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Effect of Breed of Sire on Carcass Traits and Meat Quality of Katahdin Lambs

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Abstract

Crossbred lambs (*n* = 40) of 137 ± 3 days of age from Katahdin ewes with either Charollais (KCh), Dorper (KD), Suffolk (KS) and Texel (KT) sires were used in this study. The effect of sire breeds on carcass traits, chemical composition of muscle, meat quality and consumer acceptability was determined. Regarding carcass traits, KCh animals had the highest fat thickness. KT lambs had the smallest *M. Longissimusdorsi* (MLD) area compared tothat of KCh, KD and KS (17.0, 15.9, 15.5 and 13.9 cm^2; respectively). Breed of sire had no effect (P>0.05) on the chemical composition, pH or Warner-Bratzler shear force (WBSF) of lamb; however, it did affect meat color. KS lambs had lower L^*, a^*, b^* and Ch* values compared to the other crossbreeds ($P \leq 0.05$). Consumer acceptability of lamb was similar (P>0.05) across genotypes.

Keywords: lamb, crossbreeding, meat quality, Katahdin.

1. Introduction

Ovine production in Mexico has shown an annual increase of approximately 6.5% (33390 to 54966 Tn) during the last decade (Servicio de Información y Estadística Agroalimentaria y Pesquera [SIAP]), 2010. Among other factors, this increase is due to the better integration of the production chain with processing and marketing. This integration has created greater diversification of products such as fresh new cuts, processed lamb meat, "barbacoa" (traditional method of preparing meat cooked in its own juice) and "mixiotes" (it consists of a mix of steamed chili and meat wrapped in a thin layer of agave leave) canned and others meat products (Gómez, 2009; Arteaga, 2007).

Annual lamb consumption (87740 Tn) in Mexico is supplied by 57% national and 43% imported production (Gómez, 2009; Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación [SAGARPA]), 2006). This deficit offers Mexican producers the opportunity to increase their productivity, and satisfy the national market. To achieve this, technology must be used to increase production systems efficiency and to improve carcass and meat quality characteristics.

The introduction of several ovine breeds (wool or hair) in Mexico during the last two decades has been a great advantage to improve production efficiency and meat properties of indigenous breeds (Torres, 2009; Cuéllar, 2007). Katahdin has been used for this purpose in Mexico, however no research has been found regarding Katahdin performance on carcass or meat quality attributes. Katahdin females do not require shearing, have advantages in reproductive performance (Getz & Mannasmith, 1991; Wildeus, 1997; Burke, 2005) and resistance to parasitic diseases (Burke & Miller, 2004) and have higher ability to adapt to harsh environments (Marai, El-Darawany, Fadiel, & Abdel-Hafez, 2007; Notter, 2000). On the other hand, meat specialized breeds have higher weigh gain, superior meat conformation and higher meat quality (Santos, Bueno, Cunha, & Nieto, 2001).

Throughout the years, the crossing program has not always been properly applied and thus it has caused a high variation in the genetic arrangement of flocks, mainly in those focused on meat production. To contribute to a planned crossing program before implementation, this research was undertaken to evaluate carcass characteristics and meat quality of lamb crossbreeds from Katahdin females with specialized meat breeds such as Charollais, Dorper, Suffolk and Texel.

2. Materials and Methods

2.1 Animals and Experimental Design

The research took place between February and April of 2009 in a farm located in the state of Querétaro, Mexico. Two hundred female Katahdin sheep (K), with an average of 5.6±2.4 births, were split into 4 groups of 50 animals each. All the females were synchronized with intra-vaginal sponges followed by FSH injection and then inseminated (laparoscopy) using fresh semen from Suffolk, Texel, Charollais and Dorper (5 animals per breed) rams. A commercial diet (creep feeding) was given to the lambs from birth to weaning. Lambs were weaned at 64±2 d, after which males were separated out by genotype. All animals were handled under the same conditions and housed in partially roofed, earthen floor pens (approx. 150 m^2). After weaning, the animals were fed ad libitum with a complete diet meeting NRC recommendations and formulated to provide 14.0% crude protein (CP) and 2.9 Mcal ME/kg DM: 51.0% sorghum; 4.8% soya paste; 14.0% molasses; 8.0% sorghum hay; 9.2% dried alfalfa; 10.0% canola paste; 3.0% mineral premix (minimum of 16.0% calcium, 1.2% phosphorous, 2.0% sulphur, 17.0 mg/kg selenium, 2.0 g/kg zinc and 160000 IU/g vitamin A).

After 137±3 days (standard production period to achieve slaughter weight), 10 lambs were randomly selected from each group and slaughtered at a local slaughterhouse operating under the Mexican Inspection System.

2.2 Carcass and Meat Evaluation

Carcass traits were assessed in the cooler (2±2°C) 24 h post mortem. Carcass evaluation was performed using Mexican Standard for lamb carcass classification (NMX-FF-106-SCFI-2006). The latter includes three commercial classes Mexico Extra (MEX EXT), Mexico 1 (MEX 1), Mexico 2 (MEX 2). The standard criteria to classify carcasses are: animal age, slaughter weight, carcass conformation and fat thickness at the 12^{th} rib. Conformation was determined by means of the following subjective scale: Excellent 5-6, Good 3-4 and Deficient 1-2. After evaluation, carcasses were cut to measure fat thickness and loin area. Fat thickness was measured using a vernier calliper at the 12^{th} rib, at 4 cm from the medial-dorsal line. *M. Longissimus dorsi* (MLD) area was drawn on a transparent plastic paper and measured later using a digital planimeter Planix®.

To determine tissue composition (muscle, fat and bone+others), the left shoulder was excised and kept frozen (-18ºC) until its dissection into muscle, fat, bone and others (cartilage, tendons and fascia) following the method of Colomer, Delfa & Sierra (1988). Proximate composition (moisture, protein, intramuscular fat and ash) was determined following official methods of analysis (AOAC, 2002) using the 9^{th} or 10^{th} rib eye steak.

Muscle and fat (kidney and pelvic) color was assessed on the 12^{th} rib using a portable Konica Minolta CR-400 colorimeter (Konica Minolta Sensing, Inc., Osaka, Japan) with an integrated specular component, a D65 illuminator and a 2º observer. In addition, Hue (h*) and Chroma (C*) were calculated using the following equations:

$$h^* = \arctan(a^*/b^*) \text{ and } C^* = \sqrt{(a^*)^2 + (b^*)^2}$$

pH was measured at 24 h between the 12-13^{th} rib of the MLD using an Orion 720A potentiometer. Indirect water holding capacity (water loss) was determined on the MLD by the compression method described by Hamm (1986) and modified by Sierra (Pla, 2005). Briefly, a 0.30±0.05 g loin sample, between the 6-10^{th} rib, was placed on a No. 4 Whatman filter paper, previously weighed. The sample covered with glass was pressed under a 2.25 kg weight for 5 min. Afterwards, the filter paper was weighed again and the percentage of juice loss from the sample was calculated based on weight difference (Pla, 2005).

Warner-Bratzler shear force (WBSF) was determined according to Honikel (1998). The MLD steaks were thawed along 24 h and cooked on a double plaque broiler to an internal temperature of 70^{o}C, which was monitored with iron-constantan thermocouples (Omega Engineering Inc., Stamford, USA) and a recording portable thermometer. Upon reaching the desired internal temperature, steaks were removed from the broilers and allowed to cool to room temperature (20-25^{o}C). Subsequently, from each steak, a minimum of six 1.27-cm-diameter cores were obtained parallel to the longitudinal orientation of muscle fibers. Cores were cut perpendicularly using a texture analyzer TA. XT Plus (Stable Micro Systems).

2.3 Sensory Evaluation

The *M. Longissimus lumborum* was used for sensory evaluation. Each steak was thawed along 24 h, wrapped in aluminum foil and cooked on a double plaque broiler until 70^{o}C was reached at the geometrical center. Upon reaching the desired internal temperature, muscles were removed from the broiler and portioned into cubes of uniform dimensions (2 cm^3) and kept warm until evaluation. A consumer affective test was performed using a seven point hedonic scale from 1) I dislike it very much; to 7) I like it very much. Sample preparation was done using the methodology by Guerrero (2005). To present samples to panelists, Campo (2005) methodology was used. A total of 75 panelists from different sex, age and cultural background participated in the study. Each panelist was presented four samples and asked to score each sample for flavor, tenderness, juiciness and overall desirability.

2.4 Statistical Analysis

The effect of the breed sire (KCh, KD, and KT & KS) on carcass and meat quality was tested for significance using analysis of variance (Lentner & Bishop, 1986). Means were discriminated using the Tukey's range procedure (Statgraphics Plus 2.1). Results from the sensory evaluation were analyzed by the Kruskal-Wallis test.

3. Results and Discussion

3.1 Carcass Characteristics

Table 1 shows significant differences (P≤0.05) for carcass characteristics among genetic groups. Though slaughter age was the same for all breeds, hot carcass weight in KT was statistically lower than those of KCh, KD and KS lambs (P≤0.05). As production system was identical for all crosses, this result could be explained by differences in the growth rate among breeds as we described previously (Vazquez, Partida, Rubio, and Méndez, 2011). This effect was also observed by Burke, Apple, Roberts, Boger, and Kegley (2003) and Costa et al. (2009). Data published by Vazquez et al. (2011) on these same animals also reported a faster growth of lambs compared to KS and KT. Kuchtík, Zapletal and Šustová (2012) found Charollais crossbred lambs grew faster than Suffolk sires.

Table 1. Carcass classification and shoulder composition (means ± SD) of Katahdin crossbred lambs slaughtered at 137 days

Variable	Breed of sire			
	Charollais	**Dorper**	**Suffolk**	**Texel**
n	10	10	10	10
Classification[A]	MEX EXT^a	MEX EXT^a	MEX EXT^a	MEX 1^b
Hot carcass weight, kg	44.5±5.3^a	42.2±3.4^a	41.8±4.6^a	38.0±4.9^b
12th rib backfat, mm	6.3±1.2^a	3.6±1.3^b	4.3±1.5^b	4.3±1.3^b
MLD Area, cm^2	17.0±2.6^a	15.9±1.6^{ab}	15.5±0.9^{ab}	13.9±2.7^b
		Shoulder composition, %		
Muscle	61.1±2.6	64.6±2.9	63.3±1.7	66.3±0.7
Total fat	18.1±3.3^a	14.3±4.0^b	14.4±2.1^b	12.8±2.3^b
Bone + others	20.9±1.8	21.1±1.6	22.3±1.1	20.9±1.3

^{a,b} Means with different superscripts on the same row are significantly different (P≤0.05).

[A]Based on Mexican Standard "NMX-FF-106-SCFI-2006" for heavy lambs: MEX EXT: carcass weight more than 18 kg, excellent conformation, and fat thickness at the 12th between 3-6 mm. MEX 1 = carcass weight more than 18 kg, excellent or good conformation, and fat thickness at the 12th between 7-10 mm.

All crosses with the exception of KT (Mexico 1) were categorized as MEX EXT, which is the highest carcass class in the Mexican lamb carcass classification system. KCh crosses had higher 12th rib backfat thickness and higher percentage of fat on the shoulder than the other crosses. Charollais is an early maturing breed which deposits fat at short age, while other breeds take more time to show this condition (Kempester, Croston, Guy, & Jones, 1987). KCh crosses also showed bigger MLD area than KT (17.0 vs. 13.9 cm^2; P<0.05), probably due to the lower weight of KT animals. Horton & Burgher (1992) reported KCh crosses to have bigger MLD area than pure Katahdin breeds. Also, Momani et al. (2002) found Charollais sires to influence the MLD area positively. However, in the study by Osikowki and Borys (1976) Texel lambs were reported to have MLD area of 17.8 cm^2 at 45 Kg, which is greater than that found in this study. Notter, Greiner and Wahlber (2009) observed MLD of

12.2 cm^2 on pure Dorper lambs, which is 13.0% smaller than that found in this study for the KD cross.

Osikowski & Borys (1976) attributed KT lean carcass to the slow growth of the lambs, also pure Texel breeds tend to develop more muscle and less fat (Dawson, Carson & Moss, 2002; Johnson, Purchas, Ewan & Blair, 2005; Leymaster & Jenkins, 1993), as opposed to Suffolk, Ile de France and Merino lambs, which deposit more fat than protein at the same age (Leymaster & Jenkins, 1993). Partida, Braña & Martínez (2009) found terminal crosses between Pelibuey and Suffolk to have more fat than pure breeds.

3.2 Chemical Composition and Meat Characteristics

Table 2 shows similar chemical composition for meat from different crosses. In this study, the breed of sire did not influence muscle composition. However, it is worth mentioning that the percentage of intramuscular fat was below 3% in meat from all crosses, despite lambs in the present study were fed high-energy diets, Mexican consumers prefer lean meat, therefore production system are focused on obtaining meat with 2.2 to 2.7% of intramuscular fat as shown in this study. Other authors found similar fat percentages to those observed in our work for lambs finished with concentrate and slaughtered at similar weights (Crouse, Busboon, Field, & Ferrel, 1981; Ockerman, Emsen, Parker, & Pierson, 1982).

Table 2. M. L*ongissimus dorsi* chemical composition of Katahdin crossbred lambs (means ± SD)

Component (%)	Breed of sire			
	Charollais	Dorper	Suffolk	Texel
Moisture	73.6±0.7	72.9±0.6	73.5±0.5	73.2±0.5
Protein	22.7±0.3	22.7±0.5	22.4±0.5	23.0±0.6
Fat	2.2±0.5	2.7±0.6	2.5±0.6	2.5±1.0
Ashes	1.0±0.1	1.0±0.1	1.0±0.0	1.0±0.1

Meat color is influenced by genotype and slaughter weight (Juarez et al., 2009; Burke & Apple, 2007; Dawson et al., 2002). Table 3 shows MLD color measurements, which are consistent with those accepted by consumers with the exception of those for KS (Ekiz et al., 2009; Hopkins & Fogarty, 1998; Johnson et al., 2005). According to Khliji, Van de Ven, Lamb, Lanza, and Hopkins (2010) redness (a*) and lightness (*L**) values should equal to or exceed 9.5 and 34, respectively, in order for the consumer to consider meat as fresh. Upon KS meat color results (lowest L*, a*, b* and C* and highest h*) from this study, it appears that Suffolk sire makes meat extensively different from other paternal breeds, even with the non-fresh appearance according to Khliji et al. (2010). KS had darker meat, this concurs with Dawson et al. (2002). However, Kuchitík et al. (2011) found meat from Suffolk crossbreds to be lighter and yellower than meat from Charollais crossbreds.

Table 3. Colour, pH, WBSF and water loss for lamb *M. Longissimus dorsi* (means ± SD)

Parameter	Breed of sire			
	Charollais	Dorper	Suffolk	Texel
Lightness (L*)	39.3±1.4^a	36.8±5.7^a	30.1±1.5^b	36.0±1.8^a
Redness (a*)	14.4±1.7^a	13.6±2.0^a	8.2±1.3^b	13.4±1.4^a
Yellowness (b*)	9.1±1.0^a	7.4±1.3^b	6.2±0.5^c	7.4±0.9^b
Hue (h*)	32.5±2.6^b	29.7±3.0^b	37.4±4.2^a	29.0±1.8^b
Chroma (C*)	17.1±1.8^a	15.5±2.2^a	10.3±1.2^b	15.3±1.6^a
pH_{24}	5.52±0.0	5.58±0.1	5.49±0.1	5.51±0.1
WBSF, N	34.3±7.8	37.3±13.7	34.3±9.8	38.3±8.8
Water loss, %	26.5±2.0^c	29.5±3.5^b	30.7±2.0^{ab}	33.0±1.2^a

^{a,b,c} Different superscripts on the same row shows significant differences (P≤0.05).

Fat color is an important economic factor for lamb trade in Mexico. The higher b* values are related with the carotenoids deposited in fat as a result of pasture intake (Diaz et al., 2002; Joy et al., 2008). Table 3 shows ultimate pH, water WBSF and water loss for Katahdin terminal crosses. pH ranged from 5.58±0.1 (KD) to 5.49±0.1 (KS), with no significant differences among groups. This range of pH is standard and agrees with those (5.4 a 5.9) observed by Safari, Fogarty, Ferrier, Hopkins and Gilmour (2001) and other researchers (Ekiz et al., 2009, Dawson et al., 2002) in similar meat animals.

No significant differences were found among genetic groups for WBSF, which is in line with previous reports (Dawson et al., 2002; Ruiz de Huidobro et al., 1998; Safari et al., 2001). WBSF found for these groups can be categorized as tender if using the tenderness classification scheme proposed by Bianchi, Garibotto, Feed, Betancur and Franco (2006). Snowder and Duckett (2003) found higher WBSF values (49 N) for Dorper and Suffolk. However, other authors such as Gibson et al. (2006) found the lowest WBSF in Texel crosses and Burke and Apple (2007) showed chops from purebred Suffolk to be tougher than chops from the hair-sheep breeds.

KT showed the highest values for water loss (33.0±1.2%), followed by KS (30.7±2.0%), KD (29.5±3.5%) and KCh (26.5±2.0%). This means that the leanest carcasses had the highest ability to lose water. Other authors also found differences for the ability of the meat to retain water, using different measurements as cooking loss, water holding capacity, drip loss, water loss, etc. Safari et al. (2001) found the lower cooking loss in the genotype with the higher fat level. Santos-Silva, Mendez and Besa, 2002, however, found no differences in water holding capacity among different breeds. Ekiz et al. (2009) found drip loss to be affected by genotype but not cooking loss or water holding capacity. The average water loss for this study was around 30%, while Santos-Silva et al. (2002) found around 38.7% and Ekiz et al. (2009) found 12.21%.

In this study, no differences were found in lightness and hue in the KPH fat (Table 4) among treatments. Redness and yellowness values were higher in KCh (3.8±2.3 and 13.4±1.6) than in the other groups. KT and KD had the lowest a* (1.6±1.1 and 1.7±1.13, respectively) and b* (9.8±1.8 and 9.4±1.4) values. Redness on KPH fat could be due to the presence of blood vessels (Ruiz de Huidobro et al., 1998). Charollais and Suffolk crosses showed KPH fat with intense yellowish color.

Table 4. Fat (kidney and pelvic) color of Katahdin crossbred lambs (means ± SD)

Parameter	**Breed of sire**			
	Charollais	**Dorper**	**Suffolk**	**Texel**
Lightness (L*)	75.5±3.0	78.2±2.4	77.1±4.9	75.4±3.5
Redness (a*)	$3.8±2.3^{a}$	$1.6±1.1^{b}$	$2.5±2.2^{ab}$	$1.7±1.13^{b}$
Yellowness (b*)	$13.4±1.6^{a}$	$9.8±1.8^{b}$	$12.3±1.5^{a}$	$9.4±1.4^{b}$
Hue (h*)	88.1±1.5	79.1±8.5	83.8±8.5	80.2±6.1
Chroma (C*)	$14.1±2.2^{a}$	$10.0±1.8^{b}$	$12.7±1.8^{a}$	$9.6±1.5^{b}$

^{a,b,c} Means with different superscripts on the same row show significant differences (P≤0.05).

3.3 Sensory Evaluation

Table 5 shows the results of the sensory analysis. As shown, consumers did not find differences in flavor, tenderness, juiciness and overall acceptability among genetic groups. This is consistent with previous studies (Ekiz et al., 2009; Ruiz de Huidobro et al., 1998; Safari et al., 2001). Gibson et al. (2006) using a trained panel found no differences for lamb from Arcott, Charollais, Ile de France, Suffolk and Texel. However, Gibson found Texel tended to be tenderer, juicer, tastier and more palatable than the other genotypes. Snowder and Duckett (2003) found a clear meat quality difference between Dorper and Suffolk, having Dorper better palatability.

Table 5. Consumer response to the sensory analysis for lamb crosses (means ± standard error).

Variable[A]	Breed of sire			
	Charollais	**Dorper**	**Suffolk**	**Texel**
Flavor	4.7±1.3	4.6±1.5	5.0±1.4	4.8±1.5
Tenderness	5.0±1.5	4.5±1.6	5.1±1.8	5.1±1.5
Juiciness	4.3±1.6	4.3±1.4	4.7±1.3	4.3±1.5
General Likeness	5.0±1.2	4.6±1.5	5.0±1.4	4.9±1.3

[A]Hedonic Scale: 1 (I dislike it very much), 7 (I like it very much).

In summary, as other studies proved before, genotype could not be associated with important differences in lamb meat quality (Dransfield, Nute, Hogg, & Walters, 1990; Hopkins & Fogarty, 1998). The results of this study are in agreement to that general tendency, as differences between genotypes were generally not significant. However, KT lambs were slightly inferior for carcass characteristics than the rest of the crossbreds.

4. Conclusions

Carcass characteristics were clearly influenced by the breed of sire. However it had no effect on meat quality and consumer acceptability. Therefore, crosses with better carcass attributes and meat yield should be considered in any future genetic improvement program. Results from this experiment suggest Charollais and Dorper performed better than the other breeds and therefore may be the best choice for such programs.

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