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RESEARCH PAPER

Use of incremental levels of dehydrated olive cake in lamb diets as an alternative for grazing systems in the central dryland area in Chile: The effect on carcass traits of Suffolk Down lambs

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Abstract

P. Pérez, F. Squella, C. Aguilar, M.J. Idalsoaga, R. Vera, M.S. Morales, M. Maino, and J.I. Egaña. 2016. Use of incremental levels of dehydrated olive cake in lamb diets as alternative for grazing systems in central dryland area in Chile. The effect on carcass traits of Suffolk Down lambs. Cien. Inv. Agr. 43(2):213-221. To evaluate increased levels of dehydrated olive cake (DOC) in lambs ration on main carcass traits, 40 Suffolk Down male lambs (75.8 ± 7.4 days of age, 24.5 ± 3.1 kg live weight) were randomly assigned to one of five treatment groups. Four experimental isoenergetic and isoproteic diets were used with different levels of DOC: 0, 16, 32 and 48%, and an un-weaned group were kept with their mothers on grazing. Lambs had 8 days of adaptation to the diets, which were gradually introduced along with good quality alfalfa hay. During 47 days of the experiment, the lambs were confined in individual pens (1.4 m^2) and subsequently slaughtered at 123 ± 7 days with an average live weight of 32.56 ± 2.62 kg. The live weight at slaughter (LWS), hot carcass weight, cold carcass weight, commercial yield (CY), real dressing percentage (RDP), body components weight (blood, hide, head, legs, full and empty digestive tract, and viscera), rib eye area (REA), back fat thickness (BFT), renal pelvic fat weight, and commercial cutting yield (CCY) were recorded. Additionally, the tissue composition and its ratios were calculated from the shoulder and leg. The carcass traits, CY, RDP, and REA decreased and BFT increased with increasing amounts of DOC in the diet ($P \leq 0.05$). No significant differences ($P > 0.05$) in CCY, tissue composition and ratios among the tissues of the shoulder and leg joints were detected. The addition of DOC to the diet did not affect the quality of the lamb carcass.

Key words: Lambs, olive cake, carcass traits.

Introduction

Sheep production in Chile is based primarily on natural prairie grass, presenting wide seasonal and annual fluctuations in nutritive quantity and quality (Pérez *et al*., 2002; Pérez *et al*., 2007). Supplementation with common feeds is not suitable because of the relatively high price of grains. The use of an available agro-industrial byproduct could reduce the impact of waste production and

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provide a low-cost animal feed alternative (Beken and Sahin, 2011), reducing the dependence on grains that are used for human consumption. Among the agricultural by-products eligible for animal feed, wastes from olive oil production, such as olive cake (OC), present a possible feed option. Olive cake is defined as the mixture of the olive juice and olive-pomace that is obtained from the oil extraction process by a two-phase decantation system. The use of OC as a feed could potentially result in a healthier fatty acids profile in animals (Molina and Yañez, 2007; Vera *et al*., 2009). Olive plantations have experienced high growth in the region under study; therefore, the by-product availability from olives produced in this region is growing (Chileoliva, 2011). In addition, sheep production is the predominant animal production activity in this region. The aim of this study was to evaluate the effect of feeding increased levels of olive cake in complete diets on the main carcass traits of lambs.

Material and methods

This research was conducted at the Experimental Center Hidango (34º 06' S; 71º 47' O) from Instituto de Investigaciones Agropecuarias (INIA) and the Faculty of Veterinarian and Livestock Sciences of the Universidad de Chile (33° 35' 59.787'' S; 70° 37' 37.576'' O). Forty Suffolk Down male lambs, with a mean initial age of 75.8±7.4 days and an initial body weight of 24.5±3.1kg were randomly assigned to one of the following five dietary treatments: unweaned lambs fed in natural prairies alongside their mothers (GT) (a usual practice for farm sheep); control diet (CD) of alfalfa hay, maize grain, molasses, soybean meal, bicarbonate and mineral salts (Table 1); dehydrated olive cake (DOC) replacing 16% of the CD (TA_{16}); DOC replacing 32% of the CD (TA_{32}); and DOC replacing 48% of the CD (TA_{48}). The Control diet, TA_{16}, TA_{32} and TA_{48} were isoenergetic and isoproteic (2.5 Mcal ME·kg^{-1} DM and 140 g of crude protein kg^{-1} DM), and the offered feed met the maintenance and growth requirements, providing an average daily gain of 300 g·d^{-1} (NRC, 2007). The lambs were fed in individual cages. The lambs in the GT group grazed a pasture composed of *Hypochaeris radicata* (33%), *Trifolium glomeratum* (21%), *Bromus hordeaceus* (13%), *Vulpia bromoides* (8%), *Hordeum berteroanum* (6%), *Lolium rigidum* (5%), and traces of other species associated with *Acacia caven*. During an 8-day adaptation period, the treatment diets were gradually included along with alfalfa hay. The experimental period lasted 47 days. The lambs were weighed every 7 days prior to the morning feeding.

At the end of the experimental period, the lambs were transported to a commercial slaughterhouse

Table 1. Composition of the complete experimental rations with increased levels of dehydrated olive cake (fresh basis, g).

	Dietary treatments			
Ingredients	CD	TA_{16}	TA_{32}	TA_{48}
Alfalfa hay	570	420	295	150
Corn grain	545	455	370	285
Dehydrated olive cake	0	210	400	600
Molasses	25	25	25	25
Soybean meal	100	130	150	180
Bicarbonate	25	25	25	25
Mineral salts	6	6	6	6
Total (g/animal/day)	1240	1240	1240	1240

CD: Control diet.
$TA_{16:}$ control diet replaced with 16% of dehydrated olive cake.
$TA_{32:}$ control diet replaced with 32% of dehydrated olive cake.
$TA_{48:}$ control diet replaced with 48% of dehydrated olive cake.

and fasted (only water was available) for 12 h prior to slaughter. After weighing (LWS), the lambs were electrically stunned and slaughtered according to standard commercial procedures. The weight of the hot carcass (HCW), blood, kidney and kidney fat, feet (cuts at tarsal – metatarsal and carpal – metacarpal articulations), hide, full and empty gastrointestinal tracts, liver, heart, lungs (including trachea) and head (cut at the occipital – atlantoaxial articulation) were determined according to procedures previously described (Pérez *et al*., 2002; Pérez *et al*., 2007). The empty body weight (EBW) was calculated by subtracting the weight of the gastrointestinal contents (full minus empty gastrointestinal tract) from the LWS (Pérez *et al*., 2002; Pérez *et al*., 2007; Ekiz *et al*., 2013). Carcass yield (CY) was calculated as the hot carcass weight (HCW) divided by the LWS, and the real dressing percentage (RDP) was calculated as the HCW divided by the EBW (Velasco *et al*., 2000; Pérez *et al*., 2007). Two hours after slaughter, the carcasses were halved longitudinally with a band saw. Each half carcass (HC) was cut between the 12^{th} and 13^{th} ribs. Fat depth (BFT) and rib eye area (REA) were measured after cutting. The BFT was measured over the cut surface of the *Longissimus thoracis et lumborum* muscle at the level of the 12^{th} rib with a ruler (Pérez *et al*., 2002). The REA was measured using an LI – COR portable area meter (LI – 300 A) after tracing the transverse section of the eye muscle (*Longissimus* muscle) at the 12/13 ribs position (Dhanda *et al*., 2003; Pérez *et al*., 2007). The HCs were split into joints (chops, leg, thorax, shoulder and neck) according to the Chilean standard jointing procedure for lambs (INN, 2000; Pérez *et al*., 2007). The legs and shoulders from the left half of each carcass were packed in polyethylene bags, frozen at -25 ºC and dissected 1 to 2 months later, as described by Cuthbertson *et al*. (1972). From the dissections, the following four groups of tissues were obtained: muscle, total fat (subcutaneous and intermuscular), bone and residues (lymphatic ganglia, large blood vessel and nerves, and tendons and joints capsules) (Ekiz *et al*., 2013) and the shrink losses were measured. Each component was weighed using a balance with a 0.05 g sensitivity. The shrink losses were estimated as the differences between the initial and final weights of the anatomy pieces. These data were used to calculate the percentage of the tissue components of the shoulder and leg joint.

A completely random design for the treatment variables was conducted using a one-way analysis of variance, and significant differences between the groups were detected by Tukey-Kramer tests (Kaps and Lamberson, 2009). The data were expressed as the means and standard deviation. The mathematical model used was $Y_{ij} = \mu + T_i + E_{ij}$, where Y_{ij} was the observation i of the treatment j, μ was the overall mean, T_j was the fixed effect of treatment i and ε_{ij} was the random error with a mean of 0 and a variance of σ^2. Significant differences were accepted at $P \leq 0.05$.

Results and discussion

Main carcass traits

The results obtained for the main carcass traits are presented in Table 2. The LWS, HCW, CCW, EBW and KKCF were not significantly different ($P>0.05$) among the treatment groups. There were significant differences ($P \leq 0.05$) in CY between the CD and GT groups; therefore, the olive cake level did not affect this yield. For RDP, TA_{48} was not significantly different ($P>0.05$) among all treatments, while the GT group presented significantly higher values ($P \leq 0.05$) than the CD group for TA_{16} and TA_{32}.

The results obtained for CY were similar to those reported by Owaimer *et al*. (2004), who did not find any effect from the inclusion of olive cake on CY at an inclusion level of 12%. In regard to the other carcass traits, Mioč *et al*. (2007) found that lambs receiving the highest olive cake diet (30%) presented lower HCW and carcass yield than those fed the control diet or a diet with 15% of olive cake. Aboayasha *et al*. (1982), Belibasakis (1985)

Table 2. Effect of the dietary treatments with increased levels of dehydrated olive cake on the main carcass traits of Suffolk Down lambs. (mean ± standard deviation).

	Treatment				
Variable	GT	CD	TA_{16}	TA_{32}	TA_{48}
LWS (kg)	34.45±2.19	31.75±3.23	32.58±2.68	32.45±2.13	31.59±2.34
HCW (kg)	17.95±1.47	15.72±1.55	16.48±1.90	16.34±1.12	16.11±1.69
CCW (kg)	17.44±1.41	15.26±1.52	16.01±1.83	15.83±1.12	15.60±1.56
EBW (kg)	30.67±1.98	27.91±2.71	29.22±2.88	29.08±1.74	27.94±2.21
CY (%)	52.06±1.53 b	49.53±1.51 a	50.48±2.25 ab	50.36±1.27 ab	50.91±1.89 ab
RDP (%)	58.48±1.31 b	56.31±1.40 a	56.32±1.59 a	56.17±0.82 a	57.57±2.02 ab
REA (cm^2)	18.23±2.28 b	17.71±2.00 ab	18.35±2.13b	15.67±1.86 a	15.66±2.03 a
BFT (mm)	1.01±0.22 a	1.25±0.14 ab	1.49±0.27b	1.50±0.31 b	1.30±0.16 ab
KKCF (%)	0.45±0.23	0.33±0.08	0.48±0.17	0.49±0.11	0.53±0.12

Different letters (Tukey test) in the same row indicate significant differences among groups (P≤0.05).
GT: natural pasture, CD: control diet and, TA_{16}, TA_{32} and $TA_{48,}$ CD with increased dehydrated olive cake amounts: 16, 32 and 48%, respectively.
LWS: live weight at sacrifice, HCW: hot carcass weight, CCW: cold carcass weight, EBW: empty body weight, CY: carcass yield, RDP: real dressing percentage, REA: rib eye area, BFT: back fat thickness, KKCF: renal pelvic fat weight

and Abo Omar and Gavoret (1995) included olive cake in levels of 20 to 25% and did not find any negative effects on body weight; while Owaimer *et al*. (2004) found no effect on the hot carcass weight when a 12% olive cake diet was fed. According to the results of our study, the levels of olive cake reached 48% yet exhibited no effects on the live weight and the HCW of the lambs.

The differences in carcass traits observed between the GT and TA groups can be attributed to other possible factors, such as the weaning of the lambs that were confined during the study (TA_{16}, TA_{32}, TA_{48} and CD). Vergara *et al*. (1993) and Cañeque *et al*. (1998) found higher commercial yield in lambs staying with their mothers until they were slaughtered, which was similar to the present results. Nevertheless, they did not find any differences in the real yield. Meanwhile, Cañeque *et al*. (1998) obtained higher cold and hot carcass weights and higher empty live weight in suckling lambs, which was similar to the results from the current study, although their differences were not significant.

On the other hand, there were no differences in REA between the GT and TA_{16} treatment groups with means that were significantly greater for this trait (P≤0.05) compared to the TA_{32} and TA_{48} groups. The CD value was not significantly different among the treatment groups. The treatments with a higher inclusion of DOC exhibited smaller REA values. Owaimer *et al*. (2004) found a significant decrease in REA when lambs were fed a complete diet that included 12% olive cake.

For BFT, the GT group showed a significantly lower average than the TA_{16} and $TA_{32\ g}$ groups (P≤0.05). In contrast, TA_{48} and CD were not significantly different (P>0.05) from the other treatment groups. These values were similar to the results obtained by Borton *et al*. (2005) and Shingfield *et al*. (2012), who found differences among lambs fed forage and concentrate diets; lambs fed a forage-based diet exhibited a lower amount of back fat. However, Owaimer *et al*. (2004) reported that the BFT was significantly lower (P≤0.05) in the carcasses of lambs fed 12% olive cake than in control animals fed complete diets.

Body components

The values obtained for the body components are presented in Table 3. Only the hide, blood, empty digestive tract and tongue were affected by the diet (P≤0.05). Hide was statistically greater in the TA_{16} and CD groups than in the TA_{48} group.

Table 3. Effect of the dietary treatments with increased levels of dehydrated olive cake on the body components on the empty live weight of Suffolk Down lambs (mean ± standard deviation).

	Treatment				
Component (%)	GT	CD	TA_{16}	TA_{32}	TA_{48}
Hide	11.09±0.40 ab	11.52±0.85 b	11.46±0.87 b	11.08±0.37 ab	10.19±0.73 a
Blood	4.91±0.58 ab	5.58±0.45 b	4.84±0.58 a	5.14±0.42 ab	5.17±0.46 ab
Feet	2.47±0.17	2.36±0.16	2.33±0.16	2.39±0.12	2.41±0.10
Head	4.18±0.24	4.15±0.17	4.19±0.31	4.34±0.17	4.24±0.24
Lung +trachea	2.35±0.27	2.25±0.15	2.36±0.18	2.26±0.08	2.28±0.15
Heart	0.53±0.05	0.53±0.07	0.51±0.05	0.58±0.08	0.53±0.05
Liver	1.81±0.10	1.81±0.10	1.83±0.12	1.86±0.09	1.86±0.19
Spleen	0.18±0.03	0.19±0.03	018±0.03	0.20±0.03	0.19±0.04
Penis	0.15±0.02	0.15±0.03	0.14±0.02	0.12±0.02	0.13±0.02
Testicles	0.71±0.12	0.69±0.18	0.69±0.07	0.85±0.27	0.72±0.15
Empty digestive tract	9.64±1.02 a	10.86±0.41 b	10.26±0.12 ab	10.50±0.46 ab	10.58±0.65 ab
Kidneys	0.35±0.02	0.34±0.02	0.35±0.03	0.37±0.03	0.38±0.04
Tongue	0.26±0.02 a	0.27±0.06 a	0.46±0.10 b	0.48±0.05 b	0.68±0.06 b

GT: natural pasture, CD: control diet and, TA_{16}, TA_{32} and TA_{48} CD with increased dehydrated olive cake amounts: 16, 32 and 48%, respectively.
Different letters (Tukey test) in the same row indicate significant differences among groups ($P \leq 0.05$).

The result for blood weight was significantly lower in the TA_{16} group than in the CD group ($P \leq 0.05$); however, no other significant differences were observed among the treatment groups ($P > 0.05$).

Regarding the empty digestive tract weight, the GT group was significantly different from the CD group, while the other treatments exhibited intermediary values. For tongue, the GT and CD treatment groups exhibited lower values than the other treatment groups, but the differences were not significant ($P > 0.05$); There is no logical explanation for this result.

Our results were not in agreement with those reported by Mioč *et al*. (2007), who reported lower weights for the liver, hide and legs and higher weights for the stomach and intestines ($P \leq 0.05$) in lambs fed a diet containing 30% olive cake for 50 days. Similarly, Mioč *et al*. (2007) did not find any differences in lung and heart weights as a result of olive cake addition.

The differences observed for the empty digestive tract were similar to those reported by Cañeque *et al*. (1998), who obtained higher values for that trait in weaned lambs that remained with their mothers until slaughter.

Commercial joints

The results of the commercial joints are presented in Table 4. All of the variables were affected by the diet. The values obtained and the importance of the different joints were similar to the descriptions by Pérez *et al*. (2007) in four lamb genotypes slaughtered at 10 and 15 kg live weight, using the same quartering methodology. Generally, the carcass joints percentages were difficult to compare because of the absence of a universal quartering system and remarkable differences even within different regions in the same country.

Tissue composition of shoulder and leg

The tissue compositions of the shoulder and leg joints are presented in Table 5. There were no significant differences ($P > 0.05$) among the

Table 4. Effect of the dietary treatments with increased levels of dehydrated olive cake on the commercial carcass joints percentage on the left hemichannel from Suffolk Down lambs (mean ± standard deviation).

	Treatment				
Joints (%)	GT	CD	TA_{16}	TA_{32}	TA_{48}
Leg	35.26±3.76	34.68±2.26	35.27±1.69	36.06±3.75	35.44±4.24
Shoulder	20.16±2.29	19.78±1.10	20.01±1.78	21.42±2.04	20.26±2.35
Chops	18.77±3.15	18.41±2.09	18.30±1.36	17.79±3.18	18.12±2.28
Rib	18.86±1.03	18.66±1.72	20.64±2.65	19.61±2.53	19.60±3.17
Neck	7.36±1.35	6.98±0.71	7.13±0.76	6.30±0.55	6.83±0.61
Tail	0.81±0.19	0.84±0.15	0.90±0.13	0.86±0.14	0.92±0.14

GT: natural pasture, CD: control diet and, TA_{16}, TA_{32} and TA_{48} CD with increased dehydrated olive cake amounts: 16, 32 y 48%, respectively.

Table 5. Effect of the dietary treatments with increased levels of dehydrated olive cake on the different body component proportions of the shoulder and leg cuts from Suffolk Down lambs (mean ± standard deviation).

	Treatment				
Tissue (%)	GT	CD	TA_{16}	TA_{32}	TA_{48}
Shoulder					
Muscle	56.46±4.96	54.19±2.12	54.76±2	53.41±1.38	54.07±2.47
Bone	20.50±1.25	21.15±1.84	20.63±1.91	19.94±0.84	20.15±0.88
Cover fat	8.69±3.77	8.57±4.32	9.21±2.15	11.15±1.92	11.01±2.09
IM Fat	4.64±2.26	6.09±2.66	5.66±2.57	6.25±2.60	5.65±3.01
T Fat	13.33±4.04	14.66±3.96	14.82±2.96	17.39±2.12	16.66±3.86
Residues	6.91±1.62	7.35±1.43	7.49±1.18	6.83±1.12	6.99±1.31
Losses	2.80±1.84	2.64±1.11	2.29±0.82	2.42±0.40	2.14±0.59
Ratios					
Muscle/fat	4.65±1.58	3.93±1.02	3.85±0.92	3.12±0.46	3.43±0.91
Muscle/bone	2.76±0.26	2.58±0.19	2.68±0.29	2.68±0.15	2.68±0.09
Muscle+fat/bone	3.42±0.23	3.29±0.42	3.41±0.45	3.56±0.21	3.52±0.24
Leg					
Muscles	61.53±2.85	59.17±2.03	56.64±5.77	58.95±3.28	58.55±2.58
Bone	19.01±1.66	20.61±1.28	20.44±2.06	19.80±0.77	19.92±0.93
Cover fat	7.08±2.20	7.48±2.65	7.92±1.67	8.46±0.96	8.45±2.05
IM Fat	3.56±1.18	4.57±1.15	3.52±0.89	4.07±1.49	5.52±1.98
T Fat	10.29±3.02	12.05±2.66	11.45±2.21	12.53±1.21	13.34±3.91
Residues	6.19±1.80	6.47±0.82	6.63±0.94	6.72±1.67	6.02±0.85
Losses	2.63±0.72	2.32±0.90	2.31±0.83	2.44±0.80	2.14±0.49
Ratios					
Muscle/fat	6.49±2.04	5.08±1.19	5.34±1.07	4.57±0.71	4.81±1.56
Muscle/bone	3.27±0.41	2.85±0.20	2.92±0.33	2.86±0.31	2.97±0.22
Muscle+fat/bone	3.82±0.56	3.44±0.28	3.50±0.47	3.50±0.31	3.64±0.25

GT: natural pasture, CD: control diet and, TA_{16}, TA_{32} and TA_{48} CD with increased dehydrated olive cake amounts: 16, 32 and 48%, respectively.
IM Fat: intramuscular fat, T Fat: total fat.

treatment groups for any of the studied variables or the tissue ratios. These results were in agreement with the report by Pérez *et al*. (2007) on suckling lambs from different genotypes that were slaughtered at 10 and 15 kg of live body weight. The tissue composition of the leg showed a better composition because it had a higher muscle percentage and a lower fat percentage than the shoulder.

Ratios among the tissue components

The results of this study are in agreement with Velasco *et al*. (1998) and Pérez *et al*. (1998), who did not find significant differences in the muscle/bone and muscle/fat ratio, respectively, among weaned animals that were confined and those that grazed alongside their mothers until slaughter. Conversely, Owaimer *et al*. (2004) did not find any differences in the muscle/bone ratio of the entire carcass of lambs fed rations containing 12% of olive cake.

The addition of DOC to the diet did not affect the lamb carcass quality at the levels used in this work.

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Resumen

P. Pérez, F. Squella, C. Aguilar, M.J. Idalsoaga, R. Vera, M.S. Morales, M. Maino y J.I. Egaña. 2016. Uso de niveles incrementales de alperujo deshidratado de oliva en dietas de cordero como una alternativa para sistemas de producción a pastoreo en la zona de secano central de Chile. Efecto sobre las características de la canal en corderos Suffolk Down. Cien. Inv. Agr. 43(2):213-221. Se evaluó la inclusión de alperujo deshidratado de oliva (ADO) en la ración de corderos sobre las principales características de la canal, utilizando 40 corderos Suffolk Down (75,8 ± 7,4 días de edad, 24,5 ± 3,1 kg peso vivo). ADO se incluyó en cuatro dietas: Dieta control con 0% ADO (DC), DC con 16, 32 y 48% ADO, más un grupo a pastoreo que se mantuvo con sus madres. Durante el ensayo (47 días), los corderos se mantuvieron en corrales individuales (1,4 m^2). Los corderos fueron sacrificados a los 123 ± 7 días, y peso vivo promedio de 32,56 ± 2,62 kg. Al sacrificio se registró: peso vivo, peso de la canal caliente, peso de la canal fría, rendimiento comercial (RC), rendimiento verdadero de la canal (RV), peso de los componentes del cuerpo (sangre, piel, cabeza, piernas, el tracto digestivo lleno y vacío, y vísceras), área del ojo del lomo (AOL), espesor de grasa dorsal (EGD), peso de grasa perirenal y rendimiento de corte comercial (RCC). Adicionalmente, en espaldilla (E) y pierna (P) se estudiaron los componentes del tejido (CT) y sus proporciones (PT). El incremento de ADO en la dieta causó una disminución de RC, RV y AOL y un aumento de EGD ($P<0,05$). No se detectaron diferencias ($P>0,05$) en RCC, ni en CT y PT de H y P. La adición de ADO a dietas de corderos, en los niveles utilizados en este trabajo, no afectó la calidad de la canal de cordero.

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