COBISS: 1.08
Agris category code: L01, Q01

QUALITY OF FRESH PORK AND DRY-CURED HAM: INTERACTIVE EFFECTS OF PIG BREED (BASQUE OR LARGE WHITE) AND PRODUCTION SYSTEM (CONVENTIONAL, ALTERNATIVE OR EXTENSIVE)

Bénédicte LEBRET [1, 2, 3], Patrick ECOLAN [2, 3], Nathalie BONHOMME [2, 3], Pierre-Yves POLLET [4], Jean-Yves DOURMAD [2, 3]

ABSTRACT

The influence of pig breed, production system and their interaction on the quality of fresh and dry-cured hams was determined in two pure breeds: Large White (LW) and Basque (B, local breed) reared in different production systems: conventional (C), alternative on bedding with outdoor access (A) and extensive outdoor (E). Two experimental replicates each including 5 groups of 10 castrated males (BC, BA, BE, LWC, LWA) were undertaken. The B pigs had a lower growth rate, especially for BE, and a higher carcass fatness at 145 kg, especially for BA and BC compared with LWA and LWC. Semimembranosus (SM) of BE pigs had higher ultimate pH and more red and dark meat than the other pigs, especially LWA and LWC. Intramuscular fat and saturated, mono- and poly-unsaturated fatty acid contents were higher in B than LW pigs, but were not modified by production system. B dry-cured hams had higher fat thickness, marbling, red color intensity and oily scores, especially BE, and lower occurrence of veining defect than LW hams. B hams were judged tender, easier to cut and less dry than the LW which had higher salty and acid tastes, but texture and taste were not influenced by production system. This study highlighting the high quality and specificity of pork from local breeds and extensive systems is of interest for pork chains involved in Protected Denomination of Origin approach.

Key words: pigs / breed / production system / growth performance / meat quality / dry-cured ham

1 INTRODUCTION

The sensory quality of pork and pork products including appearance, texture, taste and flavour, as well as technological quality result from complex interactions between genetic background, rearing and slaughtering conditions of pigs, and meat processing. Even though many factors influencing meat quality (MQ) have been identified so far, its variability remains high. Besides, the muscle properties underlying high quality remain unclear. To improve biological knowledge on the development of MQ and identify biomarkers for its monitoring, an experiment was designed to induce a high MQ variability using two contrasted pig breeds: the conventional Large White, and the French local Basque genetically distant from other European pig breeds (Laval *et al.,* 2000) and exhibiting high quality pork (Guéblez *et al.,* 2002; Alfonso *et al.,* 2005). These pigs were reared in different production systems themselves influencing MQ (Lebret, 2008; Lebret *et al.,* 2011a). The aim of the experiment was to characterize the respective and interactive effects of breed and production system on quality of pork and pork products (fresh loin and dry cured ham) and identify biomarkers of pork quality traits using functional genomics approaches (Lebret *et al.,* 2011b; Damon *et al.,* 2013). This manuscript focuses on the influence of breed, production systems and their interactions on growth performance, carcass composition, muscle traits and quality of dry-cured hams.

1 Corresponding author, e-mail: Benedicte.Lebret@rennes.inra.fr
2 INRA, UMR1348 PEGASE, 35590 Saint-Gilles, France
3 Agrocampus Ouest, UMR1348 PEGASE, 35000 Rennes, France
4 Filière Porc Basque, 64430 Les Aldudes, France

2 MATERIALS AND METHODS

2.1 ANIMAL DESIGN

The experiment involved two successive replicates (R1 and R2) each including 50 castrated male pigs from pure Basque (B, n = 30) or Large White (LW, n = 20) breeds. At around 35 kg body weight (BW), B and LW littermates were placed either in a conventional (C; slatted floor, 1.0 m^2/pig): pigs BC and LWC, or an alternative system (A; bedding and outdoor access, 2.4 m^2/pig): pigs BA and LWA (n = 10/breed/system) at INRA-PEGASE experimental farm. In addition, at 35 kg BW, 10 half-littermates of BC and BA pigs were placed in an extensive (E) free-range system (pen of 2.5 ha with a shed, 650 m altitude) in a farm of the Basque pork chain: pigs BE. In order to slaughter all pigs at 145 kg BW and around the same time, and based on differences in growth rate between breeds and production systems (Guéblez *et al.,* 2002), BE pigs were put in experiment 5 months, and BC and BA pigs 3 months before LWC and LWA pigs. Pigs of both A and C systems received standard growing (35–75 kg) and finishing (75–145 kg) diets with 2.0 to 2.5, 2.5 to 3.0, and 3.0 kg/pig/day during the periods 35–75, 75–110 and 75–145 kg, respectively. BE pigs had free access to the natural resources of the pen (grass, acorns and chestnuts) and received a growing-finishing diet with 1.4 to 2.6 kg, 2.3, and 2.0 kg/pig/day during the periods 35–110, 110–130 and 130–145 kg, respectively. BC, BA, LWC and LWA pigs were slaughtered at INRA slaughterhouse and BE pigs in the commercial slaughterhouse of the Basque pork chain (Saint- Jean Pied-de-Port). Pre-slaughter handling and slaughtering conditions were standardized between all pigs (Lebret *et al.,* 2011b).

2.2 CARCASS AND MUSCLE TRAITS

Hot carcass weight and back fat thickness (midline, $4^{th}/5^{th}$ lumbar vertebra level) were recorded on the day of slaughter. Semimembranosus muscle (SM) was sampled 35 minutes *p.m.* for pH_1 determination. After 24h, SM ultimate pH (pHu) and colour coordinates (triplicates of L*: lightness, a*: redness, b*: yellowness, C*: saturation and h°: hue angle after 1h30 blooming) were measured, and SM samples taken for determination of intramuscular fat (IMF) and fatty acid (FA) contents by gas chromatography (cf Lebret *et al.,* 2011a for analytical methods).

2.3 SENSORY QUALITY OF DRY CURED HAMS

Hams of R2 replicate (n = 50) were processed into dry-cured hams following the traditional method of the Basque pork chain (64430 Les Aldudes, France). To process all hams in a single batch, 4 days after slaughter, fresh hams were rapidly frozen (industrial plant) and kept at −20 °C up to 7 weeks. Hams were transported to the processing plant, slowly thawed (4 °C) and processed into dry cured hams (19 months). Hams were then deboned, trimmed of most external fat and the half (foot side) part sent under vacuum to the sensory laboratory (A Bio C, 64410 Arzacq, France). One ham per treatment (n = 5) was assessed per session; whole ham slices (1.8 to 2.0 mm thick) were scored by 12 trained panellists for appearance, odour, texture and flavour on a discrete scale from 0 (absence) to 6 (high), and individual scores averaged for data analyses.

2.4 STATISTICAL ANALYSES

Data were submitted to a variance analysis (GLM procedure, SAS) including the treatment (breed × production system, n = 5), experimental replicate (n = 2) and their interaction as main effects. Bonferroni's test was used for multiple comparisons of least squares (LS) means.

3 RESULTS AND DISCUSSION

The B pigs exhibited a lower growth rate than the LW, in particular the BE pigs (Table 1). Overall, the growth rate of BA and BC pigs was reduced by 46% compared with LWA and LWC, and that of BE was reduced by 36% compared with BC and BA pigs. Thus the B pigs, especially BE were older at slaughter (at 145 kg BW), which agrees with the well-known breed differences on growth traits (Guéblez *et al.,* 2002; Alfonso *et al.,* 2005). Differences in feeding management between BC or BA on the one hand and BE pigs on the other hand, who received reduced feed supply during beginning of growing (−25%) and end of finishing (−20 to −30%) periods compared with BC and BA, explain their slower growth rate and older final age. This indicates that in the E system, feeding resources do not fulfil the pig nutritional requirements which are increased due to higher physical activity and thermoregulation (Lebret, 2008). As a consequence of growth rate and feed intake differences between treatments, feed conversion ratio was much higher for B, in particular BE, than LW pigs. At similar carcass weight, B pigs had fatter carcasses than LW, as expected (Guéblez *et al.,* 2002). BE pigs were leaner than BC or BA, as a result of their lower feed intake (Lebret, 2008). Similar results were obtained in both replicates, except a lower final weight due to slightly lower growth rate

Table 1: *Growth performance (35–145 kg) and carcass traits*

	Treatment: breed × production system[1]					Significance[2]			
	BA	BC	BE	LWA	LWC	RSD	T	R	T × R
Final BW, kg	146.3^{ab}	139.3^{a}	141.8^{ab}	144.7^{ab}	148.0^{b}	8.2	*	ns	**
Growth rate, g/d	544^{b}	498^{b}	335^{a}	756^{c}	772^{c}	86	***	ns	ns
Final age, j	312^{b}	319^{b}	423^{c}	230^{a}	228^{a}	17	***	ns	ns
Average daily feed intake, kg/d[3]	2.67	2.39	2.10	2.88	2.88	-	-	-	-
Feed conversion ratio, kg/kg[3]	4.97	4.86	5.73	3.90	3.76	-	-	-	-
Hot carcass weight, kg	118.9	114.4	113.9	113.9	118.3	6.8	ns	ns	*
Back fat thickness, mm	50.6^{c}	46.2^{c}	38.9^{b}	24.4^{a}	23.9^{a}	5.1	***	ns	*

[1] Breed: B–Basque, LW–Large White; Production system: A–Alternative, C–Conventional, E–Extensive
[2] RSD: residual standard deviation; T–Treatment (n = 5); R–Replicate (n = 2); *** P < 0.001; ** P < 0.01; * P < 0.05; ns–P > 0.05; LSmeans values in a row with different superscript differ (P < 0.05)
[3] Experimental unit = group

of BE pigs in R2 than in R1. This reveals the variability of rearing conditions in extensive systems, even when considering the same farm and management practices. Within breeds, there were no differences in growth performance or carcass fatness between A and C pigs, by contrast with previous results obtained on synthetic line crossbreeds (Lebret *et al.,* 2011a). This likely results from the limited feed supply in the present work, compared with ad libitum feeding in the previous one.

Breed and production system strongly influenced SM meat quality (Table 2). pH 35 min did not differ, but BE pigs exhibited higher pHu and lower L* than the other B pigs, and moreover than LW pigs. The B pigs had higher a* than LW independently of production system, and the BE pigs had the lowest b* value. Consequently, hue angle (h°) was the lowest for the BE pigs and the highest for the two LW groups, indicating darker red colour of meat from BE pigs. B pigs exhibited much higher IMF content than the LW, without any significant difference between production systems within breeds. The higher IMF of the B pigs resulted from their higher contents in saturated and mono-unsaturated FA, and poly-unsaturated (PUFA) to a lesser extent. PUFA differences were mainly explained by the higher level of n-6 PUFA in the B compared with LW pigs, without any effect of production system within breed. The n-3 PUFA level, overall much lower, was higher in the BA and BC pigs than the LWA and LWC, the BE being intermediate. Thus, n-3 PUFA content was not improved

Table 2: *Semimembranosus muscle and meat quality traits*

	Treatment: breed × production system[1]					Significance[2]			
	BA	BC	BE	LWA	LWC	RSD	T	R	T × R
pH 35 min	6.52	6.47	6.54	6.45	6.41	0.16	ns	ns	ns
pH 24 h	5.63^{a}	5.59^{a}	5.83^{b}	5.48^{a}	5.50^{a}	0.18	***	ns	ns
Colour L* (lightness)	47.0^{a}	47.3^{a}	44.7^{a}	51.9^{b}	52.2^{b}	2.9	***	***	*
Colour a* (redness)	14.2^{b}	13.5^{b}	13.4^{b}	10.8^{a}	9.9^{a}	1.8	***	ns	ns
Colour b* (yellowness)	8.0^{b}	7.7^{b}	6.2^{a}	7.8^{b}	7.2^{ab}	1.3	***	**	ns
C* (saturation)	16.3^{b}	15.6^{b}	14.7^{ab}	13.3^{a}	12.3^{a}	2.1	***	ns	ns
h° (hue angle)	29.2^{b}	29.6^{b}	24.8^{a}	35.7^{c}	36.1^{c}	2.5	***	***	ns
Intramuscular fat, %	4.37^{b}	4.12^{b}	3.90^{b}	2.02^{a}	2.28^{a}	1.2	***	ns	*
Saturated[3]	1297^{b}	1210^{b}	1070^{b}	591^{a}	708^{a}	405	***	ns	*
Mono-insaturated[3]	2061^{b}	1932^{b}	1853^{b}	758^{a}	897^{a}	654	***	ns	ns
Poly-insaturated[3]	314^{b}	295^{b}	338^{b}	234^{a}	233^{a}	64	***	ns	ns
n-6	275^{b}	257^{b}	300^{b}	206^{a}	205^{a}	55	***	ns	ns
n-3	31^{b}	29^{b}	27^{ab}	22^{a}	22^{a}	7	***	ns	ns

[1, 2] cf Table 1; 3 mg/100 g fresh muscle

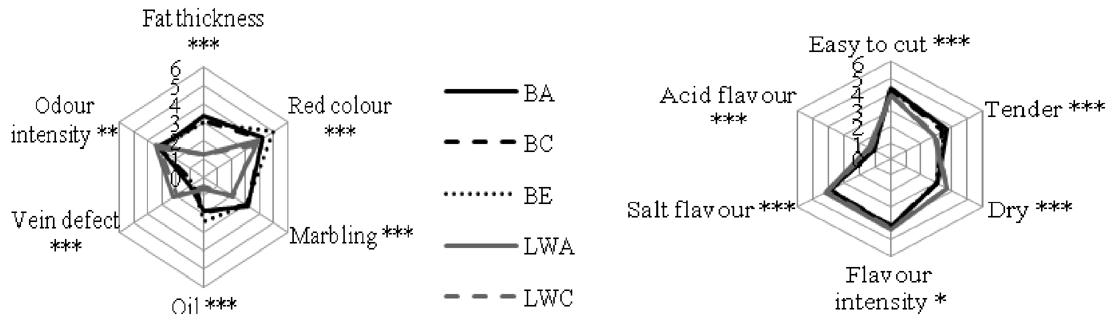

Figure 1: *Appearance, odour, texture and flavour of dry cured hams according to treatment (breed × production system);* *** P < 0.001; * P < 0.05

in pork from the E system despite its high content in grass (Lebret, 2008), probably due to the limited intake of grass by finishing pigs during the winter season, as in the present study. Differences in SM quality traits and lipid composition between treatments agree with the results obtained on the *Longissimus* muscle of these pigs (Lebret *et al.,* 2011b).

Sensory analysis highlighted strong influences of breed and production system on appearance, odor, texture and flavor of dry-cured hams (Fig. 1). B hams exhibited higher fat thickness, marbling, red color intensity and oily aspect than LW hams. In particular BE hams were judged more red and oily in agreement with their lower L* and h° values and higher PUFA (low melting point) level. The veining defect that impairs product appearance was less frequent in B hams which also exhibited slightly lower odor intensity than LW hams. B hams were judged tender, easier to cut and less dry than LW hams, which exhibited slightly higher global flavor, and salty and acid tastes. However, texture and taste were not affected by production system.

4 CONCLUSION

The quality of fresh pork and dry-cured hams is determined by both breed and production system. In particular the Basque pigs produced in the extensive system exhibited high technological and eating qualities of fresh and dry-cured hams, thus demonstrating interactive effect of the genotype and environment in the development of pork quality and specific products. These data will be helpful to local pork chains to ascertain their products characteristics and support their involvement in Protected Denomination of Origin labeling approaches.

5 ACKNOWLEDGEMENTS

Authors thank INRA and A Bio C staff for excellent assistance, and gratefully acknowledge the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities for the Integrated Project Q-PORKCHAINS FOOD-CT-2007- 036245.

6 REFERENCES

Alfonso L., Mourot J., Insausti K., Mendizabal J.A., Arana A. 2005. Comparative description of growth, fat deposition, carcass and meat quality characteristics of Basque and Large White pigs. Animal Research, 54: 33–42

Damon M., Denieul K., Vincent A., Bonhomme N., Wyszynska-Koko J., Lebret B. 2013. Associations between muscle gene expression pattern and technological and sensory meat traits highlight new biomarkers for pork quality assessment. Meat Science, in press, doi: 10.1016/j.meatsci.2013.01.016

Guéblez R., Labroue F., Mercat M.J. 2002. Performances de croissance, carcasse et qualité de viande de quatre races locales. Techni-Porc, 25: 5–15

Laval G., Iannuccelli N., Legault C., Milan D., Groenen M.A.M., Giuffra E., Andersson L., Nissen P.H., Jargensen C.B., Beeckmann P., Geldermann H., Foulley J.L., Chevalet C., Ollivier L. 2000. Genetic diversity of eleven European pig breeds. Genetics Selection Evolution, 32: 187–203

Lebret B. 2008. Effects of feeding and rearing systems on growth, carcass composition and meat quality in pigs. Animal, 2: 1548–1558

Lebret B., Prunier A., Bonhomme N., Foury A., Mormède P. Dourmad J.Y. 2011a. Physiological traits and meat quality of pigs as affected by genotype and housing system. Meat Science: 88 14–22

Lebret B., Damon M., Gondret F., Lefaucheur L., Louveau I., Prunier A., Bonhomme N., Ecolan P., Wyszynska-Koko J., Lepetit J., Méteau K., Barthélémy S., Pollet P.Y., Dourmad J.Y. 2011b. Variation de la qualité de la viande de porc selon la race: Basque ou Large White et le système d'élevage: conventionnel, alternatif ou extensif. Journées de la Recherche Porcine, 43: 39–46