Carcass characteristics and yield of the primary cuts of lambs fed broom millet (*Sorghum bicolor* var. Technicum, jav)

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The effect of broom millet (*Sorghum bicolor* var. Technicum, jav), entire or ground was studied in the carcass characteristics and primary cuts in 40 pelibuey ovines (Dorper x Pelibuey), of 31.55 ± 6.02 kg of live weight during 42 d. Seventy five percent of broom millet entire was substituted by that ground. A completely random design with two treatments and four replicates was used. A feeding test with 40 animals receiving integral diets was conducted. The inclusion of entire broom millet did not influence significantly on the final live weight, weight of the hot carcass, rib eye area, width of the dorsal and renal-pelvic fat, weight of the digestive viscera and weight of the primary cuts. However, the carcass yield decreased ($P < 0.05$) (56.01 vs. 52.94 %) as well as the percentage of empty body (84.74 vs. 81.62 %) and increased ($P < 0.05$) the percentage of filled viscera (26.39 vs. 23.94 %), weight of the gastrointestinal content (6.84 vs. 5.71 kg) and percentage of the gastrointestinal content (18.38 vs. 15.26 %). It is concluded that the inclusion of entire broom millet in the feeding of lambs diminishes the carcass yield, without affecting its characteristics, weight of the primary cuts and their relation.

Key words: *carcass characteristics, cut, broom millet, Pelibuey sheep*.

In the semi-arid tropics, where rainfall is scarce, the introduction of crops resistant to draught offering satisfactory yields is needed. In these areas, few crops grow (SAGARPA 2003), mainly the broom millet (*Sorghum bicolor* var. Technicum, jav.) is efficient to take advantage of the low water availability under these conditions, as it is resistant to the adverse effects of the environment (Robles 1976). The cereal grain used in animal feeding is characterized by having 12.11and 17.83 % of protein and crude fiber, respectively. It is a by-product of the broom industry.

During the finishing stage of fattening lambs from grazing systems, this product is used to diminish the dependence of other more expensive. The use of the grain ground could improve management and facilitate the mixing with the rest of the ingredients of the diet. Besides, a higher exposition in the digestive tract can be achieved. (Owens *et al*. 1997). However, feeding hair sheep with fibrous feeds, which physical form is modified with this process, could vary the productive response, the gastrointestinal content and can influence on the quality characteristics of the carcass (Lloyd *et al*. 1981).

The objective of this study was to determine the effect of the broom millet, ground and entire, on the carcass characteristics and primary cuts of lambs.

Materials and Methods

Location and climate. An experiment was conducted for 42 d in the Experimental Unit for Small Ruminants belonging to the Faculty of Veterinary Medicine and Husbandry of the Autonomous University of Sinaloa, and in the Municipal Slaughter House of Culiacán, Sinaloa. The area is characterized y climate BS1 (h') w (w) (e), defined as semi-dry, very hot, with rainfall in the summer, according to the classification of Köppen (García 1988). It is located at 107º 24' west longitude and 24º 48' north latitude, at 38 m.a.s.l. The annual average temperature is of 25.9 º C, with 30.4 ºC maximum in June and July and 20.6 ºC minimum in January. The relative humidity is of 68 %, with 81 % maximum in September and 51 % minimum in April. The annual average rainfall is of 688.5 mm (CIAPAN 2002).

Animals and treatments. Fourty Pelibuey sheep (Dorper x Pelibuey) were used, with 31.55 ± 6.02 kg of live weight and adapted to housing and experimental diets during 14 d before the beginning of the experiment. Based on the live weight, the animals were distributed in groups of four, in ten experimental pens. They were all roofed, with measures of 3 x 2 m, equipped with metallic feeders of five holes, with manual separators and drinkers. The animals were orally treated against parasites with Closantel (ClosantilMR) at 5 % (7.5 mg/kg of live weight) and they were sub-cutaneoulsy immunized against pneumonic Pasteurelosis.

Each experimental diet had five groups, with four animals each. The table 1 shows the composition of the diets. The forage source used was Sudan hey, ground at particle size of 2.5 cm. The cereal was ground at a size of 3 mm until reaching meal appearance.

A random block design with four replicates was used. The treatments consisted of supplying broom millet, integral or ground.

Experimental procedure. After 42 d of consuming the

Table 1. Nutrients composition and content of integral diets with broom millet entire or ground for Dorper x Pelibuey lambs

Ingredients	Treatments , % of inclusion	
	Entire broom millet	Ground broom millet
Entire broom millet	75.0	0.0
Ground broom millet	0.0	75.0
Sudan hey	6.0	6.0
Meet meal	4.0	4.0
Sugarcane molasses	10.0	10.0
Animal fat	2.5	2.5
Mineral pre-mixture	2.5	2.5
Total	100 %	100 %
Nutrimental content (dry basis)[1]		
Crude protein, %	14.40	14.40
DE, MJ/kg	12.13	12.13
ME, MJ/kg	9.79	9.79
ENg, MJ/kg	3.77	3.77
Crude fiber, %	11.90	11.90
Ether extract, %	4.20	4.20

[1]Analysis calculated from values published (NRC 1984), except values for broom millet for which those of Coronel (2005) and Nikkhah *et al*. (2004) were considered.

diets, the final live weight (FLW) was recorded. Twenty animals, ten from each treatment, were slaughtered after 18 h of fast, according to the procedures of NOM-ZOO-033-1995. After removing the viscera, the rumen, as well as the small and large intestines were weighed empty and full. The weight of the empty body (WEB) was calculated.

Once the animals were slaughtered, the weight of the hot carcass (WHC) was obtained and the carcass yield (CY) and the renal-pelvic fat (RPF) were calculated. Besides, the area of the rib eye (ARE) and the width of the dorsal fat (WDF) were determined with a Vernier digital calibrator micrometer, of twelve inches. After preserving the carcass for 24 h at 2 ºC, the primary cuts were obtained: short loin (SL), long loin (LL), rib (R), leg (L), shoulder (S), neck (N) and flank (F).

Statistical analysis. For the data analysis, the statistical software SAS (2002) was used. The mean values, when necessary, were compared through Tukey's test. The simple correlation analysis of Pearson was conducted between the carcass characteristics and the primary cuts (Steel and Torrie 1988).

Results and Discussion

Table 2 presents the results of the carcass characteristics and viscera weight. There was no effect on the effect of the hot carcass. The data obtained were similar to those referred by Domínguez-Vara *et al*. (2009) and Ribeiro *et al*. (2011), who reported that the lambs were fed with 68 % of ground sorghum. The yield of the hot carcass (%) was lower ($P < 0.05$) in the lambs receiving entire broom millet. In this treatment, this result could be related with the highest amount of the gastrointestinal content in the digestive via (table 3). Lloyd *et al*. (1980) stated that the carcass yield depends mainly on two factors: the gastrointestinal content and the finalization type, so carcass yield can vary from 40 to 53 % and, exceptionally, up to 56 and 58 % for lambs of rapid growth, like Dorper breed (Notter *et al*. 2004). In the animals used in this experiment, the carcass yield is between these intervals.

The rest of the indicators (table 2) did not differ between treatments. The value of the rib eye is close to that referred by Greiner and Duckett (2005) for lambs of the Dorper breed (10.53 cm2), with carcass average weight of 25.7 kg. However, other authors (Notter *et al*. 2004 and Arvizu *et al*. 2011) found higher values (14.1 and 12.87 cm^2) for ARE, with hot carcass weights of 25.9 and 20.07 kg, respectively. Salinas-Chavira *et al*. (2004) found ARE of 9.8 cm^2, while for hair sheep, fed 60 % of entire broom millet, Coronel (2005) recorded values of 7.74 cm^2, with 19 kg of hot carcass. The result of this experiment, regarding ARE, indicates that substituting entire broom millet for that ground did not affect this variable, when averaging values in a same body weight range.

The weight and percentage of the liver and pelvis fat is of great importance in ovine and bovine, as it can be easily removed when weighing the cold carcass. This indicator has been used in assessment systems of carcasses (Kempester *et al*. 1982). Specifically hair sheep, with 21.2 kg of LW, fed common sorghum, can

Table 2. Carcass characteristics of Dorper x Pelibuey lambs, according to the physical form of broom millet in the diet

Variable	Broom millet		SE±
	Entire	Ground	
Final liveweight, kg	37.60	37.50	1.39
Weight of the hot carcass, kg	20.05	21.00	0.90
Carcass yield, %	52.94	56.01	0.70*
Area of the rib eye, cm^2	11.22	10.81	0.44
Fat of liver and pelvis, g	318.00	366.00	0.04
Width of the dorsal fat, mm	1.79	1.77	0.03

*P < 0.05

Table 3. Effect of the physical form of broom millet on the weight of the digestive viscera of Dorper x Pelibuey lambs

Variable	Broom millet		SE±
	Entire	Ground	
Weigth of the empty body, kg	30.76	31.79	1.25
Weigth of the empty body, %	81.62	84.74	0.67**
Full viscera, kg	9.83	8.67	0.34
Empty viscera, kg	2.99	2.96	0.08
Full viscera, %	26.39	23.29	0.74*
Empty viscera, %	8.03	8.01	0.20
Gastrointestinal content, kg	6.84	5.71	0.29*
Gastrointestinal content, %	18.36	15.26	0.67*

*P < 0.05 **P < 0.01

reach from 358 g (Obregón 2003) to 581 g (Coronel 2005). However, in the Dorper breed, this value can vary from 900 g (Notter *et al*. 2004) to 938 g (Shackelford *et al*. 2005), with 45.7 kg of LW and 25.9 kg of WHC, and 58.5 kg of LW and 29.9 of WHC, respectively. For the Katahdin breed, it reaches values of 970 g, with 56.7 kg of LW and 29.5 kg of WHC, being superior to those recorded in this study.

The width of the dorsal fat was inferior to 2.60 mm, value referred by Coronel (2005) in hair sheep, fed with a diet where the entire broom millet substituted the common in 60 %. It was also lower to that reported by Notter *et al*. (2004), Greiner and Duckett (2005) and Shackelford *et al*. (2005), of 6.36, 6.35 and 7.87 mm, respectively, for sheep of the Dorper breed, and of 6.8 mm for the Dorper x St.Croix crossbreeding (Bunch *et al*. 2003). In this study, the WDF value is out of the interval from 2.5 to 6.5 mm, considered as optimum by Snowder *et al*. (1994) in fatty carcasses of the breeds Rambouillet, Targhee, Columbia and Polypay. These results differ from those of Petit and Castonguay (1994), who used corn silage (2.44 mm). This was expected as the silage has higher energy content (3.10 Mcal DE/kg DM or 12.97 MJ DE/kg DM, NRC 2007) compared to that used in this study (12.13MJ DE/kg DM).

In the sheep receiving entire broom millet, the percentage yield of the empty body was lower ($P < 0.01$) and increased ($P < 0.03$) the percentage yield of the full viscera, as well as the weight and the percentage of the gastrointestinal content (table 3). This inverse relation is favorable for the assessment of the carcass characteristics, because, according to Boggs and Merkel (1993), the specific weight of the diet may disguise the weight gain of the animal. The breed and feeding of the animals may influence on these indicators.

In this study, the weight of the empty body was of 31.3 kg, similar to that reported by Nagalakshmi *et al*. (2011), who informed 30.3 kg. However, in this experiment, the gastrointestinal content was higher (6.84 vs. 1.6 kg). For the empty body and the gastrointestinal content, Ribeiro *et al*. (2011) notified values of 33.44 kg and 5.4 kg, respectively. The resuls of Silva *et al*. (2005), in respect to live weight and empty body of sheep from the Ile de France and Churra de Terra Quente breeds, were of 41.8 vs 36.5 kg and of 23.8 vs. 20.7 kg, respectively, when consuming diets with high and low energy content. However, Kabbali *et al*. (1992) reported values of 25.5 y 21.1 kg for the Moroccan breed when the animals were under processes of low nutrition and re-feeding.

The results of this experiment indicate that there was no visceral growth, but the digestive viscera expand and store higher gastrointestinal content when receiving higher density feeds. This could be associated with the

higher intake and with the increase of the organs weight (Drouillard *et al*. 1991).

According to Osorio *et al*. (1999), in animals from grazing systems, regularly, this indicator is higher as the content of the different digestive organs is also superior. Therefore, knowing the gain composition is of great importance when using non-conventional and unknown feeds to develop more efficient production systems (Fernándes *et al*. 2010).

The weight of the primary cuts in sheep was similar between treatments (table 4). The values are between the range informed by Coronel (2005), when including 30 and 60 % of ground broom in diets fro sheep, finished at 35 kg of LW. However, they contrast with those obtained by Estrada-Angulo *et al*. (2004), who fed growing Pelibuey lambs (17.3 kg of LW), with 61 % of a similar ingredient. These authors observed that the weight of the short loin, leg, shoulder and flank was higher.

Table 5 shows the correlation matrix between the carcass characteristics and primary cuts of Dorper x Pelibuey lambs. Except for LW and CY, and WHC and SL, all the relations between the indicators studied were from medium to high and positives. The importance of these correlations is based on their utility to predict, *in vivo*, the performance of the carcass characteristics and estimate the yield in primary cuts or other carcass components (Yaprak *et al*. 2008). The values of the lambs carcass is between the range recorded by other authors, and confirm that the animals with higher LW tend to obtain high weights for the cuts and increase their yields (Snowder *et al*. 1994, Vargas *et al*. 2007 and Vieira *et al*. 2007). In this study, the ARE and WDF, are highly correlated, indicating that muscle and the sub-cutaneous adipose tissue growth at the same time. These results differ from those reported by Cartaxo and Sousa (2008).

It is concluded that the inclusion of entire broom millet in sheep feeding diminishes the carcass yield, without affecting its weight or that of the primary cuts. Besides, it keeps a proper relation between the carcass characteristics.

Table 5. Correlation matrix between different indicators (n=20)

	PV	PCV	PCC	RC	AOC	GRP	EGD	LC	LL	CO	PI	PA	CU	FA
LW	1.0	0.98***	0.97***	0.37NS	0.72***	0.62***	0.65***	0.80***	0.89***	0.89***	0.96***	0.97***	0.76***	0.82***
WEB		1.00	0.99***	0.50**	0.71***	0.67***	0.67***	0.84***	0.94**	0.93***	0.96***	0.98***	0.75***	0.84***
WHC			1.00	0.59***	0.73***	0.63***	0.67***	0.82NS	0.96***	0.95***	0.97***	0.98***	0.79***	0.83***
CY				1.00	0.43*	0.36NS	0.32*	0.42*	0.67***	0.68***	0.53**	0.54**	0.49**	0.45**
ARE					1.00	0.50**	0.64***	0.65***	0.74***	0.77***	0.71***	0.68***	0.64***	0.57***
RPF						1.0	0.42*	0.46**	0.63***	0.64***	0.52**	0.64***	0.42*	0.63**
WDF							1.00	0.53**	0.73***	0.70***	0.67***	0.65***	0.41*	0.73***
SL								1.00	0.84***	0.72***	0.82***	0.77***	0.66***	0.59***
LL									1.00	0.95***	0.94***	0.92***	0.69***	0.78***
R										1.00	0.93***	0.93***	0.73***	0.81***
L											1.00	0.96***	0.75***	0.82***
S												1.00	0.74***	0.86***
N													1.00	0.55**
F														1.00

NS= Non-significant, *P ≤ 0.10, **P ≤ 0.05, ***P < 0.01.

Table 4. Primary cuts of the carcass of Dorper x Pelibuey lambs according to the physical form of broom millet in the diet

Variable	Broom millet		SE±
	Entire	Ground	
Short loin, kg	1.21	1.33	0.03
Lomg loin, kg	1.32	1.42	0.07
Rib, kg	1.06	1.11	0.07
Leg, kg	2.23	2.25	0.06
Shoulder, kg	1.54	1.58	0.09
Neck, kg	0.88	0.96	0.05
Flank, kg	0.51	0.40	0.03

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