mill (1 mm mesh size) and composited by animal within a period. Total feces were collected from all ewes for 5 days at each period (d 25 to 30) dried at 55°C and ground through a Wiley mill (1 mm mesh size). Feed, feces and orts were analyzed for DM, OM, Kjeldahl N, ether extract, ash at 605°C (AOAC, 2002), NDF and ADF (Van Soest *et al*., 1991). Non fibrous carbohydrate was calculated by 100-(%CP + %NDF + %Ash + %EE) (NRC, 2001; Table I). Using the chemical components of TMRs and feces, intake and digestibility of nutrients were calculated (Table II).

The data were analyzed by a complete randomized design as four types of olive cake in rations were considered as treatment using the GLM procedure of SAS® (1998). Means were separated using Duncan's multiple range test ($P<0.05$).

RESULTS AND DISCUSSION

Chemical composition of different olive cakes were significantly different (Table I). Destoning and exhausting significantly increased CP content of olive cake, therefore, partly destoned exhausted olive cake had the highest CP content. Crude olive cake had a low crude protein, high crude fiber, NDF, ADF and a relatively high fat content. Exhaustion decreases fat content and relatively increases crud protein, other contents. In addition, partial destoning lowers its crude fiber content (Table I). All olive by products had high NDF (68.9, 71.3, 50.3 & 54.3), ADF (51.2, 56.5, 30.5 & 36.3) and lignin (31.3, 32.3, 22.5 & 27.1%) of DM in crud olive cake, partly destoned olive cake, exhausted olive cake and partly destoned exhausted olive cake, respectively). Destoning and exhaustion of olive cake significantly decreased and increased cell wall content. In contrast, NFC content of olive cake significantly decreased by destoning, without any effect from exhaustion. The chemical composition of different types of olive by products has similar trend that reported by Sansoucy *et al*. (1985). Maymone *et al*. (1961) found that pulp or mesocarp had the highest oil content and stone or endocarp had the highest crude fiber, NDF and ADF content in of ripe olive. Therefore, chemical compositions of different types of olive cake are function of proportion of that pulp or mesocarp to stone or endocarp. Sansoucy *et al*. (1985) reported that crude olive cake has a low crude protein, high crude fiber and a relatively high fat content. Exhaustion by solvent extraction decreases its fat content and relatively increases its other contents. Partial destoning lowers its crude fiber content. As mentioned above, the crude fiber content in destoned olive cake is high. Partial destoning decreases the content considerably but even pure pulp contains about 20% crude fiber. Alibes and Berge (1983) found that olive cake has high NDF, ADF and lignin contents. In addition, a large proportion of the proteins (80 to 90%) are linked to the ADF (Nefzaoui, 1983) and only 1.5 to 3% of total nitrogen has particularly low solubility (Sansoucy *et al.*, 1985). Martin Garcia *et al.* (2003) found that the olive cake and leaves were rich NDF (62.4 & 41.3% of DM, respectively) and gross energy (18.7 & 16.8 MJ kg^{-1} DM, respectively) and poor in CP (7.9 & 7.0% of DM, respectively) and a great part of the N attached to the ADF fraction (70.6 & 53.3% of crud protein, respectively). The tannin content was higher in olive cake than in olive leaves (1.38 & 0.83% of DM, respectively).

There were significant differences on DMI between treatments over the experiment in this study. The animals that fed with partly destoned olive cake had significantly higher dry matter intake (Table II). In addition, destoning significantly increased dry matter intake in compare to others treatments. The lowest dry matter intake was seen in T1 that contained crude olive cake. Dry matter intake in T4 was lower than T3, that is result of higher palatability and fat content of partly destoned olive cake in compare to

Table I. Chemical composition of different types of olive cake

Chemical compositions	Types of olive cake			
	Crud olive cake	Exhausted olive cake	Partly destoned olive cake	Partly destoned exhausted
Dry matter	87.6	86.7	88.1	87.5
Crud protein	7.6c	7.2c	8.8b	9.7a
Crud fiber	38.7a	39.6a	22.1b	21.4b
Ether extract	5.7b	3.4c	6.4a	3.3c
Crud ash	7.4	8.1	7.6	8.4
NFE	40.6b	41.7b	55.1a	57.2a
Neutral detergent fiber	68.9a	71.3a	50.3b	54.3b
Non fibrous carbohydrate	10.4b	10.0b	26.9a	24.3a
Acid detergent fiber	51.2b	56.5a	30.5d	36.3c
Lignin	31.3a	32.3a	22.5c	27.1b

[a, b, c] Means within a row with different subscripts differ ($P < 0.05$).

Table II. Feed intake and digestibility of nutrients of rations in Zel ewes that fed different olive cake by-products over the experiment

Item	Treatments				SEM	P-Value
	1	2	3	4		
Dry matter intake (kg day^{-1})						
0 - 30 day	1.755b	1.795ab	1.882a	1.782ab	0.015	0.0192
30 - 60 day	1.844b	1.873b	1.935ab	1.981a	0.004	0.0255
60 - 90 day	2.050b	1.970b	2.222a	2.030b	0.016	0.0005
Overall	1.869b	1.879b	2.030a	1.931b	0.042	0.0016
Digestibility of dry matter (%)						
0 - 30 day	66.06b	67.03b	73.45a	74.19a	2.477	<0.0001
30 - 60 day	66.66b	67.54b	73.20a	73.97a	3.112	0.0032
60 - 90 day	66.82b	67.52b	73.75a	73.45a	3.211	0.0021
Overall	66.51b	67.36b	73.47a	73.87a	2.930	<0.0001
Digestibility of Neutral detergent fiber (%)						
0 - 30 day	32.04b	33.23b	43.35a	41.19a	2.763	<0.0001
30- 60 day	31.36b	32.21b	42.12a	44.97a	2.672	<0.0001
60-90 day	30.42b	31.72b	41.55a	43.45a	2.422	0.0003
Overall	31.27b	32.39b	42.34a	43.20a	2.619	0.0003
Digestibility of Crude protein (%)						
0 - 30 day	41.66b	43.11b	47.32a	48.33a	2.040	0.0001
30- 60 day	42.34b	42.57b	46.44a	47.14a	2.109	0.0026
60-90 day	42.30b	41.35b	47.11a	49.34a	2.432	0.0018
Overall	42.10b	42.34b	46.96a	48.27a	2.190	0.0002

[a, b, c] Means within a row with different subscripts differ ($P < 0.05$).

Table III. Body weight, growth rate and feed conversation in of Zel ewes that fed different olive cake by-products over the experiment.

Item	Treatments				SEM	P-Value
	1	2	3	4		
Body Weight (kg/day)						
0 - 30 day	26.28	26.55	26.75	26.44	0.617	0.6069
30- 60 day	30.33b	30.58b	31.98a	30.38b	0.145	0.0046
60-90 day	34.55b	34.88b	37.13a	34.50b	0.187	0.0006
Overall	39.00b	38.88b	42.58a	38.95b	0.223	0.0001
0 - 30 day	12.73b	12.33b	15.38a	12.51b	0.337	0.0006
Growth Rate (kg/day)						
0 - 30 day	0.135b	0.134b	0.174a	0.131b	0.004	0.0460
30- 60 day	0.141b	0.130b	0.171a	0.139b	0.004	0.0452
60-90 day	0.148b	0.133b	0.181a	0.148b	0.041	0.0086
Overall	0.141b	0.137b	0.176a	0.139b	0.025	0.0006
Feed conversation						
0 - 30 day	7.696b	7.470b	9.254a	7.357b	0.254	0.0099
30- 60 day	7.475b	7.637b	8.848a	6.937b	0.188	0.0229
60-90 day	7.330b	6.772b	8.185a	7.307ab	0.295	0.0068
Overall	7.457b	7.282b	8.736a	7.207b	0.139	0.0060

[a, b, c] Means within a row with different subscripts differ ($P < 0.05$).

partly destoned exhausted olive cake. Also, inclusion of destoned olive cake significantly increased digestibility of DM, NDF and crude protein of ration. Therefore, T3 and T4 had significantly higher digestibility coefficients than T1 and T2 for, NDF and crude protein of ration over the all periods and the experiment (Table II). In addition, Filya *et al*. (2006b) and Teimouri Yansari *et al*. (2007) found that destoning of olive cake significantly decreased cell wall content and in contrast, increased NFC content. Filya *et al*. (2006b) evaluated the effects of procedures of milling and milling-screening on feed value of dried olive cake, using *in situ* nylon bag method. The milling and milling-screening processes increased contents of DM, crude ash, OM, CP, crude fat and nitrogen free extracts, while decreased crude cellulose, NDF, ADF, ADL and hemicellulose contents of olive cake. Metabolizable energy values were 1193.75 and 1188.36 kcal kg^{-1} of DM for un-treated and milled olive cake, respectively were increased to 1560.73 kcal kg^{-1} of DM in milled-screened olive cake. The milled-screened procedure increased the rumen degradability of DM, organic matter, NDF, ADF and acid detergent lignin of olive cakes. Teimouri Yansari *et al*. (2007) evaluated the ruminal DM, crud protein and NDF degradability of raw, exhausted, partly destoned and partly destoned exhausted olive cake by products, using nylon bag technique. They found that destoning and exhausting significantly increased crude protein content of olive cake. Therefore, partly destoned exhausted olive cake had the highest crud protein content. Crude olive cake had a low crude protein, high crude fiber, NDF and ADF and relatively high fat content. Partial destoning lowers its crude fiber, NDF and ADF. They reported that destoning significantly increased the soluble fraction, slowly digestible fraction, potentially degradable fraction, fractional rate of disappearance and effective degradability for DM, NDF and crude protein of crude olive cake. Maymone *et al.* (1961) found that pulp or mesocarp had the highest oil content and stone or endocarp had the highest crude fiber, NDF and ADF content in of ripe olive. Therefore, chemical compositions of different types of olive cake are function of proportion of that pulp or mesocarp to stone or endocarp. Sansoucy *et al*. (1985) reported that crude olive cake has a low crude protein, high crude fiber and a relatively high fat content. Exhaustion by solvent extraction decreases its fat content and relatively increases its other contents. Partial destoning lowers its crude fiber content. As mentioned above, the crude fiber content in olive cake is high. Partial destoning decreases the content considerably but even pure pulps contain about 215 g kg^{-1} crude fiber.

Not only olive cake had high NDF, ADF and lignin contents, but also a large proportion of the proteins (800 to 900 g kg^{-1} of protein) are linked to the ADF (Nefzaoui, 1983) and only 15 to 30 g kg^{-1} total nitrogen has particularly low solubility (Sansoucy *et al*., 1985). Martin Garcia *et al*. (2003) found that the olive cake and leaves were rich in NDF (624 & 413 g kg^{-1} DM, respectively) and gross energy (18.7 & 16.8 $MJkg^{-1}$ DM, respectively) and poor in crude protein (79 & 70 g kg^{-1} DM, respectively) that a great part of the nitrogen attached to the ADF fraction (706 & 533 g kg^{-1} crude protein, respectively). In addition, the present of phenolic compounds in olive cakes by products is related to lower voluntary feed intake and digestibility of their nutrients content. Information concerning the amount and types of phenolic compounds in olive by product and destoned olive cake nutrients availability is scarce in comparison to raw olive cake. However, olive cakes obtained after destoning had lower total phenol and tannin content than the raw olive cakes. Additionally, phenolic compounds could covalently bind mainly to sulphur amino acids, while tannins are phenolic secondary compounds in plants that are able to complex with proteins (Broderick & Albrecht, 1997) and also directly or indirectly the carbohydrates (Porter, 1989). It could be hypothesized that tannin and phenolic components limit the nutritive availability of carbohydrates and protein for olive cakes.

There were no significant differences on initial body live weight of sheep, but there were significant difference on body weight, growth rate and feed conversation between treatments over the first, second, third periods and overall the experiment (Table III). The values of body weight, growth rate and feed conversation in T3 and T4 were significantly greater than T1 and T2. It seems that lower NDF, ADF, lignin, higher digestibility and higher palatability are the reason of these phenomena. Filya *et al*. (2006a) evaluated the effects of dried, milled and screened olive-cake on fattening performance of lambs that fed on the ration contained 0.0, 50, 100, 150 and 200 g kg^{-1} DM olive cake during 70 days of fattening period. They found that total and daily live weight gains and feed conversion ratio had no significant differences for lambs were fed control and consumed 50, 100 and 150 g/kg olive cake. However, total and daily live weight gains and feed conversion ratio of the lambs of consumed 200 g kg^{-1} olive cakes were found less than control and the lambs of consumed 50 and 100 g kg^{-1} olive cakes. They concluded that increased crude fiber and ash contents in the group of consumed 200 g kg^{-1} olive cake had an effect on these results. In addition, they suggested that as a result, raw olive cake can be used successfully maximumally up to 150 g kg^{-1} in the lamb fattening diets. Using diet containing 200 g kg^{-1} olive cakes, Ragni *et al*. (2003) found that feeding treatments determined quite similar growth performances to control. No statistical differences aroused between treatments regarding final body weight achieved, feed intake or feed conversion index. Data obtained at slaughtering showed that pH values were measured on the of *longissimus lumborum* muscle at slaughtering and following 24 h refrigeration were markedly higher in the control group than in lambs fed olive cake. Moreover, Ragni *et al.* (2003) found that olive cake enhanced the net cold dressing percentage compared to the control feeding and incidence of the neck cut in the control group, but a greater proportion of the lumbar region in

lambs. Additionally, Omar *et al*. (1995) employed different percentages of olive cake supplementation for lamb feed (from 100 to 400 g kg^{-1} DM); found no significant differences between the distributions of the tissue components within the pelvic limb.

CONCLUSION

The results of these experiment have explained that low degradable fraction of DM, crud protein and NDF of olive by products are the most important limitation factors in ruminant nutrition, however, destoning of olive cake significantly increased the its digestible content and nutritive value. On the basis of our results, destoned olive cake may have higher nutritive value than the others olive cake by products and it has improved body weight gain, growth rate and feed conversations.

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