Effect of Feeding Olive Cake in Complete Diet on Performance and Nutrient Utilization of Lambs

A. N. Owaimer, M. S. Kraidees, M. Al-saiady, S. Zahran and M. A. Abouheif*
Animal Production Department. College of Agriculture. P.O. Box 2460. King Saud University
Riyadh 11451. Saudi Arabia

ABSTRACT : Forty-five Najdi ram lambs were equally and randomly allotted to five dietary groups with three replications per diet to evaluate the effect of feeding olive cake in complete diet on nutrient digestibility, growth performance and carcass characteristics. The diets were: a whole-mixed control diet (C) containing 12% wheat straw and four diets: namely O, ON, OU and OUE, where crude olive cake, 3% NaOH-treated olive cake, 5% urea-treated olive cake (U) and ensiled U, respectively were incorporated to replace the wheat straw of C diet. The results showed that the digestibility of DM, CP, EE and NFE and TDN were higher ($p<0.05$) in OUE diet as compared to the control diet; there were no changes ($p>0.05$) in the corresponding values between O, ON and OU diets. The nutrient digestibilities, body weight gain, feed efficiency and Longissimus area were significantly ($p<0.05$) lower in ON diet as compared to other experimental diets. Average daily DM intake and weight gain were higher ($p<0.05$) in lambs fed O, OU and OUE diets than those fed C diet. The moisture and protein contents in the soft tissue from ON treatment were lower ($p<0.05$) than those tissues from C, O, OU and OUE treatments. In conclusion, these results indicated that crude olive cake is a better substitute of wheat straw when fed to growing lambs. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 4 : 491-496)***

Key Words : Olive Cake, Performance, Carcass, Digestibility, Najdi Lambs

INTRODUCTION

To mitigate the shortage of feeds and fodders and to make animal production profitable, efforts have been made on improvements and utilization of agro-industrial products and non-conventional feeds. Among the various agro-industrial products, crude olive cake is available in appreciable quantities in northern Saudi Arabia and can form a roughage source for the ruminants. The use of crude olive cake, a mixture of skins, pulp, woody endocarp and seeds obtained after the extraction of oil, in animal feeding is limited because of its low nutritive value (Aguilera et al., 1992) and seasonal availability (Sansoucy, 1987; Hadjipanayiotou, 1994). Attempts were therefore concentrated on the development of methods for upgrading the nutritional worth of crude olive cake and its subsequent utilization in balanced ruminant rations. Several reports have showed that crude olive cake when ensiled either alone or in combination with other conventional or non-conventional ingredients produces good quality and palatable fodder (Hadjipanayiotou, 1994; Hadjipanayiotou and Koumas, 1996; Hadjipanayiotou, 1999). Similarly, chemical treatments with NaOH (Nefzaoui et al., 1983) and urea (Hadjipanayiotou and Koumas, 1996; Jassim et al., 1997) have been used for attaining a greater and improved utilization of crude olive cake. Present study was, therefore, conducted to assess the potential of feeding olive cake treated by various methods as substitute for wheat straw in complete diet on nutrient digestibility and growth performance of Local Najdi ram lambs.

* Corresponding Author: M. A. Abouheif. Tel: +966-1-4678487, Fax: +966-1-4678474, E-mail: abouheif@hotmail.com
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MATERIALS AND METHODS

Preparation of treated-olive cakes

Fresh olive cake collected from modern olive oil extraction plant at Al Watania Agricultural Company was used for the preparation of treated olive cakes Olive cake is the residue obtained at the mill after extracting the oil by pressing the whole olive fruits; thereafter, crude olive cake (OC) was prepared simply by sun drying for 3 days till 10% moisture content was attained. During this period, OC was turned upside down 2 to 3 times a day. NaOH-treated olive cake (N) was prepared by spraying fresh olive cake with 100 ml of 30% (w/v) NaOH solution per kg DM of olive cake. Urea-treated olive cake (U) was prepared by spraying fresh olive cake with 100 ml of 50% (w/v) urea solution per kg DM of olive cake. Ensiled urea-olive cake (EU) was prepared by placing U in a plastic barrel of 0.5 m^3 capacity. The materials in the barrel were then well pressed and covered with a black polyethylene sheet and a 10-15 cm layer of soil was placed over the plastic sheet; thereafter, the barrel was opened after a period of 30 days. Sun drying procedures for N, U and EU were similar to the one used for OC. Chemical compositions of OC, N, U, and EU are presented in Table 1.

Feeding trial

A total of 45 Najdi ram lambs, weighing an average of 26.7 kg, were used to study the potential of feeding olive

Table 1. Chemical composition (% DM) of crude and treated-olive cakes used in the experimental diets

Item	Olive cake treatment[1]			
	OC	N	U	EU
DM	88.02	93.24	93.42	93.27
OM	84.43	79.33	83.18	82.96
CP	6.54	6.58	23.98	19.98
CF	42.61	39.11	42.13	41.35
EE	4.64	0.99	4.85	4.54
NDF	89.36	77.71	82.27	81.01
ADF	68.21	66.86	66.66	65.26
NFE	30.64	32.65	15.22	17.12
Lignin	23.45	23.19	24.39	23.51
Ash	15.57	20.67	16.82	17.04

[1] OC=crude olive cake; N=3% NaOH-treated-olive cake; U=5% urea-treated olive cake; EU=ensiled 5% urea-treated olive cake.

cake treated by various methods as a substitution for wheat straw in complete diet on growth performance, nutrient digestibility, nitrogen balance and carcass characteristics. Lambs were stratified by weight and randomly allotted to five treatment groups with nine lambs per dietary treatment. Lambs of each treatment group were equally divided into three replicates; each replicate was housed in a concrete-floored pen in an open-sided building. The dietary treatments were: a whole-mixed control diet containing 12% of wheat straw, and four dietary treatments where OC, N, U and EU were incorporated as substitution for wheat straw in O, ON, OU and OUE diets, respectively. The experimental diets were prepared as mixed diet in mash form consisting of 75% concentrate and 25% roughage; the dietary ingredients (Table 2) were ground through a 4.76 mm screen and mixed thoroughly in a stainless steel vertical mixer.

A preliminary feeding period of 15 days were allowed to accustom the lambs to the designated new diet and new surrounding; during this period, lambs were dewormed and vitamin A-D-E injections were given. Upon initiation of the feeding trial, an adequate amount of feed was weighed at the beginning of each week into a plastic container for each replicate. From these, a sufficient amount of feed was offered three times daily and adjusted as needed to minimize refusals; remaining refusals of each time were remixed into the fresh diet that was offered next time. Refusals were removed at the end of each week, weighed, sampled for DM determination and then discarded. Throughout the experiment, feed consumption data was recorded weekly and lambs were weighed once in a fortnight before offering any feed.

Digestibility and nitrogen balance study

After 35 days of feeding trial, a metabolism study was conducted with 15 rams to determine digestibility and nutritive value of each experimental diet. Rams were randomly selected and withdrawn from the feeding trial at

Table 2. Ingredients and chemical composition of experimental diets (% DM)

Item	Experimental diets[1]				
	C	O	ON	OU	OUE
Ingredients:					
Wheat straw	12.0	-	-	-	-
Alfalfa hay	13.0	13.0	13.0	13.0	13.0
Olive cake[2]	-	12.0	12.0	12.0	12.0
Barley	55.0	55.0	55.0	55.0	55.0
Maize	6.6	7.6	7.6	13.0	11.4
Soybean meal	10.6	9.6	9.6	4.2	5.8
Mineral supplement[3]	2.6	2.6	2.6	2.6	2.6
Trace mineral[4]	0.2	0.2	0.2	0.2	0.2
Chemical composition:					
CP	17.4	17.1	17.2	17.1	17.2
CF	10.2	11.4	11.3	11.2	11.3
NDF	42.0	43.2	41.8	41.2	40.4
ADF	15.2	17.4	17.5	16.9	16.8
NFE	62.2	61.3	60.1	60.8	61.6
EE	2.0	2.1	1.6	2.2	2.1
Ash	8.2	8.1	9.8	8.7	7.8

[1] C=control diet; O=crude olive cake; ON=3% NaOH-treated-olive cake; OU=5% urea-treated olive cake; OUE=ensiled 5% urea-treated olive cake.
[2] Representing OC, N, U and EU in the O, ON, OU and OUE diets, respectively.
[3] Composed of 35% sodium bicarbonate; 30% ground limestone; 20% dicalcium phosphate; 15% sodium chloride.
[4] Contained per kg: $CoSO_4$, 0.30 g; $CuSO_4$, 20.1 g; $FeSO_4$, 10.0 g; ZnO, 50.0 g; $MnSO_4$, 40.2 g; KI, 0.75 g; NaCl, 878.65 g; vitamin A, 500,000 IU; vitamin D, 500,000 IU; vitamin E, 10,000 IU.

the rate of one ram per each replicate, fed *ad libitum* and individually confined in false-bottom metabolic crates to facilitate separate collection of total feces and urine. A preliminary period of 3 days in order to accustom the lambs to new surrounding followed by 7 days collection period was conducted. Weights of feed offered and ort were recorded daily, sampled, ground to pass through a 1 mm screen and stored. Feces voided were collected before feeding in the morning, weighed and a 10% aliquot of total feces was dried at 65°C for 24 h. The dried samples were ground through a 1 mm screen and stored for later analyses. Total daily urine outputs of each ram was collected in a plastic bucket containing 100 ml 6 N HCl to prevent nitrogen loss and a 10% aliquot was sampled; at the end of collection period, samples of urine of each ram were mixed for nitrogen determination.

Carcass study

Lambs were slaughtered after 9 weeks of feeding. Slaughtering was carried at the King Saud University's abattoir after 18 h shrink without feed. Live body and hot carcass weights were obtained from all lambs at the time of slaughter. After the carcasses were chilled for 48 h, the following measurements were obtained: 1) longissimus area taken by direct grid reading of the longissimus muscle at the 12th rib; 2) fat thickness over the center of the

Table 3. The effect of replacement of wheat straw with olive cake treated by various methods on nutrient digestion and nitrogen utilization by Najdi lambs

Parameter	Dietary treatment[1]					
	C	O	ON	OU	OUE	SEM
Apparent digestibility (%)						
DM	75.85^{b}	75.97^{b}	72.38^{b}	73.96^{b}	79.14^{a}	1.71
OM	76.99^{bc}	78.04^{ab}	74.41^{c}	76.47^{bc}	80.62^{a}	1.63
CP	68.30^{bc}	68.82^{bc}	67.99^{c}	71.70^{b}	77.91^{a}	1.29
CF	53.36	49.32	48.23	48.85	50.54	2.61
NDF	68.59^{a}	69.22^{a}	58.83^{b}	67.80^{a}	68.67^{a}	3.13
ADF	49.59^{a}	47.04^{a}	38.44^{b}	39.54^{a}	51.50^{a}	2.84
EE	77.06^{b}	83.33^{a}	83.92^{a}	83.19^{a}	82.05^{a}	2.33
NFE	83.54^{b}	84.45^{b}	83.47^{b}	84.84^{b}	87.16^{a}	1.91
Nutritive value						
TDN (%)	69.21^{b}	72.25^{b}	68.17^{b}	70.31^{b}	76.46^{a}	1.52
DCP (%)	11.89	11.78	11.62	12.31	12.93	0.45
Nitrogen balance						
N intake, g/d	31.91^{c}	44.54^{a}	37.54^{b}	39.28^{b}	39.54^{b}	1.08
N retained, % intake	22.56^{b}	21.42^{b}	20.75^{b}	21.26^{b}	25.90^{a}	1.36

[1] C=control diet; O=crude olive cake; ON=3% NaOH-treated-olive cake; OU=5% urea-treated olive cake; OUE=ensiled 5% urea-treated olive cake.
[a, b, c] Means in the same row bearing different superscripts differ ($p<0.05$).

longissimus muscle; 3) body wall thickness 11 cm lateral to the dorsal process between the 12th and the 13th ribs. Thereafter, the 9-11th rib joint was separated from the right side of each carcass and physically separated into bone and soft tissues. The soft tissues were ground through a 4 mm plate, mixed and reground again. During the second grinding, 3 subsamples 10-12 g were taken from each carcass to form 30-35 g sample that was placed in a plastic bag, frozen and stored at -20°C for chemical analyses.

Chemical and statistical analysis

Samples of experimental diets, feces and urine and ground soft tissues were analyzed for moisture, ash, ether extract and crude protein according to AOAC (1990). NDF and ADF were determined according to Goering and Van Soest (1970). Growth performance, carcass characteristics and digestibility data were statistically analyzed by ANOVA using GLM procedures (SAS, 1988). Duncan's multiple range test was used to test for significant differences among means.

RESULTS AND DISCUSSION

The chemical compositions of crude and treated-olive cakes utilized in the experimental diets are presented in Table 1. Except for ash content, the chemical composition of OC was comparable with those values reported by Hadjipanayiotou (1994 and 1996) and Jassim et al. (1997). The high ash content was probably due to the contamination of fresh cake with sand during the sun-drying. Generally, the proximate composition data would indicate that nutrient contents of sun-dry OC are comparable to that of wheat straw (Li et al., 2002), which is a commonly used fodder in Saudi Arabia. The CP contents of U and EU were increased by 3.67 and 3.06 times the CP content in OC, respectively. The decreased CP after ensiling was probably due to the loss of some nitrogen when the added urea-N was converted to ammonia. This result was contrary to a previous finding by Hadjipanayiotou (1994) who found that all urea-N applied on olive cake was retained on it and that probably was due to the lack of urease needed to convert urea to ammonia during the ensiling process. The increase in CP content after urea treatments had a diluting effect on the concentration of NFE, which dropped by 50.3 and 44.1% in U and EU, respectively in comparison with OC. NaOH-treated crude cake had lower EE and higher ash contents as other olive cake treatments. The observed drop in EE content in N treatment was probably due to the production of unknown chemical compounds by the reaction of alkaline with the remaining intrinsic olive oil. The proximate constituents of the composite experimental diets (Table 2) are comparable to many formulated rations prepared for sheep production (SID, 1988). It is evident from the table that the contents of almost all the nutrients were similar in all dietary treatments, but ON diet had lower EE content and higher ash content when compared to other dietary treatments. Furthermore, the replacement of wheat straw in the control diet with either crude or treated-olive cake resulted in a slight increase of CF and ADF contents of the diets. Similar results were also recorded by Jassim et al. (1997) and Hadjipanayiotou (1999).

The apparent digestibilities of various experimental diets are given in Table 3. The digestion coefficients of DM, OM, CP, EE and NFE in OUE diet were 4.3, 4.7, 14.1, 6.5 and 4.3% higher ($p<0.05$) than those values obtained from the C diet, respectively; however, OUE diet had higher digestibility compared to other experimental diets. When

Table 4. The effect of replacement of wheat straw with olive cake treated by various methods on growth performance of Najdi lambs

Parameter	Dietary treatment[1]					
	C	O	ON	OU	OUE	SEM
No. of lambs	9	9	9	9	9	
Initial weight, kg	26.7	26.6	26.5	26.8	26.8	0.43
Final weight, kg	39.6^{ab}	41.3^{bc}	39.3^{a}	41.1^{bc}	41.8^{c}	0.82
Average daily gain, g/d	208^{a}	235^{b}	206^{a}	230^{b}	245^{b}	9.11
DM intake:						
kg/d	1.33^{a}	1.43^{b}	1.43^{b}	1.44^{b}	1.49^{c}	0.04
% body weight	4.01^{a}	4.21^{b}	4.35^{b}	4.24^{b}	4.34^{b}	0.06
Conversion ratio,						
kg DM/ kg gain	6.41^{b}	6.10^{a}	6.96^{c}	6.25^{b}	6.06^{a}	0.48

[1] C=control diet; O=crude olive cake; ON=3% NaOH-treated-olive cake; OU=5% urea-treated olive cake; OUE=ensiled 5% urea-treated olive cake.
[a, b, c] Means in the same row bearing different superscripts differ ($p<0.05$).

wheat straw of the control diet was replaced by crude or treated olive cakes in O, ON and OU diets, there were no significant changes in digestibility coefficients of DM, OM, CP, CF and NFE. These results are not in line with earlier report by Hadjipanayiotou (1994) who found that treating olive cake with urea improved its digestibility values compared to crude olive cake, but the ensiling of urea-treated olive cake did not further increase nutrient digestibility. The digestibility of NDF and ADF were significantly ($p<0.05$) depressed in ON diet compared to other diets; however, it is obvious that nutrient digestibility for ON diet were significantly ($p<0.05$) lower than those of other diets. Although it was speculated that treating olive cake with NaOH increases its digestibility (Nefzaoui et al., 1983), this was not true in this study. It is possible that the lower digestibility was due to the lower EE content in ON diet. This result was in line with the finding by Li et al. (2002) who concluded that diets containing a defined amount of oil could be more appropriate in stimulating digestion. Also, the decline in nutrients digestibility of ON diet may have been the result of a formation of unidentified factor that negatively affects the normal activity of rumen microorganisms. This unknown factor, however, was probably formed during the chemical reaction between NaOH and the remaining intrinsic olive oil in the cakes. This, however, needs further investigation.

Total digestible nutrients (TDN) concentration was significantly ($p<0.05$) higher in OUE diet compared to other diets; no difference in TDN value was observed between C, O, ON and OU diets (Table 3). This result was in accordance with the findings reported by Abouheif et al. (1999) who found that higher digestibility coefficients in a diet ultimately resulted in increasing TDN value in that diet. Nitrogen intake was significantly ($p<0.05$) lower for the C diet than for those fed other diets, whereas, nitrogen intake for the O diet was the highest ($p<0.05$) among all diets. All experimental diets were isonitrogenous, however, the observed changes in nitrogen intake were attributed to the corresponding trends for feed intake in these lambs which are in agreement with the previous findings by Abouheif et al. (1999). Nitrogen retention as a percent of nitrogen intake was approximately 20.6% higher ($p<0.05$) in OUE diet than other diets; no differences in nitrogen retention value was observed between the other diets.

All lambs remained in good health and no digestive disturbance or feed rejection were observed throughout the feeding trial. Similar results were reported by Hadjipanayiotou and Koumas (1996) and Jassim et al. (1997) who found that the inclusion of either crude or ensiled olive cake in the rations of ruminants produced no harmful or palatability problems. Feeding performance data are presented in Table 4. The average daily DM intake of all lambs was above 4 kg per 100 kg live weight. Average daily DM intakes were higher ($p<0.05$) in lambs fed crude or treated-olive cake diets than those fed control diet. Contrary, Hadjipanayiotou and Koumas (1996) found that the consumption of diet containing urea-treated olive cake silage was lower than those fed control diet, and this was primarily associated with the stronger ammonia smell of the silage. However, our ensiled olive cake had very mild ammonia smell. Among the olive cake-treated diets, lambs fed OUE diet had approximately 4.2% higher intakes ($p<0.05$) than those lambs fed O, ON and OU diets. Similar result was reported by Reddy (1992) who found that ensiled urea-treated neem seed kernel cake was better substitute of crude cake when fed to growing buffalo calves. The increase of DM intake with OUE diet might be attributed to the corresponding increase in DM digestibility which is in agreement with the previous findings by Aderibigbe and Church (1980). Average daily weight gains were higher ($p<0.05$) in lambs fed O, OU and OUE diets than those fed C diet; these changes in body gain were probably attributed to the corresponding trends in DM intakes. On the other hand, Hadjipanayiotou and Koumas (1996) and Hadjipanayiotou (1999) found that feeding olive cake silage or urea-olive cake as a partial replacement for barley hay did not affect the body weight gain of dry or lactating ewes; though, ewes on silage diet gained nonsignificantly less body weight than those on the control diet. The discrepancy between the later results and ours are probably due to the

Table 5. The effect of replacement of wheat straw with olive cake treated by various methods on carcass characteristics of Najdi lambs

Parameter	Dietary treatment[1]					
	C	O	ON	OU	OUE	SEM
Warm carcass wt. (kg)	18.40	19.66	18.94	19.36	19.40	0.52
Dressing (%)	47.1	47.3	47.7	47.0	47.3	0.09
Longissimus area (cm^2)	11.87^{b}	11.45^{b}	9.83^{c}	12.06^{ab}	12.73^{a}	0.33
Body wall thickness (mm)	13.4	14.0	13.5	13.8	14.0	0.61
Fat thickness (mm)	7.7	6.6	6.6	7.0	6.8	0.63
Soft tissue: bone ratio[2]	4.42	4.41	4.63	4.35	4.31	0.23
Chemical composition[3]						
Moisture (%)	49.56^{a}	50.76^{a}	46.94^{b}	50.03^{a}	49.21^{a}	1.35
Protein (%)	15.02^{a}	15.04^{a}	13.33^{b}	15.23^{a}	14.83^{ab}	0.73
Ether extract (%)	34.65^{b}	33.43^{b}	39.01^{a}	34.00^{b}	35.21^{b}	0.98
Ash (%)	0.77	0.76	0.72	0.76	0.75	0.08

[1] C=control diet; O=crude olive cake; ON=3% NaOH-treated-olive cake; OU=5% urea-treated olive cake; OUE=ensiled 5% urea-treated olive cake.
[2] Physically separated tissues (fat+lean) from 9-11th rib joint. [3] Chemical analysis of the physically separated soft tissues from 9-11th rib joint.
[a, b, c] Means in the same row bearing different superscripts differ ($p<0.05$).

differences in nutritive values between barley hay and the wheat straw used in this trial. The inclusion of NaOH-treated olive cake in the diet had a noticeable ($p<0.05$) negative effect on body weight gains. It seems that the decline in gains with feeding ON diet was presumably a direct consequence of reduction in nutrients digestibility. In addition, the DM requirement per kg live weight gain were the lowest ($p<0.05$) in lambs fed O and OUE diets, whereas it was the highest ($p<0.05$) in those fed ON diet. This indicated that lambs fed on crude or ensiled urea-treated olive cake diet converted DM more efficiently than those given other diets.

The effects of feeding various dietary treatments on carcass characteristics are presented in Table 5. Except for longissimus area, the inclusion of olive cake treated by various methods in the diets did not alter ($p>0.05$) the physical characteristics of the carcass. The longissimus area produced from the lambs fed OUE diet was the largest ($p<0.05$) among all dietary treatment groups, whereas those from the lambs fed ON diet were the smallest ($p<0.05$). Various treatments did not alter the percentage of ash in the soft tissue of the physically separated 9-11th rib joint, while the percentage of ether extract exhibited a significant ($p<0.05$) increase in the ON treatment in comparison with other treatment groups. Accordingly, the percentages of moisture and protein in the soft tissue from ON treatment were lower ($p<0.05$) than those tissues from C, O, OU and OUE treatments. The decline of protein percentage in soft tissue of ON-fed lambs may have been the result of an adverse effect of unidentified factor which could have led to retarded body weight gain and consequently protein and moisture accretion.

On the basis of performance data, it appears that crude olive cake is a better feed ingredient when compared with wheat straw which is commonly used roughage in Saudi Arabia. Although olive cake is a highly fibrous feed, ensiling process has been shown to be a feasible means of converting and utilizing olive cake into reasonably nutritious feed when treated with urea. Such a product can make a significant contribution to sheep production as part of a total mixed ration in intensive operations. It is important to note here that treating olive cake with NaOH had an adverse effect on digestibility and growth performance of the growing lambs; however, further investigations are needed to elucidate the causes of this effect.

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