

Effects of olive cake on fattening performances, carcass characteristics and meat quality of lambs

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Abstract

This study aims to evaluate the effect of olive cake (OC) partially de-stoned in lambs' diet on fattening performances, carcass characteristics and meat quality. Thirty-six lambs (18 females and 18 males) of Deroua breed were divided into 6 homogeneous groups (3 groups of females and 3 groups of males) each containing 6 animals. An identical diet was assigned to two groups of both sexes. The three diets tested include T0 (0% OC), T1 (20% OC) and T2 (40% OC). Experiment lasted 74 days preceded by 10 days of adaptation to diets. During the experimental period all lambs were weighed every 15 days and intake was monitored daily. At the end of the experiment, all animals were slaughtered and carcass weights, conformation and fattening scores and mesenteric fat (MF) were recorded. Afterwards, carcasses were stored in cold room for 24 hours. Subsequently, pH24 and color of the meat at the *Longissimus dorsi* muscle and pelvic renal fat (PRF) were recorded. The results showed no significant effect of the diet on average daily gain (ADG). Feed cost was reduced in males by 4.74 MAD and 3.57 MAD per kg of live weight gained for T2, T1 respectively and feed conversion ratio was improved. Diet had no significant effect on carcass yield, fattening state and conformation scores, PRF and MF. However, sex effect was significant on MF and PRF and on meat pH24 with superiority in females. Olive destoned cake can be incorporated up to 40% in lamb fattening to reduce feed cost and without effect on fattening performance.

Keywords: Olive cake, lambs, fattening performances, carcass, meat

Effets des grignons d'olives sur les performances d'engraissement, les caractéristiques de la carcasse et la qualité de la viande des agneaux.

Résumé

L'objectif de cette étude est d'évaluer l'effet de l'utilisation des grignons d'olives (GO) partiellement dénoyautés en alimentation des agneaux sur les performances d'engraissement, les caractéristiques de la carcasse et la qualité de la viande. Trente-six agneaux de la race (18 femelles et 18 mâles) ont été répartis en 6 lots homogènes (3 lots de femelles et 3 lots de mâles) de six animaux chacun. Chaque deux lots (1 mâle et 1 femelle) ont été affectés à un régime alimentaire. Trois régimes ont été testés : T0 (0% GO), T1 (20% GO) et T2 (40% GO). L'essai s'est déroulé sur une durée de 74 jours précédé d'une période d'adaptation de 10 jours; les agneaux ont été pesés tous les 15 jours et l'ingestion a été contrôlée quotidiennement. A la fin de l'essai, tous les animaux ont été abattus et le poids des carcasses, les notes de conformation et d'engraissement et le gras mésentérique (GM) ont été enregistrées. Par la suite les carcasses ont été déposées dans la chambre froide pendant 24h. Après, le pH24 et la couleur de la viande mesurés au niveau du muscle *Longissimus dorsi* et le gras pelvi-rénal (GPR) ont été enregistré. Les résultats de l'essai n'ont montré aucun effet significatif du régime alimentaire sur le gain moyen quotidien (GMQ). Le coût alimentaire a été réduit de 4,74 MAD et 3,57 MAD par kg de poids vifs gagné chez les mâles, respectivement pour T2, T1 et l'indice de conversion a été amélioré. Aucun effet significatif du régime alimentaire n'a été observé sur le rendement carcasse, les notes de conformation et d'engraissement, le GPR et GM. Toutefois, L'effet du sexe était significatif sur le GM et GPR et sur le pH24 de la viande avec une supériorité chez les femelles. En conséquence, les GO partiellement dénoyautés peuvent être incorporées jusqu'à 40% en engraissement des agneaux pour réduire le coût alimentaire et sans effet sur les performances d'engraissement.

Mots-clés : Grignon d'olive, agneaux, performances d'engraissement, carcasse, viande

تأثير ثفل الزيتون على قدرات التسمين، خصائص السقيطة وجودة اللحم عند الخراف

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ملخص

الهدف من هذا البحث هو تقييم تأثير استخدام ثفل الزيتون منزوع النواة (GO) في علف الخراف على قدرات التسمين، خصائص الذبيحة وجودة اللحم. تم تقسيم ستة وثلاثين خروفا من سلالة الدروة (18 أنثى و 18 ذكراً) إلى 3 مجموعات من الإناث و 3 مجموعات من الذكور لكل واحدة منها مكونة من ستة رؤوس. تم تخصيص لكل مجموعتين (مجموعة ذكور ومجموعة إناث) نظام غذائي واحد. تم اختبار ثلاث حميات حسب نسبة (GO): T0 (0%GO) ، T1 (20%GO) ، T2(40%GO). استمرت التجربة لمدة 74 يوماً مسبقة بعشرة أيام للتأقلم مع الحميات. خلال مدة التجربة تم وزن الخراف كل أسبوعين ومراقبة الإستهلاك يومياً. في نهاية التجربة ، تم ذبح جميع الخراف وتم تسجيل وزن السقيطة وتنقيطها (الشكل ودرجة السمنة) و شحم الخروف أو الدوارة (GM). عقب ذلك مباشرة، تم وضع الذبائح في غرفة التبريد لمدة 24 ساعة. بعد ذلك، تم تسجيل pH24 ولون اللحم على مستوى عضلة الطولى الراسية و شحم الحوض الكلوي (GPR). أظهرت نتائج هذه التجربة عدم وجود تأثير معنوي للنظام الغذائي على متوسط النمو اليومي (GMQ) أو معامل تحويل الحمية، فيما انخفضت تكلفة العلف بمقدار 4.74 درهم و 3.57 درهم لكل كيلوجرام من الوزن الحي المكتسب عند الذكور، على التوالي في T2 و T1 مقارنة مع T0. لم يلاحظ أي تأثير معنوي للنظام الغذائي على مردود السقيطة والشكل ودرجة السمنة و GPR و GM. خلافا لذلك، كان تأثير الجنس معنوياً على GM و GPR وعلى pH24 للحوم مع تفوق في الإناث. يمكن استعمال ثفل الزيتون حتى نسبة 40% لتغذية الخراف لخفض تكلفة العلف دون التأثير على قدرات التسمين.

الكلمات المفتاحية: ثفل الزيتون، قدرات التسمين، الخراف، السقيطة، اللحم.

Introduction

In Morocco, small ruminant sector constitutes a permanent treasury for breeders. It also contributes to financing other agricultural activities and ensures the household food supply. The slaughter lambs production occupies an important place in the sheep breeding activity. It is practiced by breeder-fatteners or by fatteners to valorize their products and improve their income. Besides, it is a relatively easy to practice because it does not require neither a great investment nor a high technicity level (Boujenane, 2008). However, climate change and the increasing of raw material prices on the international market have made this activity difficult and unprofitable. In this context, the use of locally available food resources is becoming an inevitable choice. The olive by-products, in particularly olive cake, can constitute an alternative forage resource to reduce the costs related to animal feed and to attenuate the pressure on the sylvo-pastoral resources. Previous research (Hadjipanayiotou, 1999; Ben Salem et Znaidi, 2008; Vasta et al., 2008; Sadeghi et al., 2009, Benbati et al., 2014, El Otmani et al. 2021) has shown that these by-products can be used in animal feed to satisfy animals' needs during drought periods without negative effects on animal performance.

In Morocco, the olive sector constitutes one of the most important components of Moroccan agriculture. The national olive production in 2019/2020 was estimated at around 1.409 Million tons, more than 1.269 tons of was destined for extracting olive oils (MAPMDREF, 2020). Alburquerque et al. (2004) reported that processing one ton of olives generates about 350 kg of olive cake. Considering this value, in 2019/2020 Morocco produced about 444,150 tons of olive cake. The totality of these quantities is used as energy source, after being exhausted, by the brick and cement factories.

The goal of this work is to evaluate the effect of incorporating partially destoned olive cake (OC) in lambs' diet on fattening performance, carcass characteristics and meat quality.

Materials and Methods

Diets and animals used

Thirty-six lambs (18 males and 18 females) of the Deroua breed, aged 90 ± 10 days and with a body weight around 19.4 ± 1.86 kg, were used. The lambs were weighed and allocated randomly into six homogeneous groups (3 groups of males and 3 groups of females). Each two groups (1 males and 1 females) were randomly assigned to one diet. Three diets, according to the level of partially destoned olive cake (OC) content, were tested: T0: control diet containing 0% OC, T1: diet containing 20% OC, and T2: diet containing 40% OC. The diets composition is presented in the Table 1. The animals were provided with fresh water and mineral and vitamin blocks (MVC).

All animals were vaccinated against *enterotoxemia* and were dewormed against internal and external parasites.

Table 1. Composition of tested diets

	Chemical composition (%)					Raw materials (%)		
	DM	MM	CP	NDF	ADF	T0	T1	2
Barley	91.47	2.62	9.13	39.76	-	45	32	20
Corn	90.48	1.39	9.82	14.52	-	18	15	13
SM	92.96	4.17	24.71	47.78	30.13	36	32	26
OC	92.73	3.97	6.98	61.37	44.09	0	20	40
MVC	-	-	-	-	-	1	1	1
DM: Dry matter; MM: Mineral matter; CP: Crude protein; ND: Neutral detergent fiber; ADF: Acid detergent fiber; MVC: Mineral and vitamin supplement, SM: Sunflower meal, OC: Olive Cake.								

Experimental design

The experiment was conducted in the Deroua experimental station belonging to the National Institute of Agricultural Research of Tadla, Morocco. The experiment lasted 74 days preceded by an adaptation period of 10 days. The rations were distributed in the morning around 8:30 am with an interval between the distribution of alfalfa hay and concentrate of 2 hours. The quantities of Alfalfa hay to be distributed were daily calculated using the following formula (1). During the adaptation period, lambs received progressively lower concentrate and forage quantities than calculated to satisfy their needs.

(1) Quantity to be distributed per group = (Quantity ingested - the refusal) x 1.1*

*The factor 1.1 represents an increment to take into account the refusal

The concentrate quantity was initially fixed at 60-70% of the ration in order to avoid digestive complications. It is corrected every week according to the quantity of alfalfa consumed and the lamb's corporal weight evolution. The diets were formulated according to the INRA-France recommendations (Agabriel, 2007) for fattening lambs. Water was distributed at will, cleaning of batches, feed bunks and water troughs were done daily. The lambs had access at will to the Mineral and Vitamin Complement (MVC) blocks.

Pre-slaughter controls

Intake and weight control were the two parameters monitored. The control of the ingestion was realized through the daily control of the offered quantities and the refusal with an electronic scale with 30 ± 0.01 kg as a capacity. The lambs were weighed at the beginning and at the end of the experiment and every 7 days. All weightings were done in the morning on fasted animals using an electric scale which capacity was 120 ± 0.01 kg.

At the end of the experiment, 18h before slaughtering, all 36 lambs were moved to the waiting room of the slaughter house belonging to the INRA Deroua Experimental Station. Just before slaughtering, the animals were weighed and the live weight was

recorded. The animals were then slaughtered, skinned and eviscerated. The carcasses are weighed and the weight of the hot carcass is recorded. Afterwards, the pH of meat at slaughter (pH0) is measured in the *Longissimus dorsi* muscle using a hand-held food pH meter (HANNA HI99163). Subsequently, the carcasses were placed in the cold room for 24 hours at a temperature of $\pm 4^{\circ}\text{C}$. The carcasses were subsequently placed in the cold room at $\pm 4^{\circ}\text{C}$ for 24 hours. Later, cold carcass weights were recorded, carcass fatness and conformation were assessed, mesenteric and pelvic fat deposition were measured and meat quality (pH and colour) was evaluated. Color assessment was evaluated after 24 hours post mortem using the Konica-Minolta CR-410® colorimeter with a measurement and illumination area of $\varnothing 8$ mm and $\varnothing 11$ mm, and a viewing angle of 0° , calibrated with the white CR-A43 calibration plate. The color was measured according to the CIE (1986) system L^* , a^* , b^* (L^*): Lightness index; (a^*): red index; (b^*): Yellow index). The measurements were done at the *Longissimus dorsi* muscle. The carcasses conformation appreciation was done according to the EUROP scale. About state of fattiness, it is assessed by the quantity of cover fat and kidney fat.

The feed cost was estimated basing on the raw material prices used during the experiment.

Statistical analysis of data

Statistical analysis of data was accomplished using a two-way (ANOVA2) using the

Slaughter controls.

PROC GLM procedure of the SAS statistical package (version 9.4) according to the following statistical model:

$$Y_{ijk} = \mu + a_i + b_j + (ab)_{ij} + e_{ijk}$$

With:

- Y_{ijk} = performance of animal (k) of sex (j) receiving diet (i) ;
- μ = general mean;
- a_i = diet effect ;
- b_j = sex effect;
- $(ab)_{ij}$ = diet*sex interaction effect;
- e_{ijk} = residual error.

Results and discussion

Growth performances: weight and average daily gain (ADG)

Average body weights at beginning and at end of the experiment and the ADGs are reported in Table 2. Body weight evolution was marked by a comparable growth for the different diets, nevertheless a slightly superiority is recorded for the 20% OC diet. About sex, weights recorded in males are higher than those recorded in females. The achieved results are in agreement with those reported by Christodoulou et al. (2008) on Florina lambs and with incorporation levels of 5%, 10%, 15% of OC. On the other hand, statistical analysis of data revealed that diets had no effect on final body weight ($P=0.65$). However, the effect of sex was highly significant indicating that males gained more body weight than females. These results are in accordance with those obtained by Benbati et al. (2014) on the same breed incorporating 10%, 20% and 30% OC levels and those reported by Jorfi et al. (2014) in the Timahdite breed incorporating 5% and 15% of OC in the diet.

Regarding the average daily gain, the results recorded in females of all three groups are approximately similar; whereas in males a slight superiority was observed in the lambs receiving the T1 diet. The ADG recorded in this experiment are similar to those reported by Kotsampasi et al. (2017) incorporating 24% of partially destoned olive cake into the diet of fattening Florina (Pelagonia) lambs. Statistical analysis of data showed no significant effect of diet on ADG recorded during all the experimental. However, the sex effect on ADG was very significant; males achieved higher GMQs than those recorded for females. Similarly, Al Jassim et al. (1997) did not observe any significant difference in growth weight by partially replacing barley with urea treated olive cake. Additionally, Sadeghi et al. (2009) reported that incorporating 20% of destoned OC for fattening Zel breed lambs has improved the weight gain. Similarly, Christodoulou et al. (2008) reported no effect on the ADG when incorporating 15% OC at fattening lambs diet. Also, Ragni et al. (2003) have not found any significant effect on the GMQ when introducing 20% of OC to fattening Comisana breed lambs. However, Mioč et al. (2007) had reported that incorporating OC at 15% and 30% levels for fattening Paramenka breed lambs had negatively affect ADG.

Table2. Average daily gain (0-74days) and weight according sex and diet

	T0		T1		T2		ESM	P		
	M	F	M	F	M	F		T	sex	T*sex
IBW	21.4	18.3	21	17.3	20.9	17.7	-	-	-	-
FBW	38.5 ^a	32.5 ^b	40.0 ^a	32.7 ^b	38.4 ^a	31.8 ^b	2.16	0.1798	<.0001	0.5355
ADG	234 ^a	184 ^b	258 ^a	187 ^b	238 ^a	173 ^b	25.7	0.1837	<.0001	0.9454
IBW: Initial body weight; FBW: Final body weight; ADG: Average daily gain										

Intake, feed conversion ratio and feed cost

The intake quantities of feed (coarse + concentrate) recorded in function of diet and sex are presented in Table 3. The results show that there are not differences in intake values for the three diets. However, the quantities ingested by males are slightly higher than those recorded for females. This difference can be explained by the higher ingestion capacity of males. Regarding the feed conversion ratio, the values recorded in females are higher than those recorded in males. This difference is explained by the fact that females start to deposit fat earlier than males and therefore the feed conversion ratio is reduced. The best feed conversion ratio was recorded in males receiving the T1 diet, i.e. 5.15. This result is explained by the improvement of the feed use efficiency following the incorporation of OC (Sadeghi et al., 2009). These results are similar to those reported by Vera et al. (2013) and Tufarelli et al. (2013). However, they are slightly lower than those reported by Benbati et al. (2014). For feed cost, the results reported in Table 3 show that substituting partially barley by olive cake for males reduced feed cost by 3.57 MAD and 4.74 MAD per kg gained body weight respectively for 20% and 40% incorporation levels. Whereas for females, cost reduction was about 3 MAD and 4.83 MAD per kg gained body weight respectively for T1 and T2 diets.

Table 3. Intake, feed conversion ratio and feed cost according to diet and sex

	T0		T1		T2	
	M	F	M	F	M	F
Intake (kg DM)	1.27	1.15	1.35	1.20	1.35	1.17
FCR (kg DM/kg gained)	5.32	6.26	5.15	6.44	5.53	6.78
Price of a kg of feed (MAD)	3.76	3.76	3.19	3.19	2.76	2.76
Feed cost (MAD/kg of weight gain)	20.00	23.54	16.43	20.54	15.26	18.71
M: male; F: female; DMI: Dry matter intake; FCR: feed conversion ratio; ADG: Average daily gain; MAD: Moroccan dirham						

Carcass characteristics

Carcass yield and conformation and fattening state

The hot and cold carcass yields according to the diet and the sex are presented in Figure 1. The yields recorded in females are slightly higher than those recorded in males for the three diets. In addition, the yield (50.2%) recorded in lambs feeding by 20% OC diet was higher than those registered in lambs feeding by 0% OC and 40% OC diets (49.7% and 49% respectively). The difference recorded between the different groups could be due to an improvement in feed use efficiency following OC incorporation (Sadeghi et al., 2009).

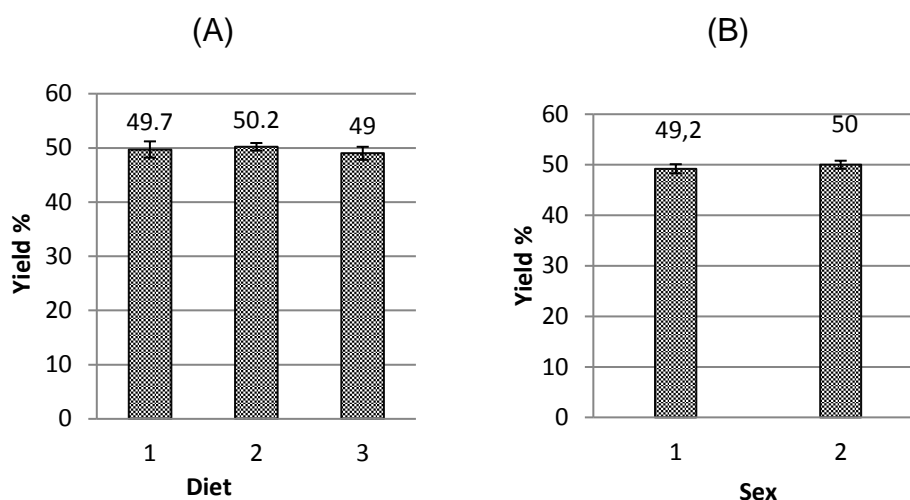


Figure 1. (A) Carcass yield according to diet; **(B)** Carcass yield according to sex

The statistical analysis revealed no significant effect of both diet and sex on carcass yield (Table 4). Similarly, Christodoulou et al. (2008) showed that no significant effect of diet ($P=0.64$) but a low significant difference related to the sex factor ($P=0.04$) was found using diets containing 5%, 10%, 15% of OC. Also, Ragni et al. (2003) reported that incorporating destoned olive cake at 20% level for fattening heavy lambs improved significantly the slaughter performances. In contrast, Mioč et al. (2007) concluded that incorporation of OC at 15% and 45% levels had negatively affected carcass yields.

With regard to conformation and fat state, the results obtained showed that females were more fattened than males and that the 20% OC diet allowed a modest improvement in conformation state (Table 4). Statistical analysis indicated that no significant effect of the diet on conformation state, whereas sex effect was highly significant. The results recorded during this work are in agreement with those reported by Benbati et al. (2014) who indicated that the incorporation of OC had no significant effect on fatness and conformation states. Similarly, Tufarelli et al. (2010) reported no significant effect of including 20% partially destoned OC in the lambs' diet on conformation and fattening state. In contrast, the findings of this work were higher than to those reported by Mioč et al. (2007).

Table 4. Carcass yield (%), conformation and fattening state according diet and sex

	T0		T1		T2		SEM	P		
	M	F	M	F	M	F		T	sex	T*sex
HCY	51.3	51.7	50.5	52.4	49.6	50.6	2.32	0.46	0.09	0.54
CCY	50.1	49.3	49.5	51	48.1	49.8	2.53	0.42	0.29	0.12
CF	2.7	2.5	2.9	2.6	2.5	2.4	0.35	0.24	0.22	0.76
FS	2.3	2.9	2.3	2.9	2.3	2.6	0.34	0.74	<.0001	0.28
HCY: hot carcass yield; CCY: cold carcass yield; CF: conformation; FS: fattening state; M: male; F: female; SEM: Standard error of the mean										

Fat deposit

The evaluation of this trait was based on the assessment of mesenteric fat and pelvic fat. For mesenteric fat, the results showed, in average, that lambs have been fed with 0% OC diet have more mesenteric fat deposited, 907g against 864, 741g, respectively for 20% OC and 40% OC diets (Table 5). Concerning sex, it was observed that females deposited more mesenteric fat than males, i.e. 920g versus 755g. About pelvic-renal fat, the results obtained showed a slight superiority of the 0%OC diet, i.e. 484g against 458 and 454g respectively for the 20% OC and 40% OC diets. As for sex, the recorded values for females were higher than those recorded for males, i.e. 581g versus 350g.

Statistical analysis of both parameters revealed no significant effect of diet on mesenteric and pelvic-renal fat (Table 5). The lowest values of these two parameters were recorded in the lambs receiving the T2 diet (40% OC). Similarly, Benbati et al. (2014), reported that incorporation of OC at 10%-20% and 30% into the fattening lambs' diet has not significantly affected mesenteric fat. With regard of the sex effect on fat deposition, the analysis of the results showed a very significant effect of sex on both mesenteric and pelvic-renal fat. In the same way, Horcada-Ibanez et al. (2009) reported a significant effect of sex on fat deposition in Argonesa lambs and that females deposited more fat than males.

Table 5. Mesenteric and pelvic-renal fat (kg) according to diet and sex

	T0		T1		T2		ESM	P		
	M	F	M	F	M	F		T	sex	T*sex
MF	0.83 ^b	0.98 ^a	0.80 ^b	0.94 ^a	0.64 ^b	0.84 ^a	0.21	0.40	0.006	0.1200
PRF	0.32 ^b	0.65 ^a	0.36 ^b	0.56 ^a	0.37 ^b	0.54 ^a	0.13	0.91	<.0001	0.6112
MF: Mesenteric fat; PRF: Pelvic-renal fat; M: male; F: Female; SEM: Standard error of the mean										

Meat quality

Meat quality was evaluated by measuring the pH and color of the *Longissimus dorsi* muscle. The mean values of both parameters according to diet and sex are presented in Table 6. For pH₂₄, the recorded values were normal and are inside the interval [5.5 ; 5.7] reported by Garrido et al. (2005). The analysis of data showed that pH₂₄ was not significantly affected by diet. However, the sex has induced a significant effect on this meat quality parameter. The pH₂₄ values recorded in females are slightly lower than those recorded in males. This result can be explained by whether the females were less stressed or their muscle glycogen level was higher in the females. Similarly, Sucu et al. (2018) reported that incorporating 20% of destoned OC for fattening Merino-Kivircik crossbred male lambs had not affected pH of meat. With regard for meat color, this parameter was not affected by both parameters diet and sex. The registered values of L, a* and b* indicate that the color of the meat is red (L*=37; a*=20.7; b*=9.8) (Alberti, 2005). Our results are in agreement with those reported by Ozdogan et al. (2017) who reported that incorporating the OC at 12.5 and 25% had no significant effect on meat color.

Table 6. pH24 and color parameters measured at the *Longissimus dorsi* muscle according to diet and sex

	Lot			Sexe		SEM	P		
	T0	T1	T2	Male	Female		T	Sex	T*sex
pH24	5.72	5.67	5.72	5.78 ^a	5.62 ^b	0.028	0.7031	0.0040	0.3774
L*	39.9	40.48	40.15	40.29	40.05	0.337	0.7993	0.7314	0.2631
a*	21.36	20.69	21.36	20.66	21.39	0.407	0.8090	0.3962	0.4268
b*	5.01	3.86	4.32	4.07	4.72	0.281	0.2610	0.2553	0.8794
(L *): Lightness index; (a *): red index; (b *): Yellow index									

Conclusion

The results achieved in this work showed that incorporating olive cake at levels of 20% and 40% to fattening lambs had no significant effect on fattening performance (final weight, average daily gains), carcass characteristics (carcass yield, fat deposit and conformation and fattening state) and meat quality (pH and meat color). However, the use of this feed resource as an alternative to cereals (barley) has reduced production costs related to animal feeding. Therefore, the use of this resource for feeding sheep during periods of low forage or when the price of raw materials increases excessively is a good solution to mitigate the escalating prices of raw materials on the international market and improve the rentability of the livestock activity.

Conflict of interest

Authors declare that they have no conflict of interest

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