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Pork quality of autochthonous genotype Casertana, crossbred Casertana x Duroc and hybrid Pen ar Lan in relation to farming systems

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Abstract. In the last decades, the development of livestock has coincided with improvements of the animals performance. The swine has been strongly selected for several traits that determined a significant spread of some genetic types, more productive than the old autochthonous genetic types (AGT). Therefore, the AGT suffered a growing demographic contraction. The AGT are able to reduce the loss of genetic variability, potentially useful for the new generation and they play an important economic role for their productive capacity in harsh environments; furthermore, they can be used to obtain natural and 'traditional' products. In the current research the black AGT Casertana (CT) was compared with the crossbreed CT×Duroc in relation to gender (castrated males and entire females) and farming systems: Open Air and Outdoor (plus access to the bush) for some qualitative properties of meat. In addition 'Fiocco' ham, a traditional product, from CT, CT×DU and Pen ar Lan pigs was analyzed. The results showed that the CT pigs had a significantly higher percentage of fat, a thicker adipose tissue, and their meat had lower values of hardness, chewiness, shear force, and appeared significantly redder than other genotypes meat. The farming systems and gender did not affect the carcass composition and physical traits of meat.

Key words: pork, meat quality, authochtonous genetic type, Casertana pig.

INTRODUCTION

In the last decades, the development of livestock coincided with a socio-economic progress that in many countries has led to an increase in the demand of livestock products. The strong selective activity of pig breeds resulted in a greater spread of certain genetic types, more productive than others and, therefore, a growing demographic contraction of the ancient autochthonous genetic types (AGT). In the '70 FAO called for the attention of the political, scientific, and operational communities on the danger of extinction of AGT, the only ones able to play an important role in some harsh areas; each AGT fits in harmoniously with its breeding nutritional and extranutritional specific features (Casabianca & Matassino, 2006). The Casertana pig (CT) is a black AGT reared in South of Italy and, as other native breeds of southern European countries, provides meat with an additional value due to the quality of the raw meat and cured products (Zullo et al., 2003; Barone et al., 2006, 2008a, 2008b; Castellano et al, 2008; Pugliese & Sirtori, 2012). CT pigs are prone to adipogenesis, have a strong aptitude for fat deposition and have a high percentage of body fat, producing more than double backfat thickness as LW pigs (Murgiano et al., 2010). Another characteristic of AGT is the slow growth that allows the pigs to reach a commercial slaughter weight (about 150 kg) at a considerably older age than improved pigs and, obviously, the rearing of them is very expensive (Maiorano, 2009).

To improve the productivity of AGT without modifying the quality of meat, or reducing the amount of intramuscular fat, the cross with the Duroc is often being employed (Edwards, 2005; Pugliese & Sirtori, 2012). The Duroc pig is also suitable for outdoor systems and appears to have a genetic predisposition to deposit intramuscular fat (Edwards, 2005).

The autochthonous genetic types are better suited to outdoor system than improved breeds. The products (raw or typical cured products) obtained from pigs reared with this system transfer to the consumers the so-called argument of ‘ethical quality’, because of conditions of animal wellbeing, of physical activity, and of the capacity of the animals to express the natural behaviour of the species.

The aim of this research was to evaluate the effects of genotype, rearing systems and gender on pigs carcass traits and on qualitative characteristics of raw meat and ‘traditional’ product: 'Fiocco' (*culatello*) ham.

MATERIALS AND METHODS

A total of 64 pigs [29 entire females (EF) and 35 castrated males (CM)] belonging to three genotypes: 23 Casertana (CT), 32 CT crossed with Duroc boar (CT×DU) and 9 Pen ar Lan (PAL) were analyzed (Table 1). The PAL pigs were fed 100% concentrate without outdoor area (Intensive system), while the others two genotypes were reared in adjacent outdoor areas called Open Air and Outdoor, providing about 210 m^2 per pig. The Outdoor group, when the environmental conditions allowed, was moved to the bush, about 2400 m^2, where pigs were left free until late evening, integrating their diet with indigenous resources such as acorns, berries, tubers, brooms, and wild plants and their fruits.

Table 1. Number of pigs per rearing system and genotype

Genotype	Rearing system					
	Open Air		Outdoor		Intensive	
	CM	EF	CM	EF	CM	EF
CT	5	5	7	6		
CT×DU	10	7	9	6		
PAL					4	5

Both genetic types CT and CT×DU had received the feed (the same concentrate of PAL) twice a day (morning and evening) on the basis of live weight and had benefited of open air pasture with Alfalfa, Couch Grass (*Cynodon dactylon*), Clover (*Trifolium*) and wild grasses.

The concentrate, the same for all genotypes, had the following chemical composition: 85.71% dry matter (DM) and on a dry matter basis: 19.4% crude protein (CP), 7.41% acid detergent fiber (ADF), 19.39% neutral detergent fiber (NDF), 4.5% ether extract (EE) and 7.4% ash.

Animals were conventionally slaughtered and, after 72 hours of ageing, the left side of each carcass was dissected into primary fatty cuts (backfat, belly, jowl, kidney fat) and lean cuts (ham, shoulder, loin, neck). For each cut the dissection into meat, fat (subcutaneous fat with skin), and bone was made and their weight were registered in order to calculate the percentage of meat and fat on carcass. The backfat thickness was measured with a ruler at three different locations: shoulder, loin and leg.

The instrumental evaluation of colour (CIEL*a*b*) and rheological traits (texture profile analysis - TPA and Warner Bratzler Shear Force–WBS) of meat was carried out on *Longissimus* muscle of the two genotypes CT and CT×DU. The colour was measured using a U-3000 spectrophotometer equipped with integrating sphere. The operating conditions of the instrument were: observer at 2°, source D_{65}. Two, 1.3 cm thick samples were allowed to bloom for 1 h at 4°C, before recording the data.

The TPA variables, determined with Texturometer (Zenken, Tokio), were hardness (the total energy required for the first deformation per chew, kg), cohesiveness (A2 per A1, where A1 is the area under the first deformation per chew and A2 is the area under the second deformation per chew, texturometer unit), springiness (sample capacity to recover its original shape after the deforming force has been removed, mm) and chewiness (hardness×cohesiveness×springiness). WBS values were determined with Instron universal testing machine (Mod 5565) and represents the force (kg) required to cut a meat sample of 2.54 cm of diameter.

Colour and TPA parameters were also detected on 'Fiocco' (*culatello*) ham, at the end of the seasoning period (12 months), for all 3 genotypes.

The analysis of variance (ANOVA) was performed by the GLM procedure of SAS using a factorial model were genetic type, gender and rearing system were considered main factors. The statistical significance of comparisons between mean values was tested with Student *t-test*.

RESULTS AND DISCUSSION

The comparison between genotypes about slaughtering and dissection parameters showed a higher fat thickness in Casertana, especially in shoulder and buttock region ($P < 0.01$); Duroc sired genotypes had no determined differences at the loin level (Table 2). Fatty cuts accounted for 34% of the chilled carcass in CT, 31% in CT×DU and only 27% in PAL ($P < 0.05$), while the percentage of lean cuts was not statistically different among the three genotypes (Table 2). This suggests a different development and/or growth of tissues in the considered genetic types. Recently, Maiorano (2009) noted that the slower bone ossification in local breeds than that in improved pigs, conditions the muscle growth and fat deposition. As it is well known, the use of the Duroc breed is usually planned in order to increase the quantity and quality of the meat (Sellier, 1998) and to improve other characteristics such as prolificity, growth rate, feed efficiency, lean content (López-Bote, 1998). Blanchard et al. (1999) reported that slaughtered pigs possessing 50% Duroc genes in comparison to 0% Duroc genes produced more tender meat, had improved pork flavour, and a higher overall acceptability. The results of the present experiment, however, showed that the WBS, hardness, and chewiness of the meat in CT were significantly better compared to Duroc sired genotypes ($P < 0.01$) (Table 3). The meat of CT was also redder, with an a* value approximately two times that of CT×DU (6.66 vs 3.42; $P < 0.01$), and also with higher values of b* ($P < 0.01$) and Chroma ($P < 0.001$).

Table 2. Effects of genotype, rearing system and gender on carcass traits* (mean value ± SE)

Trait	Genotype			Rearing system		Gender	
	CT	CT×DU	PAL	Open Air	Outdoor (+bush)	CM	EF
CC, kg	144.35^{B} ± 3.12	163.14^{A} ± 2.85	160.00^{A} ± 5.21	155.02 ± 3.01	153.97 ± 2.88	157.70 ± 2.84	152.30 ± 3.04
LC, kg	94.02^{B} ± 2.12	104.63^{A} ± 1.89	106.17^{A} ± 3.52	100.55 ± 2.06	98.95 ± 1.97	101.23 ± 1.94	98.28 ± 2.08
LC CC^{-1}, %	65.27 ± 0.51	64.04 ± 0.46	66.37 ± 0.85	64.85 ± 0.53	64.44 ± 0.51	64.64 ± 0.50	64.65 ± 0.54
Shoulder, kg	19.90^{B} ± 0.45	24.60^{A} ± 0.41	24.24^{A} ± 0.75	22.43 ± 0.44	22.23 ± 0.42	22.66 ± 0.41	22.00 ± 0.44
Loin, kg	24.97 ± 1.41	22.09 ± 1.26	19.97 ± 2.35	24.49 ± 1.46	22.85 ± 1.40	23.59 ± 1.38	23.75 ± 1.48
Ham, kg	16.81^{B} ± 0.76	20.28^{A} ± 0.68	22.81^{A} ± 1.27	18.04 ± 0.79	19.09 ± 0.76	19.23 ± 0.74	17.90 ± 0.80
Fiocco, kg	18.83^{B} ± 0.37	22.81^{A} ± 0.34	23.46^{A} ± 0.62	21.02 ± 0.36	20.78 ± 0.34	21.00 ± 0.33	20.80 ± 0.36
Neck, kg	13.09^{B} ± 0.37	14.86^{A} ± 0.33	15.67^{A} ± 0.62	14.05 ± 0.36	14.04 ± 0.34	14.27 ± 0.34	13.82 ± 0.36
FC, kg	48.02^{a} ± 1.29	50.85^{a} ± 1.15	3.12^{b} ± 2.15	49.06 ± 1.31	50.04 ± 1.26	50.39 ± 1.24	48.71 ± 1.33
FC CC^{-1}, %	33.62^{a} ± 0.84	31.19^{b} ± 0.78	26.93^{c} ± 1.40	31.75 ± 0.87	32.90 ± 0.84	32.22 ± 0.82	32.44 ± 0.88
Backfat, kg	12.93^{A} ± 0.58	12.89^{A} ± 0.53	7.13^{B} ± 0.97	12.97 ± 0.58	13.06 ± 0.55	13.04 ± 0.55	12.99 ± 0.59
Belly, kg	22.02^{B} ± 0.44	25.70^{A} ± 0.39	26.75^{A} ± 0.73	23.87 ± 0.40	24.00 ± 0.39	23.98 ± 0.38	23.90 ± 0.41
Jowl, kg	5.40 ± 0.18	5.82 ± 0.16	5.54 ± 0.30	5.63 ± 0.18	5.62 ± 0.17	5.70 ± 0.17	5.55 ± 0.18
Kidney fat, kg	7.67 ± 1.06	6.44 ± 0.95	3.70 ± 1.76	6.60 ± 1.11	7.34 ± 1.06	7.67 ± 1.04	6.27 ± 1.12
FT Shoulder, mm	67.38^{a} ± 2.75	58.97^{b} ± 2.46	46.70^{c} ± 4.59	59.46^{b} ± 2.67	67.20^{a} ± 2.56	63.75 ± 2.52	62.91 ± 2.70
FT Loin, mm	44.78^{a} ± 2.49	38.79^{a} ± 2.23	28.55^{b} ± 4.15	39.14 ± 2.48	44.65 ± 2.37	41.73 ± 2.34	42.07 ± 2.50
FT Leg, mm	49.02^{A} ± 2.41	39.44^{B} ± 2.15	24.57^{C} ± 4.01	42.87 ± 2.41	46.1 ± 2.31	47.31 ± 2.27	41.66 ± 2.43

* CC–Cold carcass, LC–Lean cuts; FC–Fatty cuts; FT–Fat thickness; Means with the same superscripts letters, within a factor, are not different (lower cases $P < 0.05$, and upper cases $P < 0.01$).

The hue angle showed a different behaviour and was significantly higher in CT×DU ($P < 0.01$) (Table 3), suggesting a shift within the red hue towards the yellow part of the spectrum (Dugan et al., 1997). According to Pugliese et al. (2005), the redder meat of AGT CT could be due to slower growth and higher slaughter age compared to crossbreed, with the older age groups reared under Open Air system (19–20 vs 15–16 months).

Table 3. Effects of genotype, rearing system and gender on meat quality* (mean value ± SE)

Trait	Genotype		Rearing system		Gender	
	CT	CT×DU	Open Air	Outdoor	CM	EF
Hardness, kg	1.52^{B} ± 0.257	2.29^{A} ± 0.14	1.92 ± 0.22	1.89 ± 0.17	1.81 ± 0.22	1.99 ± 0.17
Cohesiveness, TU	0.579 ± 0.02	0.590 ± 0.02	0.564 ± 0.02	0.605 ± 0.01	0.574 ± 0.02	0.595 ± 0.01
Springiness, mm	11.83 ± 0.38	12.54 ± 0.21	12.07 ± 0.33	12.29 ± 0.26	11.98 ± 0.33	12.38 ± 0.26
Chewiness, TU	1025^{B} ± 234	1743^{A} ± 133	1334 ± 206	1433 ± 161	1266 ± 207	1501 ± 159
WBS, kg	6.87^{b} ± 0.55	9.23^{a} ± 0.82	6.77^{b} ± 0.73	9.35^{a} ± 0.65	8.96 ± 0.68	7.15 ± 0.71
L*	53.16 ± 1.31	55.20 ± 0.98	53.09 ± 1.26	55.26 ± 1.06	54.47 ± 1.07	53.88 ± 1.17
a*	6.66^{A} ± 0.50	3.42^{B} ± 0.37	4.76 ± 0.47	5.31 ± 0.40	5.47 ± 0.40	4.61 ± 0.44
b*	17.19^{A} ± 0.31	15.82^{B} ± 0.23	16.51 ± 0.30	16.50 ± 0.25	16.76 ± 0.25	16.25 ± 0.28
Chroma	18.51^{A} ± 0.42	16.25^{B} ± 0.32	17.29 ± 0.41	17.47 ± 0.34	17.76 ± 0.34	16.99 ± 0.38
Hue	1.21^{b} ± 0.02	1.36^{a} ± 0.02	1.30 ± 0.02	1.27 ± 0.02	1.27 ± 0.02	1.30 ± 0.02

* Means with the same superscripts letters, within a factor, are not different (lower cases $P < 0.05$, and upper cases $P < 0.01$); TU=Texturometer unit.

Regarding 'Fiocco' ham, the product obtained from CT (18.83 kg at dissection) at the end of seasoning showed greater hardness (4.65 vs 3.27 and 3.15 kg; $P < 0.01$) and chewiness values ($P < 0.05$), a lower springiness value ($P < 0.05$), a higher redness index (a* value) ($P < 0.05$) and a lower b* value ($P < 0.01$) while the product obtained from the CT×DU was significantly less red than PAL ($P < 0.05$) (Table 4). Carcass composition and meat quality (*longissimus* muscle) were not influenced by the rearing system, although the pigs that had access to bush showed a higher fat thickness at the shoulder region (67.20 mm vs 59.46 mm; $P < 0.05$) (Table 2).

Table 4. Effects of genotype on qualitative traits of cured 'Fiocco' ham* (mean value ± SE)

Traits	Genotype		
	CT	CT×DU	PAL
Hardness, kg	4.65^{A} ± 0.265	3.15^{B} ± 0.28	3.27^{B} ± 0.31
Cohesiveness, TU	0.592 ± 0.016	0.624 ± 0.016	0.619 ± 0.019
Springiness, mm	13.06^{b} ± 0.24	14.11^{a} ± 0.25	14.40^{a} ± 0.29
Chewiness, TU	3653^{b} ± 267	2913^{a} ± 278	2970^{ab} ± 316
L*	44.22^{b} ± 0.92	45.03^{b} ± 0.65	46.71^{a} ± 0.64
a*	3.44^{a} ± 0.62	1.96^{b} ± 0.43	2.92^{a} ± 0.43
b*	11.95^{A} ± 0.55	13.87^{B} ± 0.38	14.77^{B} ± 0.38
Chroma	13.10^{B} ± 0.57	14.26^{AB} ± 0.40	15.24^{A} ± 0.39
Hue	0.44 ± 0.23	0.73 ± 0.16	0.88 ± 0.16

* Means with the same superscripts letters, within a factor, are not different (lower cases $P < 0.05$, and upper cases $P < 0.01$); TU = Texturometer unit.

According to Pugliese & Sirtori (2012), the effects of rearing systems on the physical traits of pork, both autochthonous and improved breeds, are often contradictory. Cinta senese breed showed higher percentage of intermuscular fat and bones in outdoor system than indoor reared pigs, also higher shear force and a* and lower L* value (Pugliese et al., 2005). Outdoor reared Nero Siciliano pigs produced lighter and yellower meat, probably due to their higher intramuscular fat content (Pugliese et al., 2004). Enfält et al. (1997) showed on outdoor crossbred pigs (Yorkshire, or Yorkshire × Landrace sows, and Duroc or Yorkshire as terminal sire) that this system produces leaner carcasses and meat with lower ultimate pH, higher drip loss, shear force, and higher internal reflectance values.

Gender did not significantly influence meat quality (Table 3) as well as the carcass cuts composition (Table 2). Castellano et al. (2007) on AGT CT, showed that gender did not affect significantly rheological characteristics of meat, but only colour, with a lower value of a* ($P < 0.001$) and a higher value of b* ($P < 0.001$) in entire females in comparison with castrated males.

CONCLUSIONS

The ancient autochthonous genetic type Casertana pigs confirm the aptitude to produce carcasses with significantly higher percentage of fat and better texture parameters of meat. These traits make the Casertana suitable for the production of high value-added processed products, like 'fiocco' ham.

The primary attributes of meat quality were not influenced by rearing system and gender, but the quality is a combination of real (objective) and perceived attributes of the product. Indeed the positive characteristics related to consumer perceptions, such as the environmental impact, cultural and socio-economic aspects of the production system, are high successful to guide the consumers choices.

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