Carcass yield and primal cuts of lambs fed on different diets in the humid tropics

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ABSTRACT

In the humid tropics of Mexico, sheep production is an important economic activity, mainly focused on the sale of barbacoa and barbacoa tacos; however, no primal cuts of lambs are offered.

Objective: To assess carcass yield and primal cuts of lambs fed on different diets in Loma Bonita, Oaxaca, Mexico.

Design/Methodology/Approach: Five diets were assessed to measure carcass yield and primal lamb cuts: corn stover, corn silage, Chinese hibiscus (locally known as *tulipán*), cracked corn, and grazing. A completely randomized experimental design was used. The following variables were measured: hot and cold carcass weight, hot and cold carcass yield, neck weight, leg weight, shoulder weight, loin weight, rib weight, rib eye area determination, and fat thickness.

Results: Lambs fed on cracked corn achieved a higher carcass yield (44.2%) than the other treatments ($P \leq 0.05$), a leg weight of 3.87 kg, and loins 2.57 kg heavier than the other treatments, in average ($P \leq 0.05$).

Study Limitations/Implications: It was difficult to obtain homogeneous groups of lambs in terms of age and weight.

Findings/Conclusions: Lambs fed on cracked corn recorded higher carcass yields and better leg and loin primal cuts than lambs fed on the other diets.

Keywords: Lamb meat, sheep feed, tropical region.

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INTRODUCTION

In 2008, world sheep population consisted of 1.209 billion individuals and the sheep industry generated 9.78 million tons of meat (FAO, 2020). In Mexico, sheep inventory is made up of 8.7 million heads, with a production of 65,846 t of meat in 2021. The states of Mexico, Hidalgo, Veracruz, Jalisco, Puebla, and Zacatecas account for 54.2% of the sheep meat produced (SIAP, 2020).

Sheep meat is rich in protein (19.1%), fat (22.0%), ash (0.88%) (Du *et al*., 2019), iron, zinc, selenium, vitamins A, B3, and B12, and folic acid (de Andrade *et al*., 2016).

Commercial carcass weight in Portugal, Italy, and Spain is 8, 9, and 11 kg, respectively, while in Northern Europe carcass weight ranges from 16 to 23 kg (Vnučec *et al*., 2014).

In Mexico, approximately 800 g of lamb meat are consumed. In the central zone of the country, 85% of the sheep meat is consumed as barbacoa (90%) and the remaining 10% is prepared *al pastor* and *al ataúd*, served as *mixiotes* and lamb *birria*, and used to substitute roast goat kid (as *cordero lechal* and *cordero*), as well as sold as fine lamb cuts (Partida *et al*., 2013, Espinoza-Marín *et al*., 2017).

Given its high quality, consumers consider sheep meat as a luxury product with great nutritional attributes (Sañudo, 2006) and to date there has been an increased interest in lean lamb cuts (Anderson *et al*., 2015).

The objective of this study was to determine the carcass yield and primal cuts of lambs fed on diets based on corn stover, corn silage, Chinese hibiscus (*Hibiscus rosa sinensis*), cracked corn, and African star grass in Loma Bonita, Oaxaca, Mexico.

MATERIALS AND METHODS

Location of the study site

The work was carried out at the Universidad del Papaloapan, in the municipality of Loma Bonita, Oaxaca, Mexico. Its geographical coordinates are 18° 06' N and 95° 52' W and it is located at 25 m.a.s.l. It has a warm humid climate, with rainfall in summer, and an average temperature of 24.7 °C (INEGI, 2005).

Treatments and experimental design

Forty male lambs with 18±2 kg live weight were used and the following diets were tested: 1) Diet 1 with 38% corn stover, 37% star grass (SG), 19% soybean paste (SP), 5% molasses (MO), and 1% mineral salts (MS), 16.2% crude protein (CP), and 2.3 Mcal kg^{-1} MS^{-1}; 2) Diet 2 with 41% corn silage, 35% SG, 18% SP, 5% MO, 1% MS, 16.7% CP, and 2.5 Mcal kg^{-1} MS^{-1}; 3) Diet 3 with 26% *Hibiscus rosa sinensis*, 59% SG, 9% SP, 5% MO, 1% MS, 16.7% CP, and 2.6 Mcal kg^{-1} DM^{-1}; 4) Diet 4 with 44% cracked corn grain, 32% SG, 18% SP, 5% MO, 1% MS, 16.8% CP, and 2.8 Mcal kg^{-1} MS^{-1}; and 5) Diet 5 with grazing (*Cynodon nlemfuensis*) and commercial concentrate (15% protein). Lambs were fed: 1) reception diet for 7 days, consisting of African star grass forage; 2) adaptation diet for 15 d; and 3) fattening diet. Finished lambs (90 d) were transferred to the laboratory where they were weighed and slaughtered, recording a LW of 30 kg and a ≥3 body condition, according to the Body Condition Scaling developed by Russell (1969), which ranges from 1 (thin) to 5 (overweight).

Variables under study

Hot carcass weight (kg) is the quantity of carcass after slaughter and skinning. Cold carcass weight (kg) is the quantity of carcass preserved at 4 °C for 24 h. Hot carcass yield (%) is the proportion of the animal's carcass, expressed as the ratio of hot carcass weight (HCW) to live weight (LW) at slaughter ($HCW=HCW/LW\times100$). To determine

cold carcass yield (%), the carcass was refrigerated at 4 °C and the weights obtained 24 h post-mortem were recorded, and the yield was calculated as the difference between the hot carcass yield and the cold carcass yield. Neck weight (kg) was determined separating the head at the atlanto-occipital joint to the 7th cervical vertebra. The weight of the rib (kg) was established sectioning from the 1st to the 12th thoracic vertebrae. Loin weight (kg) was determined making a section from the 12th and 13th thoracic vertebrae to the 6th and 7th lumbar vertebrae. The front leg was weighed (kg) separating the scapula from the thorax up to the carpal-metacarpal joint. Leg weight (kg) was determined by a cut from the pelvic joint to the edge of the tarsometatarsal joint. The rib eye area (*Longissimus dorsi* muscle, between the 12th and 13th ribs) was outlined on acetate and the area (cm^2) was calculated with AutoCAD®. Finally, fat thickness was measured in mm at the height of the 13th thoracic vertebra.

Statistical analysis of the information

The experimental design was completely randomized. The information was subjected to an analysis of variance, while the variables that showed statistical significance were subject to a comparison of means (Tukey; $P \leq 0.05$), using the statistical package SAS 9.1 (SAS Institute, 2013).

RESULTS AND DISCUSSION

Hot carcass weight

Hot carcass weight (16.7 kg) was higher with the cracked corn-based diet than with the other treatments ($P \leq 0.05$; Table 1), because corn (3.7 Mcal kg^{-1} DM^{-1}) contains 7.3% protein, 3.3% fat, and 63.8% starch (FEDNA, 2016), which promote muscle formation and fat deposition, generating lambs with greater live weight (kg) and body size.

With corn silage and *Hibiscus*, hot carcass weights were similar to those reported by García *et al.* (1998) for Pelibuey sheep fed on Rye grass and oat straw (hot carcass weight: 10.5 kg). Hernández-Montiel *et al.* (2016) fed lambs on *Canavalia* seeds and quantified

Table 1. Carcass yield of Pelibuey lambs fed on different diets.

Diet	LWS (kg)	HCW (kg)	CCW (kg)	CCY (%)	Diference
Corn stubble	27.0c†	10.4c	10.1c	38.6b	6.9c
Corn silage	28.1bc	10.9c	10.5c	38.7b	7.5c
Tulip (*Hibiscus*)	27.9c	10.6c	10.0c	38.0b	7.4c
Cracked corn	37.7a	16.7a	16.5a	44.2a	17.7a
Crazing	30.6b	12.0b	11.8b	40.0b	10.5b
Mean	30.3	12.1	11.8	40.0	10.0
HSD	2.7	0.9	0.8	3.3	2.7
CV (%)	4.1	3.5	3.2	3.8	12.5

LWS: live weight at slaughter (kg); HCW: hot carcass weight (kg); CCW: cold carcass weight (kg); CCY: cold carcass yield (%). "Diferencia" refers to the difference between initial weight and the weight of lambs at slaughter. †a, b, c: literals in columns indicate a statistically significant difference ($P \leq 0.05$). HSD: Tukey's honestly significant difference test ($P \leq 0.05$); CV: Coefficient of variation (%).

12.4 kg in hot carcass weight, a similar result to the one obtained in this work with the grazing diet (12.0 kg) (Table 1).

Cold carcass weight

Cold carcass weight (16.5 kg) of lambs fed on cracked corn is similar to the results of the study conducted with Pelibuey lambs (16.6 kg) in a hot dry climate by Macías-Cruz *et al.* (2010). However, the cold carcass weight of lambs provided with corn silage and grazing diet had values of 10.5 kg and 11.8 kg, respectively. This result was in line with the results of Hernández-Montiel *et al.* (2016) who reported a 12.1 kg weight for the cold carcass weight of sheep fed on *Canavalia*.

In this trial, cold carcasses weighted 10.1 kg and 10.0 kg for the corn stover and *Hibiscus* diets, respectively (Table 1). This result is attributed to the varied energy content of the diets; therefore, the animals were smaller and lighter at the time of slaughter.

Cold carcass yield

There were significant differences among treatments. Cracked corn diet provided to sheep showed the highest carcass yield (44.2%), while, in the other treatments, it ranged from 38.0 to 40.0% (Table 1), possibly as a result of the higher live weight at the time of slaughter. Similar results were obtained by Partida and Martinez *et al.* (2010), who reported a carcass yield of 41.1% in Pelibuey sheep fed on sorghum, soybean, and corn silage, and 30 kg at slaughter. Frías *et al.* (2011) recorded a meat yield of 42.0% in Pelibuey sheep. Carcass yield in this study was attributed to differences in the energy content of the diets, which was reflected in the productive behavior and; therefore, affected carcass yields.

Yield of primal cuts of sheep meat

Neck weight

Neck weight was not significant between treatments (Table 2).

Table 2. Yield of primal cuts of sheep fed different diets in Loma Bonita, Oaxaca, Mexico.

Diet	Neck (kg)	Rib (kg)	Loin (kg)	Foreshank (kg)	Leg (kg)	REA cm^2	BFT (mm)
Corn stubble	0.79a†	1.47ab	0.71c	1.13c	1.24c	14.7bc	0.3a
Corn silage	1.31a	1.65a	0.84b	1.15c	1.39b	14.2bc	1.2a
Hibiscus	0.77a	1.49ab	0.73c	1.20b	1.24c	12.3c	0.3a
Cracked corn	1.04a	1.72a	2.57a	1.75a	2.18a	17.2a	1.3a
Crazing	0.84a	1.20b	0.78b	1.19b	1.35b	15.3b	0.5a
Mean	0.95	1.51	1.13	1.28	1.48	14.7	0.7
HSD	0.55	0.29	0.10	0.03	0.07	0.9	1.2
CV (%)	26.9	9.0	4.1	1.3	2.3	8.3	26.4

CV=coefficient of variation (%). HSD=Tukey's honestly significant difference ($P \leq 0.05$). †a, b, c: literals in columns indicate a statistically significant difference ($P \leq 0.05$). REA=Rib eye area (cm^2); BFT=back fat thickness (mm) in the *Longissimus dorsi* muscle.

Rib weight

There were significant differences in rib weight between diets: control had the lowest value, while corn silage and cracked corn resulted in the highest rib weights (Table 2). Estrada *et al.* (2012) calculated 1.6 kg in rib weight when whole sorghum was offered to sheep. Ríos *et al.* (2012) recorded a rib weight of 2.9 kg when Pelibuey × Katahdin sheep were fed on waste chickpeas. Rib weight differences in this trial are related to the slaughter weight of the lambs (Table 2).

Loin weight

There were differences in loin weight between treatments (Table 2): it reached 2.57 kg with cracked corn, while it ranged from 0.71 to 0.84 kg with diets prepared with corn stover, corn silage, *Hibiscus* and the control. These results are explained by the different weight of the animals. Estrada *et al.* (2012) reported a loin weight of 1.21 kg in Pelibuey × Dorper lambs. The results of the cracked corn diet matched the findings of Magaña-Monforte *et al.* (2015) who reported a loin weight of 2.61 kg in Pelibuey × Katahdin sheep. A corn grain diet increased the size of the sheep, resulting in greater loin weight. Corn provided energy that was converted into muscle; additionally, animals expend less energy under stabling conditions.

Shoulder weight

Significant differences were recorded between treatments regarding shoulder weight. Cracked corn grain diet produced 1.75 kg, a higher value than the other diets, whose shoulder weight values ranged from 1.13 to 1.20 kg. Ríos *et al.* (2012) reported a shoulder weight of 3.18 kg when feeding chickpea grains to sheep. These variations are caused by differences in dietary energy and body weight of sheep at slaughter.

Leg weight

There were significant differences between treatments. Cracked corn diet (2.18 kg) was superior ($P \leq 0.05$) to corn silage, grazing, *Hibiscus*, and corn stover, which ranged from 1.24 to 1.39 kg (Table 2). Estrada *et al.* (2012) reported a leg weight of 2.23 kg in Pelibuey lambs fed on sorghum —an equivalent value to that of the cracked corn diet. This suggests that cereals favor muscle conversion and fat deposition, resulting in lambs of greater size and live weight.

Rib eye area (REA)

REA reached 17.2 cm^2 and 12.3 cm^2 with cracked corn and *Hibiscus*, respectively ($P \leq 0.05$). Hernández-Espinoza *et al.* (2012) reported 14.2 cm^2 in Pelibuey lambs with REA; similar results were obtained with silage (14.2 cm^2) and corn stover (14.7 cm^2) (Table 2). A REA of 15.3 cm^2 was determined in the case of grazing lambs —a result equivalent to that of Ríos *et al.* (2012), who estimated a REA of 15.7 cm^2 in Pelibuey × Katahdin sheep. In this study, carcass size and weight modified the REA dimensions.

Back Fat Thickness (BFT)

No significant differences were recorded between diets. The highest BFT (1.3 mm) was obtained with cracked corn, while grazing recorded 0.5 mm. These results are in line with Hernández-Montiel *et al.* (2016), who obtained 0.7 mm of BFT for Pelibuey sheep.

CONCLUSIONS

A higher carcass yield was achieved with confined lambs fed on a cracked corn grain-based diet. Finally, including an appropriate feeding program in sheep production is a good alternative for obtaining value-added meat cuts, which will result in a higher economic income for the producers of Loma Bonita, Oaxaca, Mexico.

REFERENCES

Anderson F, Pannier L, Pethick DW, Gardner GE. (2015). Intramuscular fat in lam muscle and the impact of selection for improved carcass lean meat yield. *Animal 9*(6):1081-1090. https://www.sciencedirect.com/science/article/pii/S1751731114002

de Andrade JC, Sobral L de A, Ares G, Deliza R. (2016). Understanding consumers' perception of lamb meat using free word association. *Meat Science* 117: 68-74. https://doi.org/10.1016/j.meatsci.2016.02.039

Du, S., You, S. H., Bao, J., Gegentu Jia Y, S., Cai, Y. M. (2019). Evaluation of the growth performance and meat quality of Mongolian lamb fed grass, hay or pellets of Inner Mongolian native grass. *Small Ruminant Research* 181: 34-38. https://doi.org/10.1016/j.smallrumres.2019.10.008

Espinoza-Marín, R., Hernández-Mendo, O., Ortega-Cerilla, M. E., Hernández-Sánchez, D., Huerta-Bravo, M. (2017). Perfil de ácidos grasos de barbacoa de borregos Pelibuey. *Agroproductividad 10*(2): 3-8. https://revista-agroproductividad.org/index.php/agroproductividad/article/view/944

Estrada, A., Dávila, H. R., Herrera, R. S., Robles, J. C., La, O. O., Castro, B. I., Portillo, J. J., Ríos, F.G., Contreras, G. (2012). Características de la canal y rendimiento de los cortes primarios de corderos alimentados con sorgo escobero (*Sorghum bicolor* var. Technicum, jav). *Revista Cubana de Ciencia Agrícola 46*(2): 145-150. https://www.redalyc.org/articulo.oa?id=193024447005

FAO (Organización de las Naciones Unidas para la Alimentación y la Agricultura). (2020). Ganadería. https://www.fao.org/faostat/es/#data/QA (Consulta: marzo 2020).

FEDNA (Fundación Española para el Desarrollo de la Nutrición Animal). 2016. Maíz nacional. https://www.fundacionfedna.org/node/370 (Consulta: abril 2020).

Frías, J. C., Aranda, E. M., Ramos, J. A., Vázquez, C., Díaz, P. (2011). Calidad y rendimiento en canal de corderos en pastoreo suplementados con caña de azúcar fermentada. *Avances en Investigación Agropecuaria 15*(3): 33-44. http://ww.ucol.mx/revaia/portal/pdf/2011/sept/3.pdf

García, M. J. A., Núñez, G. F. A., Rodríguez, A. F. A., Prieto, C., Molina, D. N. I. (1998). Calidad de la canal y de la carne de borregos Pelibuey castrados. *Técnica Pecuaria en México*. 36: 225-232. https://cienciaspecuarias.inifap.gob.mx/index.php/Pecuarias/article/view/625/623

Hernández-Espinoza, D. F., Oliva-Hernández, J., Pascual-Córdoba, A., Hinojosa-Cuellar, J. A. (2012). Descripción de medidas corporales y composición de la canal en corderas Pelibuey. *Revista Científica FCV-LUZ* 22: 24-31. https://produccioncientificaluz.org/index.php/cientifica/article/view/15686/15659

Hernández-Montiel, W., Ramos-Juárez, J. A., Aranda-Ibañez, E.M., Hernández-Mendo, O., Munguía Flores, V. M., Oliva-Hernández, J. (2016). Alimento fermentado elaborado con semillas de *Canavalia ensiformis* sobre el crecimiento y la canal de corderos Pelibuey. *Revista Mexicana de Ciencias Pecuarias 7*(2): 213-232. https://cienciaspecuarias.inifap.gob.mx/index.php/Pecuarias/article/view/4175/3436

INEGI (Instituto Nacional de Estadística Geografía e Informática). (2005). Cuaderno Estadístico Municipal de Loma Bonita, Estado de Oaxaca. Aguascalientes, México. 170 p.

Macías-Cruz, U., Álvarez-Valenzuela, F. D., Rodríguez-García, J., Correa-Calderón, A., Torrentera-Olivera, N. G., Molina-Ramírez, I., Avendaño-Reyes, I. (2010). Crecimiento y características de canal en corderos Pelibuey puros y cruzados F1 con razas Dorper y Katahdin en confinamiento. *Archivos de Medicina Veterinaria 42*(3): 147-154. https://www.scielo.cl/pdf/amv/v42n3/art05.pdf

Magaña-Monforte, J. G., Moo-Catzin, C. J., Chay-Canul, A. J., Aké-López, J. R., Segura-Correa, J. C., Montés-Pérez, R. C. (2015). Crecimiento y componentes de la canal de ovinos de pelo en jaulas elevadas. *Livestock Research for Rural Development. 27*(6): 1-7. https://www.researchgate.net/publication/278244199_Crecimiento_y_componentes_de_la_canal_de_ovinos_de_pelo_en_jaulas_elevadas

Partida PJA, Braña VD, Jiménez SH, Ríos RFG, Buendía RG. 2013. Producción de Carne Ovina. Ajuchitlán, Qro. Centro Nacional de Investigación Disciplinaria en Fisiología y Mejoramiento Animal-INIFAP. Qro., México. 116 p.

Partida, P. J. A., Martínez, R. L. (2010). Composición corporal de corderos Pelibuey en función de la concentración energética de la dieta y del peso al sacrificio. *Veterinaria México 41*(3): 177-190. https://www.medigraphic.com/pdfs/vetmex/vm-2010/vm103b.pdf

Ríos, R. F. G., Bernal, B. H., Cerrillo, S. M. A., Estrada, A. A., Juárez, R. A. S., Francisco, O. J., Portillo, L. J. J. (2012). Características de la canal, rendimiento en cortes primarios y composición tisular de corderos Katahdin × Pelibuey alimentados con garbanzo de desecho. *Revista Mexicana de Ciencias Pecuarias* 3: 357-371. https://cienciaspecuarias.inifap.gob.mx/index.php/Pecuarias/article/view/731/729.

Russel, A. J.F., Doney, J. M., Gunn, R. G. (1969). Subjetive assesment of body fat in live sheep. *Journal Agriculture Science Cambridge 72*(2): 451-454.

Sañudo, A. C. (2006). Calidad de la canal y de la carne en los ovinos: factores que la determinan. *Revista Argentina de Producción Animal* 26: 155-167. https://fcvinta.files.wordpress.com/2015/12/3915-calidad-carne.pdf

SAS, Institute. (2013). Statistical Analysis System. Base SAS® 9.4 Procedures Guide: Statistical procedures. Second edition. SAS Institute Inc. Cary NC, USA. 550 p.

SIAP (Servicio de Información Agroalimentaria y Pesquera). (2020). Producción ganadera. https://www.gob.mx/siap/acciones-y-programas/produccion-pecuaria (Consulta: junio 2020).

Vnučec, I., Držaić, V., Mioč, B., Prpić, Z., Pavić, V., Antunović, Z. (2014). Carcass traits and meat color of lambs from diverse production systems. *Veterinarski Arhiv 84*(3): 251-263. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.644.871&rep=rep1&type=pdf