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Variation in Carcass and Meat Quality by Genetic Group and Gender Interaction in Pigs Produced in Hot Climates

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Abstract: A total of 314 pigs were used to evaluate the effects of genetic group and gender interaction on quality parameters of pigs in an arid climate zone. Variables in the study were analyzed using a linear model with the effects of genetic group, gender, month of slaughter, genetic by gender interaction, animal age and hot carcass weight as co-variables and error as a random component. Differences ($p>0.05$) by genetic group and gender interaction were not observed but significant differences ($p<0.05$) by gender on Carcass Length (CL), Loin Eye Area (LEA) and Back Fat (BF1-BF3) were noted. Gilts showed higher CL and LEA than barrows with values of 73.62±0.44 cm and 33.67±0.70 cm^2 by trait, respectively. Barrows showed greater BF values than in gilts. Differences ($p<0.05$) by gender for a*values were monitored being higher in gilts (4.53±0.17) than in barrows (4.12±0.14). The mean value of pH was 5.72±0.01 with the lowest values seen in the hottest months. During the months with the highest temperatures, L*value tended to increase due to the highest amount of free surface water with a maximum value of 60.27. The mean value of SF was 3.03±0.04 kgf indicating tender meat. The meat from gilts showed a more intense red color whereas the barrows carcasses had more fat. High temperatures favored occurrence of PSE meat. A better control in the production system as well as in ante-mortem management is recommended so that differences among genetic groups may be detected.

Key words: Meat quality, carcass, arid climate, pork, interaction, slaughter

INTRODUCTION

In Mexico, currently, pig carcasses produced under intensive production systems are sent to the market without a quality evaluation and this has an effect on the producer's income. If a quality assessment process were used, producers of high quality animal would see an increase of price for their animals. Heat stress is considered to be an important factor in carcass and meat quality the reason for this is that it reduces the animal's comfort level and this type of stress has been associated to the presence of Pale, Soft and Exudative meat (PSE) (Grandin, 1994).

Animal related factors that have been reported as having effect on quality parameters are the genetic group to which the animals belong (Edwards *et al*., 2003) and gender (Kuhlers *et al*., 1981; Unruh *et al*., 1996). These studies however are limited to climates other than those of the region in which this study was done. Little or no information at all has been published about factors contributing to carcass and meat quality variability of pigs produced in hot climates. This research studies the effects of genetic and gender group on quality parameters of swine produced in an intensive system located in an arid climate zone.

MATERIALS AND METHODS

Farm location and production system: The study was conducted in the pig experimental farm of the Institute of Veterinary Science Research in the city of Mexicali, Mexico during a period of 12 months. The climate of the area is hot and dry with annual precipitation of <15 mm and temperatures varying between -5.0°C in the winter and 50°C in the summer.

About 314 pigs with an average slaughter weight of 82.79±1.46 kg were used. The animals included in this study belonged to the following genetic groups: Landrace (L), Duroc (D), Yorkshire (Y) and their crosses. Gender was registered as females and castrated males. An intensive four phase production system is in use. During the finishing period, the animals have free access to food under an automated system. At the end of this last phase, the pigs were slaughtered in a government approved

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slaughterhouse (Federal Inspection Type no. 54) according to federal regulated procedures (NOM-033-ZOO-1995: Humanitarian slaughter of wild and domestic animals in Mexico).

Methods and laboratory analysis: Within 8 h after slaughter the following variables were recorded: gender, Hot Carcass Weight with head (HCW) this was recorded before the carcass being was refrigerated (Friesen *et al.*, 1994), Carcass Length (CL) the length is measured from the cranial tip of the aitch bone to the cranial edge of the first rib (Garcia-Macias *et al.*, 1996), back fat thickness is measured on the first rib (BF1), last rib (BF2) and last lumbar vertebrae (BF3).

A meat sample of approximately 1 kg was obtained from the Longissimus dorsi muscle between the 10th and the 11th rib and stored in a refrigerator for later analysis. The variables measured in the meat sample were: Loin Eye Area (LEA), pH, color (L*, a*, b*), Water-Holding Capacity (WHC) and Shear Force (SF). LEA is determined in cm^2 using a plastic pattern (ISU, U.S.). The pH is measured with a puncture potentiometer (Delta Track Inc., ISFET pH 101, Pleasonton, C. A., U.S.). The color values L* (Lightness), a* (redness), b* (yellowness) were determined using a Minolta CM-2002 spectrophotometer (Minolta Camera, Co., Ltd, Osaka, Japan) utilizing an Integrated Specular Component (SCI), a D_{65} illuminant and a 10° observer. The water-holding capacity was obtained using centrifugation according to the technique reported by Sutton *et al.* (1997). SF was obtained using pieces of meat of 1 cm^2 diameter obtained from the original sample, the smaller samples were aged 24 h with and cut parallel to the muscle fiber orientation. The SF measurements ($kg\ cm^{-2}$) were determined utilizing a Lloyd texturometer (Lloyd Instruments, Fareham Hampshire, UK equipped with Warner-Bartzler shear blades with a crosshead speed of 50 mm min^{-1}. All the measurements were made in triplicate.

Statistical analysis: The variables in study were analyzed using the following linear model:

$$Y_{ijk} = \mu + G_i + S_j + (MS)_k + (GS)_{ij} + \beta_1\ (HCW) + \beta_2\ (Age) + \varepsilon_{ijk}$$

Where:

Y_{ijk}	=	The response variable
μ	=	The general mean
G_i	=	Effect of the genetic group
S_j	=	Effect of gender
$(SM)_k$	=	Slaughter month effect
$(GS)_{ij}$	=	Genetic group by gender interaction
β_1 and β_2	=	The regression coefficients associated to age
HCW	=	As co-variables
ε_{ijk}	=	Random component ~ NI (0, σ^2)

The analysis was done through GLM procedure using the SAS statistical program (Herrera-Haro and Barreras-Serrano, 2005). Non significant effects into the model were eliminated in order to increase test sensitivity of effects. When the hypothesis of mean effect equality was rejected, least square means were obtained and contrasted using Tukey procedure.

RESULTS

No genetic group by gender interaction was observed (p>0.05). Differences (p>0.05) by genetic group in quality parameters of carcass and meat (Table 1) were not observed unlike gender w here differences (p<0.05) in the carcass variables CL, LEA, BF1-BF3 were detected. Gilts presented higher means for CL than barrows with values of 73.62±0.44 and 72.42±0.36 cm, respectively. The mean values found in LEA for gilts were 33.67±0.70 and for barrows 30.83±0.58 cm^2. Males had higher values for BF than females. Expressed as BF1, they were 1.53±0.04 vs 1.35±0.05 cm for BF2 and BF3 the differences by sex were 1.60±0.04 vs 1.34±0.05 cm and

Table 1: Carcass and meat quality parameters by genetic group and gender in pigs

Variables	Gilts	Barrows	Pured breed	Cross 2-breed	Cross 3-breed
CL	73.62±0.44[a]	72.42±0.36[b]	73.09±0.48[a]	72.58±0.59[a]	73.38±0.25[a]
BF1	1.35±0.05[a]	1.53±0.04[b]	1.44±0.05[a]	1.39±0.07[a]	1.49±0.03[a]
BF2	1.34±0.05[a]	1.60±0.04[b]	1.45±0.05[a]	1.48±0.07[a]	1.47±0.03[a]
BF3	2.62±0.08[a]	2.93±0.07[b]	2.76±0.09[a]	2.77±0.11[a]	2.79±0.05[a]
LEA	33.67±0.70[a]	30.83±0.58[b]	31.48±0.77[a]	33.09±0.96[a]	32.25±0.38[a]
pH	5.71±0.02[a]	5.74±0.01[a]	5.74±0.02[a]	5.72±0.02[a]	5.71±0.01[a]
L	54.31±0.60[a]	53.66±0.50[a]	54.12±0.66[a]	53.71±0.82[a]	54.13±0.36[a]
a*	4.59±0.16[a]	4.12±0.14[b]	4.76±0.18[a]	4.07±0.22[a]	4.24±0.10[a]
b*	9.72±0.27[a]	9.26±0.23[a]	9.64±0.29[a]	9.50±0.37[a]	9.35±0.16[a]
WHC	75.90±0.56[a]	76.12±0.51[a]	76.16±0.64[a]	76.07±0.78[a]	75.81±0.36[a]
SF	2.99±0.10[a]	3.06±0.09[a]	3.06±0.11[a]	2.88±0.14[a]	3.13±0.06[a]

[a-c]Different letters means significantly different (p<0.05), CL = Carcass Length, BF1 = Backfat of the first rib, BF2 = Backfat of the last rib, BF3 = Backfat of the last lumbar vertebra, L = Lightness, a* = Redness, b* = Yellowness, LEA = Loin Eye Area, WHC = Water Holding Capacity, SF = Warner-Bartzler Shear Force

Table 2: Acronyms, definitions, number of observations (n), means and standard desviation of carcass and meat characteristics

Acronyms	Definition of variable	n	Mean	SD
CL	Carcass Length (cm)	314	73.14	4.28
BF1	Backfat on the first rib (cm)	314	1.47	0.49
BF2	Backfat on the last rib (cm)	314	1.51	0.44
BF3	Backfat on the last lumbar vertebra (cm)	314	2.86	0.75
LEA	Loin Eye Area (cm^2)	313	31.87	6.12
pH	Hidrogen potential	314	5.72	0.20
L	Lightness	314	53.81	4.81
a*	Redness, CIELAB	314	4.34	1.36
b*	Yellowness, CIELAB	314	9.58	2.44
WHC	Water holding capacity (%)	284	76.12	4.36
SF	Shear Force (Kgf)	292	3.03	0.85

2.93±0.07 vs 2.62±0.08 cm, respectively. As to the effect of season of the year during the month of March there is an increase in BF1 and BF3. With respect to meat quality parameters differences ($p<0.05$) by gender were observed only for a* values. a* value of redness was higher in gilts (4.53±0.17) than in barrows (4.12±0.14). The mean values of assessed meat quality parameters are shown in Table 2. The pH mean value was 5.72±0.01. However, observing the performance of this variable during the year, the lowest value (5.39) is reported in September, the hottest month. The mean value found in L* was 53.81±0.27. WHC presented a mean value of 76.12±0.25%. As to its performance by season of the year however, it reached the lowest values during June, July and August months. The mean value of SF was 3.03±0.04 kgf representing tenderness meat.

DISCUSSION

The CL values in gilts was higher than that in barrows, similar results have been reported by other researchers (Geri *et al*., 1990; Baas *et al*., 1992; Cassady *et al*., 2004). Mota suggests that carcass length is not related to composition but to the animal production characteristics (litter size and number of teats). Differences due to gender were also noticed in LEA, the higher LEA values in gilts were reported by Liu and Stoufffer (1995), Uttaro *et al*. (1993) and Schwab *et al*. (2007) in pigs with slaughter weight similar to the ones of this study. When the slaughter weight is 115 kg, Cassady *et al*. (2004) report differences ($p<0.05$) in LEA by gender with 44.5±0.3 cm^2 in gilts and 41.7±0.3 cm^2 in barrows. The differences resulting from gender group indicate that due to castration, muscular growth in barrows is reduced because of lack of male hormones because protein synthesis is not stimulated there is no muscular development which promote greater fat deposition in the animal. Higher fat deposition was observed in the carcasses of barrows according to Hamilton *et al*. (2000) who point out that the carcasses of castrated barrows contain more fat than the gilts carcasses. Leach *et al*. (1996) reported higher BF1 values in castrated barrows than in gilts (4.0±0.12 cm against 3.3±0.12 cm) whereas Nold *et al*. (1997) found higher BF2 values in barrows (2.22±0.09 cm) than in gilts (1.86±0.09 cm) likewise, Leach *et al*. (1996) with values of 2.5±0.10 cm in barrows and 2.1±0.10 cm in gilts. The same effect is reported in BF3 between barrows and gilts in several studies; McLaren *et al.* (1989) report values of 2.89±0.05 against 2.62±0.04 cm, Leach *et al*. (1996), observed 2.3±0.12 against 1.7±0.12 cm and 2.63±0.14 against 2.30±0.10 cm were reported by Hamilton *et al*. (2000). Kempster and Evans (1979) reported that subcutaneous fat accumulates in the lower abdomen and in castrated males the accumulation is seen in the dorsal region. Bender *et al.* (2006) determined that these differences exist because of presence or absence of endogenous hormones furthermore, there is a positive correlation established between testosterone production and animal growth supporting the results where higher fat production in castrated animals than in gilts is observed. The increase of BF1 and BF3 values during the month of March is possibly due to the fact that the pigs stayed in the final phase for longer time which resulted higher fat deposition in tissues. The occurrence of greater paleness in barrows in gilts has been observed by Langlois and Minvielle (1989). Latorre *et al*. (2004) did not find differences ($p>0.05$) between genders. Nevertheless, reporting higher a* values in gilts and barrows (5.0±0.18 and 5.5±0.18, respectively), Peinado *et al*. (2008) noted differences ($p<0.05$) by gender for this variable.

The results of this study suggest that as a consequence of the production system that is used and the local market demand for younger barrows, the animals were slaughter before they reached the same level of development as gilts so that they had a lower concentration of muscle myoglobin resulting in less colored meat. Although, the mean pH value is within the expected pH levels in normal meat (5.6-5.7) (Van Laack *et al*., 1994), these were affected by the high temperatures which caused stress in the pigs and consequently an acceleration of the metabolic reactions that resulted in a pH value (5.4) associated to PSE meat (pH = 5.4) as reported by Van Laack *et al*. (1994).

The observed value of color lightness of L* meat coincides with the values reported by other researchers (Correa *et al*., 2006; Skalep and Candek-Potokar, 2007) however, stress in pigs caused by high temperatures during summer has been considered a reason why after slaughter L* lightness was affected showing an increase in its values. Taking into account that the L* value is utilized to asses meat quality and that an L* value of 62±2 is considered by Van Laack *et al*. (1994) as a characteristic of a PSE meat it was concluded that during this period the meat was classified as PSE. Analyzing L* variable by season of the year during September month its value tended to increase due to an increased amount of free water on the surface, a maximum value of 60.27 was obtained. The mean percentage of WHC observed in this study was also reported by Pedauye with values of 72.73±8.25%. During the summer months, the WHC values diminished coinciding with PSE meat occurrence as reported by Alarcon.

As to SF, Ruiz-Ramirez did not find differences (p>0.05) in SF among pigs with different slaughter weight with mean values between 3.05±0.12 and 3.19±0.10 kg for pigs of slaughter weight between 83 and 95 kg, respectively even with higher slaughter weight (110-140 kg), the SF value was not affected (3.6±0.18 kg in gilts and 3.2±0.18 kg in barrows) (Leach *et al*., 1996).

This indicates that although there were variations in animal weight, the differences between the SF values are very small so that no difference in tenderness was determined (Leach *et al*., 1996).

CONCLUSION

Quality parameters in carcass or meat were similar in pigs of pure genetic group as well as in crosses. In the case of gender, gilts had higher values for LEA and CL besides meat of more intense red color whereas barrows only had fatter carcasses.

The results suggest the presence of problems in the production system at not allowing the detection of differences in the assessed variables furthermore, high environmental temperatures favored the occurrence of PSE meat. So, it is suggested to maintain better control in the production system as well as in ante mortem management with the purpose of detecting differences among pure genetic groups and/or crosses for quality parameters in arid climate zones.

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