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Soybean oil in grain-based diets improves growth performance of finishing lambs

El aceite de soya en dietas altas en grano mejora el desempeño productivo de corderos en finalización



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ABSTRACT

Soybean oil in diets with a high proportion of grains was evaluated for its effects on the development and characteristics of the carcass in growing lambs. Male lambs, a cross between Dorper and Rambouillet (n = 15), were randomly assigned to three grain-based diets containing 0, 3, and 6 % soybean oil (on a dry matter basis). The lambs were adapted to the diets for 14 days. The production trial lasted 49 days. Lambs fed 6 % soybean oil in the diet had better weight gains, feed conversion, and cold carcass weights compared to those that did not consume soybean oil (P < 0.05). These results suggest that the addition of 6 % soybean oil to diets with a high grain proportion increases the diet's energy density, with beneficial effects on the productive performance of lambs in the finishing phase.

Keywords: carcass dressing, fatness degree, feed intake.

RESUMEN

Se evaluó la adición de aceite de soya en dietas altas en granos en el desarrollo y características de la canal de corderos en crecimiento. Corderos machos cruzados de Dorper x Rambouillet (n=15) fueron distribuidos aleatoriamente a tres dietas altas en granos con: 0, 3 y 6 % de aceite de soya (en base seca). Los corderos fueron adaptados a las dietas por 14 d. El ensayo productivo tuvo una duración de 49 d. Los corderos alimentados con 6 % de aceite de soya en la dieta tuvieron mejores ganancias de peso, conversión alimentaria y pesos de canales frías que los corderos que no consumieron aceite de soya (P<0.05). Lo anterior permite concluir que la adición de 6 % de aceite de soya en dietas con una alta proporción de granos, incrementa la densidad energética de la dieta, con efectos benéficos en desempeño productivo de corderos en finalización.

Palabras clave: consumo de alimento, grado de engrasamiento, rendimiento en canal.



INTRODUCTION

In intensive fattening of lambs for slaughter, cereal-based feeding is a common and profitable practice, since the high starch content of the diets results in rapid growth rates (Gregorio *et al.*, 2024), although always with the risk of ruminal and metabolic acidosis (Eci & Karsli, 2024). Therefore, to increase energy levels without compromising digestive processes, the incorporation of vegetable oils into finishing diets for lambs is used (Bahramkhani *et al.*, 2022). Soybean oil is an energy source used in animal diets to improve production and has the characteristic of containing high concentrations of unsaturated fatty acids such as linoleic and linolenic acid, in addition to improving palatability and significantly reducing dust levels in diets (Shurson, 2020). Some evidence suggests that supplementation with vegetable oils may reduce the population of ruminal microorganisms responsible for nutrient digestion, although a recent review of various studies concludes that at adequate doses and in high-concentrate diets, vegetable oils with a low degree of unsaturation in their fatty acids can mitigate these negative effects (Ibrahim *et al.*, 2021). Thus, it is important to better understand the effects of vegetable oils and their impact on the rumen and on meat quality (da Costa *et al.*, 2021; Olivier *et al.*, 2024).

When soybean oil was included at a level of 5 % in the diet with 20 % forage in finishing lambs, productive performance, carcass characteristics, and muscle conformation were not affected, possibly due to the fiber level in the diet (Vicente *et al.*, 2020). The best results of oil inclusion have been observed in high-grain diets (Mirzaei *et al.*, 2021; Pewan *et al.*, 2022; Gümüs *et al.*, 2022).

The objective of this study was to determine the effects of dietary addition of soybean oil in high-grain diets on productive performance and carcass characteristics of finishing lambs.

MATERIAL AND METHODS

The experiment was conducted on a commercial farm located in the highlands of the Potosino region of Mexico (22°16'N, 101°07'W), at an altitude of 2020 m above sea level, with an average temperature of 17.2 °C and annual rainfall of 361 mm. Fifteen Dorper × Rambouillet male lambs (19.5 ± 2.9 kg) were randomly assigned to one of three experimental diets containing 0, 3, or 6 % soybean oil (dry matter basis). Diets were formulated to meet the nutritional requirements of finishing lambs aged 4 to 7 months with a live weight of 20 kg (NRC, 2007). The lambs were housed in individual pens equipped with feeders and drinkers. The lambs had a 14-day adaptation period to the pens and experimental diets. The productive trial lasted 49 days. Animals were fed twice daily (7:00 and 15:00 h) and had free access to feed and fresh, clean water.



At the beginning of the study, before the daytime feeding, initial live weight was recorded, and subsequently every 7 days for seven weeks; total weight gain and daily gain were calculated. Feed intake was recorded daily based on feed offered minus orts, which was adjusted daily to be no more than 5 % of the amount offered. Average daily weight gain during the trial was calculated for each lamb.

A 100 g sample of the offered feed was collected daily. At the study end, samples were pooled to obtain a composite sample, which was analyzed for dry matter, crude protein, starch, and ash content (AOAC, 2019), as well as neutral detergent fiber (Mertens, 2002) and acid detergent fiber (Van Soest, 1991). On day 50, after a 24-hour fasting period, the lambs were slaughtered according to NOM-033-SAG/ZOO-2014.

Table 1. Ingredients and chemical composition of the diet

	Soybean oil, % dry matter basis		
	0	3	6
Ingredients, % dry matter basis			
Ground corn	66.0	63.0	60.0
Canola meal	20.0	20.0	20.0
Dried alfalfa	8.0	8.0	8.0
Wheat bran	5.0	5.0	5.0
Soybean oil	0.0	3.0	6.0
Mineral-vitamin premix*	1.0	1.0	1.0
Chemical composition, dry matter basis			
DM, %	88.9	89.3	89.6
CP, %	16.0	15.8	15.6
NDF, %	17.3	17.1	16.8
ADF, %	9.5	9.4	9.3
ASH, %	4.6	4.5	4.5
Starch, %	33.0	31.0	29.8
ME, Mcal/kg	2.8	3.0	3.2

*Mineral-vitamin premix containing: Ca: 180 g, NaCl: 180 g, S: 5 g, K: 5.6 g, Mg: 8 g, Zn: 50 g, Fe: 20 g, I: 0.5 g, Mn: 36 g, Co: 90 mg, Se: 90 mg, Vit. A: 3000 MIU, Vit. D₃: 750 MIU, Vit. E: 25 MIU

Immediately after slaughter, carcass weight was recorded, and dressing percentage was calculated based on final live weight. Subsequently, the carcass was refrigerated for 24 h at 4 °C to obtain cold carcass weight and dressing percentage.

Carcass characteristics were evaluated using the Mexican Sheep Meat Carcass Classification, which defines the categories as Mexico Extra, Mexico 1 (select), Mexico 2 (commercial), and unclassified (NMX-FF-106-SCFI-2006, 2006). Carcass morphometry (*L. dorsi* area, carcass length, leg length, rump perimeter, thoracic perimeter, and backfat thickness) was measured using a tape measure and vernier caliper (Colomer 1998).

Using growth performance data and carcass characteristics, an economic feasibility analysis was performed (Camacho *et al.*, 2018), which calculated production value (price × live weight produced), production cost (cost of lambs + feed cost), gross profit (production value – production cost), benefit/cost ratio (gross profit / production cost), and profit-sales ratio (gross profit / production value).



Data were analyzed using a completely randomized design with a mixed model in which treatment was considered fixed and lamb was the random component. Significant differences between means were accepted at $P < 0.05$.

Since the levels of soybean oil in the diet were equally spaced, polynomial analysis was also performed to determine linear and quadratic effects of the oil on the evaluated variables (SAS, 2024).

RESULTS AND DISCUSSION

Lambs fed the diet with 6 % soybean oil had higher total and daily weight gain ($P < 0.05$), as well as better feed conversion, than those fed 0 and 3 % soybean oil. Final weight and feed intake were similar among treatments (Table 2).

Table 2. Effect of soybean oil on productive performance of finishing lambs

	Soybean oil, % dry matter basis			SEM	<i>p-value</i>	
	0	3	6		<i>L</i>	<i>C</i>
Initial weight, kg	21.9	21.5	21.7	0.91	0.32	0.43
Final weight, kg	36.2	36.0	38.9	1.87	0.25	0.45
Total gain, kg	14.3 ^b	14.5 ^b	17.2 ^a	1.07	0.02	0.24
Gain, g/d	292.0 ^b	296.0 ^b	351.0 ^a	25.2	0.04	0.09
DM intake, kg/d	1.13	1.11	1.11	0.29	0.18	0.32
Feed:gain ratio	3.9 ^a	3.8 ^a	3.2 ^b	0.40	0.03	0.06

SEM: Standard error of the mean. *L*: linear; *C*: quadratic. ^{a,b} within the same row indicate different values ($P < 0.05$)

Regarding carcass characteristics, hot and cold carcass weights were also higher in lambs fed the diet with 6 % soybean oil than in those fed 0 and 3 %. Other carcass and meat characteristics, such as muscle conformation and fatness, perirenal fat, carcass length and width, rump and thoracic perimeter, backfat thickness, and *L. dorsi* area, were similar among treatments (Table 3).

The economic analysis indicated that gross profit, benefit/cost ratio, and profit-sales ratio were higher in lambs fed the diet with 6 % soybean oil than in those fed 0 and 3 % (Table 4).

The positive results in productive performance and carcass traits in lambs fed the diets with 6 % soybean oil can be explained by the 14 % increase in caloric value compared to the control diet (2.8 vs. 3.2 Mcal/kg), together with a 9.7 % reduction in starch content (33 vs. 29.8 %).



Table 3. Effect of soybean oil on carcass characteristics of finishing lambs

	Soybean oil, % dry matter basis			SEM	p value	
	0	3	6		L	C
Hot carcass weight, kg	18.5 ^b	18.7 ^b	20.1 ^a	0.99	0.22	0.89
Cold carcass weight, kg	17.9 ^b	18.0 ^b	19.5 ^a	0.91	0.01	0.08
Muscle conformation ¹	3.6	3.4	3.4	0.45	0.22	0.21
Fatness grade ²	3.1	3.2	3.2	0.38	0.11	0.12
Perirenal fat ³	1.5	1.6	1.6	0.19	0.21	0.49
Carcass length, cm	70.4	71.1	72.5	1.33	0.31	0.24
Carcass width, cm	32.1	32.4	33.4	1.31	0.12	0.13
Rump perimeter, cm	64.2	64.6	65.2	1.02	0.13	0.43
Thoracic perimeter, cm	71.6	70.9	71.8	1.36	0.19	0.21
Backfat thickness, cm	0.7	0.7	0.8	0.12	0.17	0.18
L. <i>dorsi</i> area, cm ²	22.2	22.1	23.7	1.67	0.14	0.17

¹ 1, poor; 2, normal; 3, good; 4, very good; 5, excellent. ² 1, very lean; 2, lean; 3, slightly fatty; 4, fatty; 5, very fatty. ³ 1, poor; 2, normal; 3, excessive. SEM: Standard error of the mean. L: linear; C: quadratic. ^{a,b} within the same row indicate different values (P < 0.05)

In a previous study on lambs where soybean oil was included at a maximum level of 5% replacing alfalfa hay and sorghum grain, no increases in productive performance or feed intake were observed (Vicente *et al.*, 2020), unlike the present study, where soybean oil replaced only corn grain. It is possible that, in addition to the positive effect that oils have on the physical characteristics of high-grain diets, the reduction of high starch concentration in the diet may confer benefits to the ruminal environment, such that dry matter digestibility and rumen metabolism itself become more favorable for animal welfare, as observed in the previous study (Vicente *et al.*, 2020).

Because soybean oil contains a high concentration of unsaturated fatty acids, which are partially isomerized and biohydrogenated in the rumen and absorbed in the intestine (Jenkins *et al.*, 2014), ruminal fermentation patterns and dry matter intake are modified (Ghafari *et al.*, 2016). However, in the present study, feed intake pattern was not altered, which, together with a higher energy density in the diet, suggests a higher energy intake due to the effect of the vegetable oil. Therefore, the improvements in total gain, ADG (average daily gain), and feed efficiency demonstrate that the inclusion of 6 % soybean oil as a partial substitute for cereals is an efficient strategy to increase metabolizable energy content in high-grain diets without affecting feed intake.



Table 4. Economic analysis of feed value and production of lambs fed diets with vegetable oil

	Soybean oil, % dry matter basis			SEM	P value	
	0	3	6		L	C
Production value, US\$	108.9	106.7	110.7	2.31	0.22	0.19
Production cost, US\$	81.4	79.3	76.8	2.14	0.29	0.21
Grossprofit, US\$	27.5 ^b	27.4 ^b	39.9 ^a	1.05	0.10	0.03
Benefit/Cost ratio	0.34 ^b	0.35 ^b	0.52 ^a	0.05	0.09	0.01
Profit/Sales ratio	0.25 ^b	0.26 ^b	0.36 ^a	0.05	0.04	0.15

SEM: Standard error of the mean, ^{a,b} within the same row indicate different values (P < 0.05)

The effect of increasing dietary energy level on intake is highly variable, ranging from no modification of weight gain to a reduction in weight gain (Zhang *et al.*, 2010; Wang *et al.*, 2020). When the required energy level is exceeded, feed intake may be reduced (Ríos *et al.*, 2014).

The lack of effect of dietary soybean oil on carcass biometric measurements has been previously confirmed and attributed to the fact that when animals have similar ages and growth rates, dietary factors have a low influence on carcass indicators (da Costa *et al.*, 2023), especially when the dietary inclusion level of vegetable oil does not exceed 6 % (Nguyen *et al.*, 2018).

The increase in economic benefits found by adding 6% soybean oil to the diet is a result of improved productive performance and feed efficiency, as has been evidenced in studies with lambs supplemented with fatty acids (Dogan *et al.*, 2022).

CONCLUSION

It is concluded that the inclusion of 6 % soybean oil in high-grain diets can be an effective alternative energy substitute for grains in lambs. However, further research is needed to determine its effect on meat characteristics and the lipid profile.

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CONFLICT OF INTEREST

Authors declare they do not have any conflict of interest.



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