Characteristic of slaughter value and meat quality of three synthetic pig lines

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Abstract

The aim of the study was to evaluate the quality of meat in different lines of pigs with consideration of the intramuscular fat level of the *longissimus* muscle. The research was conducted on 60 pigs from three pig lines, P76, Redone and Galia, (20 gilts in each group), slaughtered at *ca*. 105 kg live weight. The percentage meat in the carcass and hot carcass weight were estimated. Samples were taken from the *longissimus* muscle. The pH value after 1, 3 and 24 h *post mortem*, natural drip loss, cooking yield and parameters of meat colour were measured. Furthermore, fat level and glycolytic potential (GP) of the muscle were determined. Intramuscular fat level was determined chemically, and marbling on the basis of sensory evaluation according to a Japanese photographic standard. The results showed significant differences between lines in slaughter value of carcasses and for pH_3, pH_{24}, GP, colour parameters and marbling of raw meat. The P76 line was characterised as the most meaty line with satisfactory meat quality. The Redone line was characterised by meat with the highest intramuscular fat content and marbling.

Keywords: Meat quality, intramuscular fat, P76, Redone, Galia, swine
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Introduction

In Europe pork is very important because of the high level of human consumption. Changes in the pork industry are taking place all over the world. Intensive production systems and increased meat production could cause a decrease in sensory and technological (suitability for meat processing) pork quality through the practice of crossbreeding of breeds with a high lean meat content. Average consumer's satisfaction is based on visual impression while purchasing the product (appearance of the product) and then on its sensory quality and culinary usefulness. Research carried out in recent years emphasized that for consumers the sensory quality of culinary meat, which is determined mainly by level of intramuscular fat (IMF) and other traits such as drip loss and the pH of the meat, is very important. The level of intramuscular fat is dependent on breed, portion of meat in the carcass, slaughter weight and nutrition of the animal during the growing period (De Vries *et al.*, 2000; Rosenvold & Andersen, 2003). Recent studies highlighted the link between these properties and the level of IMF in meat and marbling. These two traits vary according to breed and environmental conditions. Fat content in muscle tissue influences meat quality significantly, particularly tenderness, juiciness and flavour of meat, and drip loss. Recent studies on crosses between Naïma sows and P76 boars suggested the existence of an intramuscular fat gene in animals where high levels and a high degree of variability of intramuscular fat were observed (Jaworska *et al.*, 2006; Przybylski *et al*., 2007). The Naïma line is obtained from the crossbreeding of two lines - the Redone (from Tiameslan*)* and the Galia lines. The Tiameslan line was created by the PenArLan breeding company in collaboration with INRA, by crossbreeding Chinese x European breeds (Zhang *et al*., 2000).

However, the mechanism of accumulation of fat in muscle tissue is still not fully understood (Roehe *et al*., 2003). Recently a study by Lian *et al*. (2007) suggested that a combination of hormones (insulin, somatotropin, epinephrine and glucagon) could increase the IMF content by increasing the fatty acid synthetase (FAS) mRNA expression. The research by Jaworska *et al*. (2006) and Przybylski *et al*. (2007), crossing Naïma sows with P76 boars, suggested the possible existence of an intramuscular fat gene in these pigs, since a high degree of variability in intramuscular fat content was observed, which was characterised by a bimodal distribution. A strong relationship was also observed between marbling and drip loss with

tenderness of cooked meat. The aim of the present study was to evaluate the quality of meat in three genetic lines of pigs, the P76, Redone and Galia lines.

Materials and Methods

An experiment was carried out on 60 fattened pigs from three pigs line, the P76, Redone and Galia lines, with 20 gilts from each line. The pigs were slaughtered at about 105 kg live weight. The pigs were produced and reared under the same conditions and were fed a standard diet: A complete mixed diet consisting of cereal with additives – mineral and vitamins. In the first period (25 - 65 kg body weight) the pigs received the following diet: 13,7 MJ ME, 169.1 g crude protein and 10.41 g lysine/kg. In the second period (65 - 105 kg) the finisher diet contained 13.58 MJ ME, 155.6 g crude protein and 9.42 g lysine/kg. The animals were slaughtered in accordance with legally binding procedures (the distance from the farm to the slaughterhouse was 200 km, a rest period of about 2 h, automatic electric stunning and exsanguinations in a horizontal position).

After slaughter, backfat thickness and *longissimus* thickness were measured on a carcass at the height of the last rib *ca*. 7 cm from carcass mid-line, using a CGM apparatus (Sydel Corporation, France) (directly on the line or in the meat plant laboratory). On the basis of this measurement meat percentage in a carcass was estimated according to the equation of Borzuta (1998). Meat quality parameters were evaluated (directly on the line or in the meat plant laboratory) in samples of the *longissimus* muscle taken behind the last rib: The pH value was measured with a WTW-330i pH-meter at 1, 3 and 24 h after slaughter; meat colour was measured using the CIE L*a*b* system (L – lightness, a – reference to the red, b – saturation towards the yellow colour) with CR310 Minolta equipment at 48 h *post mortem*; natural drip loss (DL) was determined 48 h after slaughter according to the method described by Prange *et al*. (1977).

Cooking yield of meat was determined on 500 g meat samples. The cooking process was conducted to reach 72 °C inside the meat. The cooking yield was the weight of the cooked meat sample as a percentage of the raw sample. The fat in the muscle was determined according to the Polish- ISO Standard by means of the Soxhlet's method (PN-ISO 1444:2000). Glycogen, glucose and glucose-6-phosphate after glycogen hydrolysis with amyloglucosidase (Dalrymple & Hamm, 1973) and lactate (Bergmeyer, 1974) in the muscle were also determined. Based on these analyses, the glycolytic potential (GP) was calculated according to Monin & Sellier (1985).

Sensory evaluation of marbling (96 h after slaughter) was determined on raw meat using the sensory scaling methods (PN-ISO 4121: 1988); [scale 0 - 10 c.u. – conventional unit]. Additionally, the Japanese-Carcass-Grading-Standards (www.blackmorewagyu.com) were applied. For visual assessment raw pork chops were placed on white, disposable polystyrene foam trays. Trays with meat were covered with a polyethylene film, as displayed in supermarkets. Samples were put in a daylight room and analyzed at random.

The statistical analysis of variance was performed using Statistica 6.0 software (StatSoft, Inc., 2001).

Results and Discussion

The obtained results indicated that line P76 could be characterised by significantly higher ($P \leq 0.05$) meatiness as well as loin thickness in comparison to the Redone and Galia lines. These results confirm that P76 is a good line for crossbreeding with its high meatiness and good meat quality. It was confirmed in the study of Krzęcio *et al*. (2003) that in crossbreeding P76 boars with Polish Landrace sows the meatiness is similar to results from crossbreeding of Pietrain and Duroc boars with Polish Landrace (about 57%) sows. In the examined P76 fatteners, neither PSE (pale, soft, exudative) nor acid meat was found. Similar observations were found by Jaworska *et al.* (2006) for fatteners originated from the crossbreeding of P76 boars with Naïma sows. It was probably a result of the elimination of a stress sensitivity gene and a RN gene from PenArLan herds. Meat from Redone and Galia lines were characterised by a lower pH_3 and higher marbling (Table 1). Line Galia was characterised by the highest ($P < 0.05$) GP and the lowest pH_{24} while the Redone line was characterised by the lowest ($P < 0.05$) PG and the highest pH_{24} as well as the highest marbling. The Redone line also had the highest level of IMF and the lowest drip loss, though differences between lines were not statistically significant. Similar results on intramuscular fat were obtained on crossing Naïma sows with P76 boars (Przybylski *et al*., 2007).

The results obtained in this work (Table. 1) indicated that the Redone line was characterised by higher ($P < 0.05$) marbling than the Galia and P76 lines. High variability of the studied meat samples resulted in no significant difference in the level of IMF between lines (high variability in meat samples was mainly observed in the P76 and Redone lines). These differences in IMF level resulted in great variability between results from individuals (Figure 1a). In the case of the P76 line the vast majority of results were below 2%. As was showed in a study by Przybylski *et al*. (2007) such a low level of IMF is invisible during sensory analysis (Figure 1b, 1c). Using the sensory analysis as well as the Japanese standard revealed that marbling in the P76 line was significantly lower ($P < 0.05$) than in the other lines. The Redone line was characterised by a higher mean and greater variability for IMF (Figure 1a) and this caused in higher level of marbling (Figure 1b, 1c). High variability in IMF level in the Redone and Galia lines resulted in the high variability in marbling. However, significant ($P < 0.05$) differences in marbling of the tested meat samples were obtained. It was observed also that the Japanese standard enabled a more precise discrimination of marbling in the cases of the Redone and Galia lines.

Table 1 Characteristic of slaughter value and meat quality in different genetic pig lines

Traits	Genetic line			s.e.m.
	P76	Redone	Galia	
Hot carcass weight (kg)	86.1	85.1	87.5	0.99
Meatiness (%)	59.8[a]	57.2[b]	55.3[c]	0.32
Loin thickness (mm)	65.3[a]	57.6[b]	52.4[c]	0.86
Backfat thickness (mm)	12.7	13.5	14.4	0.31
pH_1	6.38	6.43	6.42	0.03
pH_3	6.31[a]	6.12[b]	6.18[b]	0.02
pH_{24}	5.60[a]	5.66[a]	5.51[b]	0.01
Glycolytic potential of *longissimus* muscle (µmol/g)	126.8[a]	109.9[b]	134.4[a]	2.44
Intramuscular fat level (%)	1.67	2.27	1.89	0.16
Cooking yield (%)	72.2	72.8	71.8	0.41
Drip loss (%)	3.61	2.45	3.75	0.25
Colour L	55.67[a]	53.95[b]	54.04[b]	0.26
a	15.99[a]	15.58[a]	17.19[b]	0.13
b	9.33[a]	5.49[b]	5.97[b]	0.23
Marbling of raw meat (0 - 10 c.u.)	2.70[a]	4.28[b]	3.83[b]	0.15
Marbling evaluated according to Japanese standard (points)	1.25[a]	2.24[b]	1.48[a]	0.07

[a], [b], [c] – means within rows with different superscripts are significantly different at $P < 0.05$.
pH_1, pH_3, pH_{24} – pH measured at 1, 3 and 24 h after slaughter.

These results regarding high variability in level of IMF and marbling related to meat quality traits in the Redone line, could indicate that the genetic predisposition of these traits in this line originated from the Tiameslan line that was developed from crossbreeding between Chinese Meishan and European lines. Our results are consistent with the study of Janss *et al*. (1997), who established a hypothesis about the existence of a main gene (in Meishan crossbreeding pigs) that affects the intramuscular fat content, and thus tenderness of meat and reduced drip loss. Similarly, Sellier (1998) suggested the existence of this gene in the Duroc breed. Sanchez *et al*. (2003) showed that a major gene had an influence on meat quality in the Tiameslan line. Gerbens *et al*. (1998) showed significant associations between genetic variation of the adipocyte (A-FABP) and heart (H-FABP) fatty acid-binding protein gene loci and intramuscular fat content in purebred Duroc pigs. Koćwin-Podsiadła *et al*. (2005), in research conducted on pig populations containing 25% and 50% Duroc genes, showed a relationship between polymorphism of the H-FABP gene (identified by endonclease HaeIII) and IMF in the *longissimus* muscle. Árnyasi *et al*. (2006) showed an association between the FABP3 gene and IMF in pigs, and in their studied, polymorphism of this gene explained 30 - 35% of the variation in IMF. Nechtelberger *et al*. (2001) did not confirm these results when studying the Large White, Landrace and Pietrain breeds. The results of Li *et al*. (2006) indicated that the Meishan is

characterised by only one allele for this gene. The mentioned results indicate that in case of the Meishan breed there is a possibility of the existence of another gene that could influence IMF.

It has been noticed that a higher level of IMF and marbling were related to a lower level of GP. In our study significant negative correlations between GP and intramuscular fat were found (r = –0.44*; P <0.05). Przybylski *et al*. (2009) also obtained a similar relationship between IMF and GP (r = –0.35*; P <0.05). In the studies of Larzul *et al*. (1998) genetic correlations between GP and carcass slaughter values were observed. The relationship indicated that meatiness was positively correlated with the level of glycogen in the muscle. This indicates that selection aimed at improving meatiness could lead to an increase in the level of glycogen in the muscles. In other studies (Larzul *et al*., 1995) on selected pigs, a significant decrease in the muscular GP was observed after four generations. In this experiment the indirect relationship on the backfat thickness was also observed. The calculated correlation between these traits was r = –0.60. This effect could be confirmed by decreasing of intramuscular fat which has been observed in recent years. The higher level of drip loss in meat could be related to a higher level of GP in muscle.

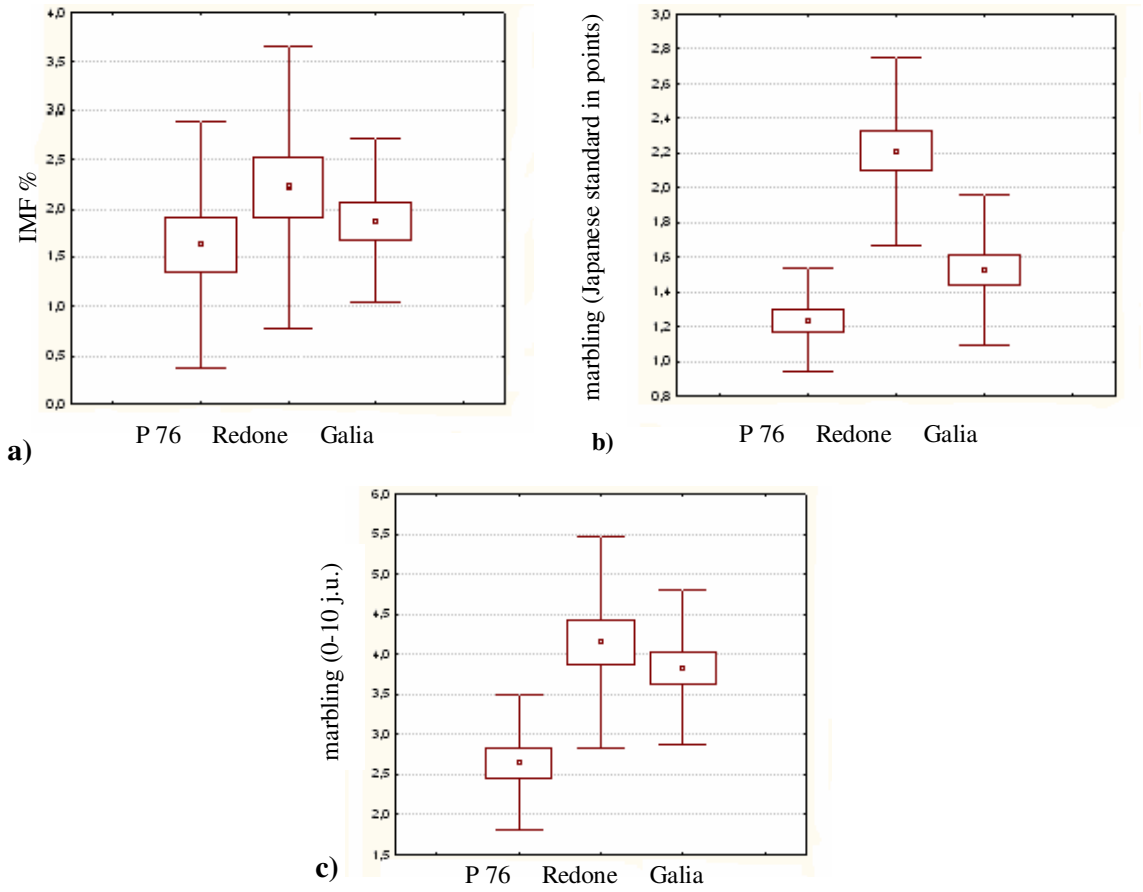

Figure 1a, b, c Distribution of intramuscular fat (IMF) (evaluated by Soxhlet method) and marbling (according to sensory scaling method and Japanese-Carcass-Grading-Standards) in a studied on genetic pig lines.

The colour of meat from the Redone line was darker (lower value of parameter L*) and the meat exhibited a lower GP and higher pH_{24}. Darker meat is often found in muscle with limited glycolysis (Swatland, 2004). In case of the Redone line the parameter a* (redness) was similar to that in the P76 line. The parameter b* (yellowness) was similar to that in the Galia line.

Conclusion

The results showed significant differences between groups in slaughter value of the carcass and in pH_3, pH_{24}, GP, colour parameters and marbling of raw meat. The P76 line was characterised as the line with most meatiness while the Redone line was displayed higher marbling and ultimate pH as well as lower GP and drip loss. The obtained results on the meat quality of the studied lines could be due to differences in the level of marbling and GP since a significant negative relationship between IMF and GP was observed in this study. These results indicate the possible existence of a major gene that influences meat quality in the Redone line that contains genes of Chinese breeds.

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