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Efecto del sistema de cría y del género en el rendimiento productivo, características de la canal y calidad instrumental y sensorial de la carne de Cerdo Criollo Negro de la Costa Ecuatoriana

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ABSTRACT

A total of 32 Creole pigs were used to evaluate the effect of rearing system and gender on performance, and carcass and meat traits. Eight barrows and eight gilts were reared in semi-confinement conditions (SC), and other sixtheen pigs (8 barrows and 8 gilts) were housed in individual pens and reared under confinement conditions (C). All pigs received commercial feed (*ad libitum* in system C and 80% in the SC system). In addition, pigs from the SC system ingested residues from the local industry (bananas, papaya, orange, etc., and what they could consume in the grazing of the plots). Throughout the study period (90 d), the growth and intake were monitored, while after slaughter the carcass yield and dorsal fat thickness were quantified. Meat quality was estimated objectively (pH and color) and subjectively (consumer panel). The pigs showed low growth rate (265 g/d), with higher rates in the C (305 vs. 225 g/d) system and barrows (270 vs. 260 g/d). The dressing out was affected by rearing system (73.65 vs. 74.30% for C y SC, respectively); while the system and gender significantly influenced the back-fat thickness (2.21 vs. 2.06 cm for C y SC, y 2.08 vs. 2.16 cm for barrows and gilts, respectively). Carcass of C pigs showed higher percentage of fat (40.8 vs. 37.5%) and lower percentage of lean (44.8 vs. 46.4%) and bone (8.22 vs. 9.38%) that SC pigs. Meat from males was darker (L * 43.7 vs. 51.5), reddish (a * 15.8 vs. 13.9), and yellowish (b * 5.5 vs. 2.7) than that from females. Meat from pigs reared in the C system was scored as lighter and less bright, with greater sweet and metallic taste and less unctuous and more persistent flavor. Aging time had limited benefit for the sensory attributes of m. *Longissimus thoracis*, with significant differences for tenderness, brightness, juiciness and unctuousness scores.

Key words: Autochthonous pig breed; confinement; semi-confinement; pork; sensory profiling.

RESUMEN

El objetivo del presente trabajo fue evaluar el efecto del sistema de cría y del género sobre el rendimiento productivo y las características de la canal y de la carne de 32 cerdos Criollos. Ocho machos castrados y ocho hembras, criados en régimen de semi-confinamiento (SC) y otros ocho machos castrados y ocho hembras alojados en corrales individuales y cebados en condiciones de confinamiento (C). Todos los cerdos recibieron un pienso comercial (ad libitum en el sistema C y restricción al 80% en el sistema SC). Adicionalmente, los cerdos del sistema SC consumieron restos de la industria local (bananas, papaya, naranja, etc., y lo que pudieron consumir en el pastoreo de las parcelas). A lo largo del periodo de estudio 90 días (d) se controló el crecimiento y consumo de los animales, mientras que tras el sacrificio se cuantificó el rendimiento canal y el espesor de grasa dorsal. La calidad de la carne se estimó objetiva (pH y color) y subjetivamente (panel de consumidores). Los animales mostraron una tasa de crecimiento baja (265 g/d) con valores mayores en el régimen C (305 vs. 225 g/d) y en los machos castrados (270 vs. 260 g/d). El sistema de cría y el género afectaron significativamente (P< 0.05) espesor de la grasa dorsal (2.21 vs. 2.06 cm para C y SC, y 2.08 vs. 2.16 cm para machos y hembras, respectivamente), mientras que el rendimiento canal (73.65 vs. 74.30% para C y SC, respectivamente) solo difirió significativamente (P< 0.05) entre sistemas. Los animales del grupo C presentaron canales con mayor contenido en grasa (40.8 vs. 37.5%) y menor de magro (44.8 vs. 46.4%) y hueso (8.22 vs. 9.38%) que las de los cerdos del grupo SC. La carne de los machos fue más oscura (L* 43.7 vs. 51.5), rojiza (a* 15.8 vs. 13.9) y amarillenta (b* 5.5 vs. 2.7) que la de las hembras. La carne de cerdos criados en el sistema C fue calificada como más pálida y menos brillante, más dulce, con más sabor metálico, así como menos untuosa y con menor persistencia del aroma. El tiempo de maduración tuvo una repercusión limitada en los atributos sensoriales del músculo *Longissimus thoracis*, encontrándose no obstante diferencias en las puntuaciones de terneza, brillo, jugosidad y untuosidad.

Palabras clave: Cerdo de raza autóctona; confinamiento; semi-confinamiento; carne de cerdo; perfil sensorial.

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INTRODUCTION

The Creole pig (*Sus scrofa*) is the most important Ecuadorian local breed. It constitutes a heterogeneous population resulting from successive crossing between Iberian stocks introduced at early the 16th century and French, English and American breeds introduced thereafter [27]. The Creole pig is known for its hardiness and adaptation to a harsh environment and is characterized by an early sexual maturity, low prolificacy, small mature size, and reduced growth and carcass performances [4]. The local breed pigs have enhanced abilities to utilize fibrous feeds compared with imported genotypes [25], and have an important place in alternative breeding systems where the by-products of the farm (bananas (*Musa* spp.), papaya (*Carica papaya*), cassava (*Manihot esculenta*), oranges (*Citrus sinensis*), etc.) could be used as a basis for pig feed. Furthermore, as shown in other local (Iberian pig) genotype [42], the absence of genetic selection with respect to lean content is associated with good meat quality [37, 38].

In Ecuador, the census of Creole pigs was estimated at 1.49 million animals [20], mostly found in rural communities (4.1 head / farm). The 3-5% of these pigs, population called “Criollo negro de la costa ecuatoriana” (Creole BEC), shows similar phenotypic characteristics to the Ibérica (Lampiña line) breed [1]. This phenotype can be characterized as an animal of medium size, poor conformation, long narrow snout, narrow chest, and higher hindlimb than forelimb, dark coloration, and sparse and short hair black slate [27]. Most of its production is done under extensive management in small herd size [4], and were fed with local resources, domestic by-products and residues from industrial plantations. In this system, weaning is late and slaughtering of animals takes place when the household needs cash to meet basic needs. This system is an alternative to the sustainability socio-economic and cultural, both the rural population and those living in the suburbs of large cities. New feeding strategies can be adopted in order to improve pig productivity and reduce the tendency toward gradual substitution of the Creole pig by high lean genotype pigs.

Very few studies were published evaluating the growth, carcass and meat characteristics of Creole BEC pig, indicating a lack of technical information, which could be used by the producers to improve the system and processes. Therefore, the aim of this research was to investigate the effects of feeding system and gender on growth performance, carcass characteristics, and meat quality of Creole BEC pigs as a part of a project that it is trying to guarantee the existence of this endangered pig genotype. Also, the effect of the ageing time on the sensory attributes of the meat is analyzed.

MATERIAL AND METHODS

Animals and rearing system

A total of 32 male and female Creole BEC pigs (representing the offspring of 8 boars) were used. Pigs were purchased (18-22 kg and 140-160 d old) from twelve local smallholders, where they were kept under extensive conditions, and transferred to the swine experimental farm "El Paraiso", located in Canton Buena Fe (Los Rios Province, coast of Ecuador). On arrival, all the pigs were identified, weighed, dewormed with Ivomec-Merial (ivermectin 0.08%), housed in groups and offered a conventional diet for 15 d (period of adaptation). Males were surgical castrated.

After the adaptation period, the pigs of each gender were randomly assigned to one of two treatments. Sixteen pigs, 8 barrows and 8 gilts, were reared following the traditional farming system (semi-confinement, SC). Other group of sixteen pigs, 8 barrows and 8 gilts, were reared in a conventional indoor rearing system (confinement, C). In the C treatment, the pigs were kept in individual pens and fed twice a d (morning and afternoon) a commercial feed (16% crude protein, 6.2% ether extract, 8% crude fiber, 2.3% ash, 3200 DE Kcal/kg) *ad libitum*. In the SC treatment, the pigs were housed overnight in individual pens, similar to those of system C, and offered 80% of the same commercial feed (at afternoon). During the daytime period, they were kept in individual paddocks (about 625 m^2/animal), where they consumed bananas (*Musa* sp.) in an initial amount of 275 g/d/pig that was increased 40 g every 5 d. These pigs also consumed roots, leaves and tubers of papaya (*Carica papaya*), cassava (*Manihot esculenta*), oranges (*Citrus sinensis*), and insects, worms, etc. Live weight and feed consumption were recorded at 0, 15, 30, 45, 60, 75 and 90 d and average daily gain (ADG) and feed conversion rate (FCR) were calculated. The experimental period lasted 90 d.

Slaughter, carcass and meat traits

After 90 d of experience, pigs were transported to a commercial abattoir, fasted for 12 hours (h) and slaughtered in two different d in which both genders and rearing systems were adequately represented. The pigs were electrically stunned, exsanguinated, scalded, skinned, and eviscerated according to standard commercial procedures. Data collected at slaughter were: slaughter weight (SW) and hot carcass weight (HCW). At 45 minutes (min) *post mortem*, initial pH (pH_{45}) was measured at the 7th thoracic vertebra of the carcasses using a portable pH-meter Lutron mod. 212 (Taipei, Taiwan) equipped with a glass electrode. Immediately after, and after making a cut in the m. *Longissimus thoracis*, CIE L*a*b* colour parameters (Commission International de l'Eclairage, 1976) were measured at three locations of a freshly cut surface of m. *Longissimus thoracis* at 12th rib after 30 min blooming using a Lutron RGB-1002 (Taipei, Taiwan) colorimeter (illuminant D65, 10° standard observer) calibrated with black and white tiles. The average of 3 random readings was used to measure *L**, *a** and *b**.

The carcasses were suspended in the air and refrigerated (Cora Refrigeración, Quito, Ecuador) at 4 °C for 24 h, and data collected were: cold carcass weight (CCW), and ultimate pH (pH_{24h}) and meat color in the same place and procedure than previously. Then, carcasses were split down the midline according to standard commercial procedures and the head was removed at the atlanto-occipital junction. In the right side of each carcass, backfat thickness (with calipers with a precision of 0.1 mm) at midline of the carcass at the position of the 1st, 12th and last ribs (three measurements are made at each location and the final value for backfat was considered the mean of the three estimations). After, 150 g samples of the m. *Longissimus thoracis* were taken at the level of the 6th rib for instrumental meat analysis (drip and cooked losses). Afterwards, three samples (of approximately 6 cm thick) of the m. *Longissimus thoracis* and *lumborum* (from the 7th rib to the last lumbar vertebra) were taken, weighed, placed in plastic bags and vacuum packaged and stored at 4ºC for 24h (cranial sample), and 7d (middle sample) and 15d (caudal sample). Aged samples were frozen at -20 ºC until subsequent sensorial meat analysis.

The left side of each carcass was fully dissected into skin, bone, muscle and fat, according to the EU reference method [43]. The carcass composition was calculated as well as the weight of each component from the dissection with respect to the half-carcass.

Sensory analysis

The day before the sensorial analyses, the samples were thawed inside vacuum-package bags for 24 h at 4 °C, removed from packages and blotted dry. Then, the samples were tempered at 15-17 ºC, packed in thin-walled polyethylene vacuum bags, and heated by immersion at 80 ºC until they reached an internal temperature of 72 °C in a continuously boiling water bath (Selecta mod. Precisterm, Barcelona, Spain) with controlled temperature. Internal temperature was monitored by an iron/constantan thermocouple wire connected to a thermometer and inserted into the geometric center of the sample. When the end point temperature was attained, bags were removed from the water bath. Samples were taken from the bag, trimmed of any external connective tissue, and cut into cubes (10 per animal) measuring 1.5 x 1.5 x 1.5 cm. Then, they were wrapped in aluminum foil, coded with a digital number and kept in covered glass containers on circulating water bath (≈ 60º C) to equilibrate their temperature and immediately after were served on glass plates at room temperature. The semi-trained panel for the sensory descriptive analysis consisted of five women as assessors involved with research studies on meat (student and staff members from Quevedo University, Ecuador, aged between 19 and 42). They had undergone a basic training program (for 2 weeks) in sensory assessment in accordance with Rutledge [40] and were all familiar with sensory assessment of meat. They were instructed to determine odour, flavour, texture and appearance. All sessions were done in a five-booth sensory panel room equipped with white fluorescent lighting (Toshiba Natural Color Evaluation lamp FL40N-EDL, Tokyo, Japan) following the UNE-EN-ISO 8589: 2010 standard. Panels were carried out over four sessions conducted on separate d within two consecutive weeks. At each session, every panelist tasted the samples in two batches over a period of two h. Samples were served randomly to panelist. Panelists were instructed to cleanse their palates with water between samples. Sensory analysis was carried out according to international standards ISO-R-4121 [21] using an unstructured line scale (0–10 cm), where a score of 0 = very low or no intensity (left side) to 10=very high intensity (right side) in the mentioned attribute. The attribute describing odour was 'piggy odour' (like the odour of a live pig/melted pork fat). The attributes describing appearance were: 'meat colour' (from light to dark). The attributes describing flavour nuances were: lard meat flavour, piggy flavour (as the flavour of a live pig/melted pork fat). Also included were brightness, tenderness, sweet taste, metallic taste, unctuousness, juiciness, persistence of flavor.

Statistical analysis

All statistical analyses were done with SAS 9.1 [41]. The effects of rearing system (C and SC) and gender (barrows and gilts) on growth and carcass traits were analyzed by the General Linear Model procedure. The model included system, gender and their interaction as fixed effects. Slaughter weight was used as covariate in carcass trait analyses. Data of meat sensory traits were analyzed by repeated measurement analysis [28] using the MIXED procedure. The model included the fixed effects of system, gender, ageing time, their interaction, and the random effect of pig nested within the system × gender interaction. Fisher's least significant difference test was used to compare least squares means. Pearson's correlation coefficients between the variables were calculated when appropriate. Statistical significance was declared at $P < 0.05$.

RESULTS AND DISCUSSION

Growth performance and feed intake

The live weight of animals ranged between 22-24 and 42-54 kg at the beginning and end of trial, respectively. Average feed intake was 1.5 ± 0.08 and 1.2 ± 0.06 kg/d in C and SC treatments, respectively (TABLE I). Values for ADG and FCR recorded in the present study were 0.27 kg/d and 4.99 kg/kg (data not shown). These values are lower than that reported in previous studies [12, 17, 38] in local breeds in traditional systems (Italian breeds, Chato Murciano, Creole). ADG and FCR values observed in this study could be attributed to the genetic potential of the population and the energy level of the diet. Rearing system and gender significantly affected ADG ($P < 0.05$). Pigs from C group grew faster ($P < 0.05$) than SC pigs (0.30 kg/d vs. 0.22 kg/d). In general, it is found that barrows grow more than gilts [26], which it corresponds with the results (0.27 kg/d for barrows vs. 0.26 kg/d for gilts), in agree with the study of but not with the results. However, Renaudeau and Mourot [38] in Creole pigs, indicated that ADG was not affected by gender. The rearing system showed a clear influence on FCR (higher in C pigs), as would have been expected given that the diets were different, and it was not possible to control the intake of the SC pigs in the paddocks.

TABLE I
EFFECT OF REARING SYSTEM AND GENDER ON LIVE WEIGHT, DAILY GAIN AND CARCASS YIELD OF CASTRATE MALE AND FEMALE CREOLE BEC PIGS

	Confinement		Semi-Confinement		RMSE	Significance		
	Barrow	Gilt	Barrow	Gilt		SYS	GEND	S x GE
Initial weight (kg)	23.8	23.9	23.6	23.5	0.33	ns	ns	ns
Final weight (kg)	52.0^{a}	51.7^{a}	43.7^{b}	43.2^{b}	0.72	***	ns	ns
Carcass yield (%)	73.6^{b}	73.7^{b}	74.7^{a}	74.3^{b}	0.25	**	ns	ns
Average Daily Gain (kg/day)	0.31^{a}	0.30^{a}	0.23^{b}	0.22^{b}	0.06	***	*	ns

RMSE =root mean square error;
SYS = rearing system; GEND = gender; ADG = average daily gain;
ns = no significant; * = P< 0.05; ** = P <0.01; *** = P < 0.001.
$^{a-b}$Means in the same row with a common superscript letter do not differ significantly (P>0.05).

Slaughter weight and carcass traits

The Creole BEG pig has traditionally been slaughtered with little age (7-8 m), so that the slaughter weight (43-51 kg) was significantly lower than that recorded in previous work on other autochthonous pig breeds [12, 17, 38]. The low weight at slaughter was possibly the main cause of low carcass yield (73.5 - 74.9 %) when compared to the results obtained in previous work in rustic pig breeds (such as Chato Murciano with 77.7%, [32];Iberian pigs with 76.9-77.9%, [8]; Celtic pigs with 79.0%, [14].

Average backfat thickness (BFT) ranged from 1.99 cm at 1st rib to 2.24 cm at last rib (TABLE II), with significant (P < 0.05) differences between locations. These results, consistent with previous studies [35], showed indicated that fat over the back of the pork carcass was not evenly distributed. The backfat thickness increased (P < 0.05) caudally, disagree with Apple at al. [2], who recorded values of 5.6, 3.25, 3.8 and 3.8cm at the 1st, 10th and last rib level, and last lumbar vertebra, respectively. The values for BFT in the current work were greater than found in Pulawska breed (0.88 cm [44]) and lower than those recorded in several rustic breed (4.9 cm in Cinta Senese [13]; 3.6-3.7 cm in Chato Murciano [34]; 7.2-8.9 cm in Majorcan Black Pig [19]). There were significant differences (P< 0.05) between rearing systems for BFT, which is similar to found by Pugliese et al. [35] and Daza et al. [8], who reported higher values in the indoor pigs. Conversely, Galián et al. [15, 16] and Poto el at. [34] found no significant differences between systems, but in all cases the outdoor group showed higher thickness. At slaughter, average BFT was greater in gilts than in barrows. Similar findings were reported by Renaudeau and Mourot [38] and Latorre et al. [26]. However, the results of the present study disagree with Fàbrega et al. [11], who indicated that the males (entire or castrated) deposit more fat than females mainly at lumbar level.

The average percentages of the carcass composition from Creole BEC obtained by means of dissection and the fat/lean and lean/bone ratios are shown in TABLE II. These results indicate that the Creole BEC pig had strong ability to deposit lipids showing high subcutaneous and intermuscular fat percentage, especially considering the low weight at slaughter, and low lean meat percentage. Renaudeau and Mourot [38] suggested that the greater ability of local breeds to deposit lipids is probably related to an indirect effect of concomitant breed difference in protein accretion and increase of extra energy available for lipid synthesis. Rearing system had a significant effect on carcass composition. The content of skin, lean and bone were higher in SC pigs when compared with C pigs, whereas the percentage of fat was lower. The lower fat percentages in outdoor pigs are in accordance to the lower backfat percentage observed in their carcasses [35], and is indirectly related with the feeding restriction, more exercise of this SC pigs and the fact that less amount of energy is available for lipids deposition. Also, gender significantly (P < 0.05) affected all traits studied. Analyzing the effect of gender, the lean percentages were higher (P < 0.01) in barrows, whereas the percentages of skin (P < 0.01), fat (P < 0.01) and bone (P < 0.01) were higher in gilts.

The average value of fat/lean and lean / bone ratios were 0.86 and 5.21, respectively (TABLE II). The rearing system and gender affected (P < 0.05) the fat / lean ratio. This ratio was higher in the carcasses of the C pigs (0.91 vs. 0.79) and gilts (0.87 vs. 0.84) when compared with the SC pigs and barrows, respectively. However, the relationship lean/bone alone was affected (P < 0.05) only by rearing system, higher in C pigs (5.47 vs. 4.94).

TABLE II
EFFECT OF REARING SYSTEM AND GENDER ON BACK-FAT THICKNESS AND CARCASS COMPOSITION OF CREOLE BEC PIGS

	Confinement		Semi-Confinement		RMSE	Significance		
	Barrow	Gilt	Barrow	Gilt		SYS	GEND	S x GE
BFT at 1ª rib (cm)	2.01^{aA}	2.09^{aA}	1.87^{bA}	1.99^{aA}	0.13	**	*	ns
BFT at 12ª rib (cm)	2.13^{aB}	2.23^{bB}	1.99^{cB}	2.13^{aB}	0.14	**	*	ns
BFT at last rib (cm)	2.26^{aC}	2.36^{bC}	2.10^{cC}	2.25^{aC}	0.15	**	*	ns
Skin (%)[1]	5.65^{a}	5.77^{a}	6.51^{b}	6.77^{c}	0.09	***	**	*
Fat (%)[1]	40.8^{a}	40.8^{a}	36.8^{b}	37.3^{c}	0.40	***	**	*
Lean (%)[1]	44.9^{a}	44.7^{a}	46.8^{b}	45.9^{c}	0.40	**	**	*
Bone (%)[1]	8.17^{a}	8.27^{a}	9.30^{b}	9.45^{b}	0.13	**	***	ns
Lean / Bone	5.49^{a}	5.40^{a}	5.01^{b}	4.89^{b}	0.25	**	ns	ns
Fat / Lean	0.90^{a}	0.91^{a}	0.77^{b}	0.82^{c}	0.02	***	**	**

RMSE = root mean square error; SYS = rearing system; GEND = gender; [1]respect to cold carcass weight; BFT = back fat thickness;
ns = no significant; * = P< 0.05; ** = P <0.01; *** = P < 0.001.
$^{a-c}$Means in the same row with a common superscript letter do not differ significantly (P > 0.05).
^{ABC}Means in the same column with a common superscript letter do not differ significantly (P > 0.05).

Meat quality

All groups showed similar values of pH_{45} and pH_{24h} (TABLE III), considered to be within a normal pH range for pigs that do not produce Pale Soft and Exudative (PSE) meat, to those recorded in most of the reviewed literature. The average values recorded by Fortina et al. [12] for $pH_{45}$are higher than those observed in our study (6.48 vs. 6.29 and 6.06 vs. 5.39, respectively), while the pH fall was lower (0.42 vs. 0.89 in the present study), revealing an incomplete post mortem glycolysis associated with pre-slaughter stress. In the present study, the rearing system and gender had no significant effect (P> 0.05) on pH measured both 45 min and 24 h *post-mortem*. Other authors [14, 38] have also found that sex does not influence the pH. However, in the literature, the effect of sex on ultimate pH remains unclear [3].

The color measurement (*L**, *a** and *b** indexes) corresponded with the dark and red meat of the autochthonous pig breeds (TABLE III). Cie L^*_{45} and b^*_{45} values were lower than those obtained by Estévez et al. [10] in free-range reared Iberian pigs slaughtered at 90 kg live-weight (37.69 and 0.4 vs. 44.99 and 4.26, respectively), whereas the a^*_{45} values were similar (10.87 vs. 10.50). Also, Renaudeau and Mourot [38] in Creole pigs, and Galián et al. [16] found higher levels for *L**, *a** and *b**. In agree with Peinado et al. [32] and Galián et al. [17], it can be seen that at 24 h, all the color parameters had increased (37.7 vs. 50.0, 10.8 vs. 14.8, and 0.4 vs. 3.0), which is normal due to ageing time [34]. Meat color measurements did not differ between rearing systems. It is generally accepted that meat from outdoor reared animals is darker than that of indoor pigs, which could probably be due to an enlarged spontaneous activity, leading to an increased mean fiber cross-sectional area. As regards meat color measurements at 24 h post-mortem, gender significantly affected (P < 0.05) the three chromatic variables assessed. It was apparent that the raw meat from gilts had a lighter, less reddish and more yellowish color when compared with barrows.

The data of the present study did not show such differences in pH_{24h} in any of the two different rearing systems, which could explain the lack of differences in DL and CL (data not show). As noted Meilgaard et al. [29], in the present study an increase in pH resulted in pork with lower L*, a*, b*, although correlations reached statistical significance only for L * (-0.367). Also, we found that the ultimate pH of m. *Longissimus thoracis* was negatively correlated to the cooking loss (-0.355), in agree with Purslow et al. [36].

Several studies evaluating all four sexes have had mixed results in relation to pork quality characteristics. Jeong et al. [22] found that a* and shear force differed significantly among the sexes. However, pH, L* and b* did not differ. Gispert et al. [18] drew similar conclusions in that L*, and a* differed, but b* and pH did not differ among the four sexes. Boler et al. [5] observed that pH differed but L*, a*, and b* did not differ. Gispert et al. [18] explained that although there were significant differences in some characteristics, the meat quality was considered to be of good quality among the four sexes. Therefore, the consumer may not be able to detect differences in meat from different sexes when meat quality is acceptable.

TABLE III
EFFECT OF REARING SYSTEM AND GENDER ON PH, COLOR, AND DRIP AND COOKING LOSSES OF *LONGISSIMUS THORACIS* M. FROM CREOLE BEC PIGS

	Confinement		Semi-Confinement		RMSE	Significance		
	Barrow	Gilt	Barrow	Gilt		SYS	GEND	S x GE
pH_{45} *Longissimus thoracis*	6.23	6.24	6.35	6.34	0.18	ns	ns	ns
pH_{24h} *Longissimus thoracis*	5.45	5.42	5.34	5.36	0.16	ns	ns	ns
L^*_{45}	35.2	40.8	35.2	39.9	0.62	ns	ns	ns
a^*_{45}	9.3	12.5	10.5	11.3	0.69	ns	ns	ns
b^*_{45}	-0.62	0.52	0.03	0.44	0.76	ns	ns	ns
L^*_{24}	43.9^{a}	54.3^{b}	43.4^{a}	48.6^{b}	0.82	ns	***	ns
a^*_{24}	15.3^{ab}	14.5^{ab}	16.3^{a}	13.3^{b}	1.03	ns	**	ns
b^*_{24}	5.61^{a}	2.66^{b}	5.37^{a}	2.68^{b}	0.90	ns	***	ns
Drip Loss %	3.37	2.72	2.88	2.99	0.35	ns	ns	ns
Cooking Loss %	26.11	25.62	28.71	28.69	0.82	ns	ns	ns

RMSE =root mean square error; SYS = rearing system; GEND = gender; ns = no significant; * = P< 0.05; ** = P <0.01; *** = P < 0.001;
$^{a-b}$Means in the same row with a common superscript letter do not differ significantly (P>0.05).

Sensorial analysis

In the present study, like other sensory studies, it was necessary to freeze some samples for a short period of time before evaluation. Average values of sensory parameters are showed in TABLE IV. Based on these results, the meat of the animals studied can be defined as moderately tender, with little brightness and color, with high odor and pork flavor, little unctuous on the palate, juicy and with moderate to high persistence of flavor. The evaluation by the sensory panel of the pork loins from the four groups did not show large differences in tenderness and pork flavor. However, significant differences (P < 0.05) were obtained for the attributes meat color, brightness, lard flavor, sweet taste, metallic taste, unctuousness, juiciness and persistence of flavor between rearing systems. Lard flavor, sweet taste, metallic taste, juiciness and persistence of flavor were significantly higher in C pigs when compared with the SC pigs, while meat color, brightness, pork odor and unctuousness were lower. Differences could be due to the characteristics of the rearing system, exercise and/or physical parameters [6, 23], but not be ascribed to a pH difference as no significant differences in pH were found between the different systems and genders (TABLE IV). In contrast to rearing system, few sensory attributes of cooked meat were affected by gender: metallic taste (higher in barrows, P < 0.01), and brightness (higher in gilts, P < 0.01). One experiment comparing sensory attributes [9] of the four sexes observed that, for fresh roasts, frozen chops and roasts, sexes differed in pork flavor, while no differences were found among sexes for juiciness, chewiness, and tenderness

It is widely accepted that the tenderness is the most important factor affecting overall meat acceptability. The tenderness was positively correlated with cooking loss (0.604), not reaching statistical significance other correlations with postmortem meat instrumental traits. Nam et al. [30] reported that tenderness score was correlated with L^* and drip loss, and negatively correlated with pH_{45}. Also, cooking loss was positively correlated with brightness (0.542), while showed negative correlations with taste attributes as sweetness (-0.486) and metallicness (-0.483), and juiciness (-0.494), which agrees with Nam et al. [30]. On the other hand, a high correlation between cooking loss and juiciness is reflected in Pillsbury [33]. As the above authors reported, these results suggest that panelists do not prefer pork in terms of taste which has high cooking loss and is perceived as tough meat. So, it may be natural that taste acceptance decreases as cooking loss increase.

The ageing time influenced a number of pork characteristics although its effect had limited benefit for the sensory attributes of m. *Longissimus thoracis* from Creole BEC pigs. Ageing time had significant effect (P < 0.05) on the tenderness, brightness, unctuousness and juiciness (TABLE IV). The values of the four traits were significantly higher (P < 0.05) as the ageing time increased. Similar results were reported by Juárez et al. [24] who analyze the evolution of the sensory characteristics of samples from m. *Longissimus thoracis* aged for 2, 7 and 14 d. Their results showed that initial and overall tenderness, juiciness and flavour intensity increased (P < 0.01) from d2 to 14, which they attribute to ageing increases the concentration of flavour precursors, responsible for forming the characteristic meat flavour during cooking. Ngapo et al. [31] found that ageing time had significant effects (P < 0.05) on the sensory quality when grilled or shabushabu, but not when roasted. These authors indicated that grilled pork at the longer ageing period had stronger sweet taste and caramel, more panelists made notes and a greater number of notes were obtained for the pork that had been stored 43 d than for 5 d. The enzymatic action is the most important factor affecting meat tenderization [39]. Juiciness showed a similar evolution along ageing between groups, in contrast to the results obtained by Campo et al. [7].

TABLE IV
SENSORY EVALUATION OF THE *LONGISSIMUS THORACIS* M. COOKED FROM CREOLE BEC PIGS. EFFECTS OF REARING SYSTEM, GENDER AND AGEING TIME

	System	Gender	Ageing time			SEM	Significance		
			1 day	7 days	15 days		SYS	GEN	AGE
Tenderness	Confinement	barrows	2.08_{y}	6.88_{x}	7.60^{b}_{x}	0.803	ns	ns	***
		gilts	2.80_{z}	6.32_{y}	8.76^{a}_{x}	0.724			
	SemiCon-finement	barrows	2.88_{z}	6.88_{y}	8.80^{a}_{x}	0.709			
		gilts	2.96_{y}	6.16_{x}	7.16^{b}_{x}	0.615			
		SEM	0.272	0.428	0.382				
Meat colour	Confinement	barrows	3.84^{b}	4.08	3.88^{b}	0.385	*	ns	ns
		gilts	4.40^{b}	4.64	3.88^{b}	0.537			
	SemiCon-finement	barrows	5.00^{ab}_{x}	3.84_{y}	5.24^{a}_{x}	0.337			
		gilts	5.52^{a}_{x}	4.88_{y}	5.32^{a}_{y}	0.376			
		SEM	0.383	0.289	0.433				
Brightness	Confinement	barrows	3.28^{b}_{x}	4.56_{xy}	4.96^{b}_{y}	0.534	*	**	**
		gilts	3.84^{ab}_{y}	5.28_{x}	5.88^{a}_{x}	0.522			
	SemiCon-finement	barrows	3.88^{ab}	4.68	5.04^{ab}	0.464			
		gilts	3.96^{a}_{x}	5.04_{y}	6.32^{a}_{xy}	0.391			
		SEM	0.432	0.442	0.500				
Lard flavour	Confinement	barrows	4.96	5.52	4.08	0.584	ns	ns	ns
		gilts	5.28	4.40	5.04	0.637			
	SemiCon-finement	barrows	5.20_{x}	4.64_{xy}	4.76_{y}	0.552			
		gilts	5.12	5.20	4.72	0.440			
		SEM	0.447	0.486	0.518				
Pork odour	Confinement	barrows	6.52_{xy}	7.36_{x}	6.28^{b}_{y}	0.673	ns	ns	ns
		gilts	6.56_{y}	8.84_{x}	7.48^{ab}_{xy}	0.539			
	SemiCon-finement	barrows	8.04	8.00	8.44^{a}	0.244			
		gilts	7.56	8.08	7.52^{ab}	0.272			
		SEM	0.422	0.336	0.483				
Pork flavour	Confinement	barrows	6.40	8.24	7.04	0.658	ns	ns	ns
		gilts	7.96	7.28	8.40	0.535			
	SemiCon-finement	barrows	8.04_{x}	6.12_{y}	7.64_{xy}	0.499			
		gilts	8.36	7.52	7.88	0.421			
		SEM	0.439	0.543	0.394				
Sweet taste	Confinement	barrows	0.76	0.76	1.00	0.170	ns	ns	ns
		gilts	1.48_{x}	0.56_{y}	0.64_{y}	0.199			
	SemiCon-finement	barrows	1.04	0.56	0.60	0.147			
		gilts	0.84	0.60	0.48	0.104			
		SEM	0.180	0.090	0.107				
Metallic taste	Confinement	barrows	0.68^{ab}_{y}	1.12^{a}_{x}	0.80^{a}_{y}	0.194	*	**	ns
		gilts	0.88^{a}	0.60^{b}	0.52^{b}	0.130			
	SemiCon-finement	barrows	0.84^{a}	0.52^{b}	0.48^{b}	0.106			
		gilts	0.44^{b}	0.52^{b}	0.52^{b}	0.058			
		SEM	0.117	0.133	0.095				
Unctuousness	Confinement	barrows	2.04_{y}	3.96^{b}_{y}	6.60^{ab}_{x}	0.722	*	ns	**
		gilts	1.96_{y}	4.72^{ab}_{x}	5.00^{b}_{x}	0.525			
	SemiCon-finement	barrows	2.92_{y}	5.12^{a}_{x}	6.04^{ab}_{x}	0.509			
		gilts	2.28_{z}	4.76^{ab}_{y}	7.40^{a}_{x}	0.613			
		SEM	0.359	0.367	0.382				
Juiciness	Confinement	barrows	3.12_{y}	6.12_{x}	7.32_{x}	0.614	*	ns	**
		gilts	3.56_{y}	6.00_{x}	7.52_{x}	0.656			
	SemiCon-finement	barrows	2.84_{y}	5.88_{x}	6.60_{x}	0.656			
		gilts	2.40_{y}	5.72_{x}	6.76_{x}	0.619			
		SEM	0.324	0.400	0.353				
Persistence of flavour	Confinement	barrows	5.96	6.16	7.16	0.439	*	ns	ns
		gilts	5.72	6.84	7.20	0.548			
	SemiCon-finement	barrows	4.76_{y}	6.34_{x}	6.62_{x}	0.563			
		gilts	5.36	6.28	6.60	0.463			
		SEM	0.500	0.368	0.438				

SEM = standard error of the means
$^{x-z}$Means in the same row with a common superscript letter do not differ significantly (P > 0.05).
$^{a-c}$Means in the same column and between the same trait with a common superscript letter do not differ significantly (P > 0.05).

CONCLUSIONS

The rearing system had a significant effect on most of the productive and carcass traits, whereas its effect was limited on the meat traits. Gender had little influence on most of the traits studied.

Ageing was found to be a suitable technique for improving the sensorial assessment of cooked meat. Ageing m. *Longissimus thoracis* from 1 to 15 d, improved scores of two major sensory attributes of meat, such as tenderness and juiciness, without prejudice to the other attributes studied.

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