PORK QUALITY AS RELATED TO HALOTHANE GENOTYPE AND SLAUGHTER CONDITIONS IN A BELGIAN STUDY

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Background

Pork quality is dependent on various genetic and environmental factors from whose halothane genotype and pre-slaughter factors such as fasting time, transport, abattoir lairage are recognized of great importance for final meat quality. However, most of our present knowledge is based on studies investigating the influence of a single or at the most two factors (Rosenvold and Andersen, 2003). It is therefore necessary to understand how different production or slaughter factors influence pork quality in actual practical conditions. This approach could subsequently be used in the control of the quality of pork products.

Objectives

The objectives of this study were to evaluate technological and organoleptic properties of pork meat representative of different Belgian production systems and to determine the contribution of significant factors to meat quality variability, in particular the halothane genotype, fasting time, lairage time and slaughtering plant.

Materials and methods

A total of 521 pigs were used in five Belgian commercial slaughtering plants over a 1 ½ year period. 79% of pigs belonged to four different quality production systems. The remaining 21% were randomly sampled in standard production. In the slaughterline, pH_1 and electrical conductivity (PQM_1) were measured 45 minutes *post mortem* in the *longissimus dorsi* muscle at the level of the two last thoracic vertebrae. The weight of 'white offals' (entire intestinal tractus) was measured with a hanging electronic scale (Kern HCB 20K50). Hot carcass weight of all pigs was determined just before chilling. One 2.5 cm thick cut of the *longissimus dorsi* muscle was removed 24 hours *post mortem* in order to measure the ultimate pH (pHu), ultimate electrical conductivity (PQMu), water holding capacity (WHC), color (CIE $L^*a^*b^*$) and tenderness (WBPSF). The pH was measured by using an inserting combined pH electrode (Ingold ref 104063123) on a Knick 913 pH-meter. Electrical conductivity was assessed with a Pork Quality Meter (Intek). The Labscan II device (Hunterlab) was used to objectively measure CIE L^* (brightness) and a^* and b^* (color) parameters. The water holding capacity was estimated as drip loss and cooking loss. Drip loss was assessed as the percentage weight loss after 4 days storage in a plastic bag at 2°C ; cooking loss was measured as the percentage weight loss after cooking in an open plastic bag in a waterbath during 50 min at 75°C. Warner-Bratzler Peak Shear Force (WBPSF) was determined with a Lloyd LR5K universal testing machine perpendicular to the muscle fibre direction on ten 1.25 cm diameter cores obtained from heated cuts. Lairage time, calculated from the time between animals arrival at the abattoir and stunning was divided into five intervals (≤ 1, 1-2, 2-3, 3-4, >4 hours). In order to assess the fasting time, the weight of white offals was expressed as a percentage of hot carcass weight. The slaughtering plants differ in several aspects : slaughterline speed, the mean number of pigs slaughtered per week, handling treatment, stunning systems. Halothane genotype was determined with a DNA test using a polymerase chain reaction technique according to the method described by Nakajima *et al.* (1996). The data were analyzed using Statistical Analysis System (SAS Institute inc., Cary, NC, USA, 1999). Several models were adjusted to the data using General Linear Models (GLM) SAS procedure to estimate the influence of halothane genotypes -homozygote negative stress (CC), heterozygote negative stress (CT) and homozygote positive stress (TT)-, lairage time (≤ 1, 1-2, 2-3, 3-4, >4 hours) and slaughterhouses (1, 2, 3, 4, 5) on the variability of pH_1, PQM_1, pHu, PQMu, drip loss, cooking loss, CIE $L^*a^*b^*$ and WBPSF. The relative weight of white offals on hot carcass was included in the models as covariate. Least Squares Means (LSM) were computed for significant effect in the models and compared pairwise by the Student's t-test.

Results and discussion

Table 1 shows the average results for the total population. A large variation for the results of pH_1, drip loss and brightness was observed, indicating the presence of pale, soft, exudative (PSE) meat. Missing data for some parameters reduce the number of samples introduced in statistical models.

The proportion of variance explained by the GLM models (R^2) and the significance level of the effects in the models are summarized in Table 2. For all parameters -except for the pHu, cooking loss and the WBPSF- a moderate to great part of variation was explained by the model (R^2 = 0.22-0.56). Similar determination coefficients (R^2 = 0.04-0.59) were reported by Casteels *et al.* (1995) when they studied the influence of halothane genotypes, stunning method and slaughter weight on the variability of meat quality using GLM models. The halothane genotype effect was highly significant ($p<0.001$) on most meat quality traits : pH_1, PQM_1, PQMu and color parameters (CIE $L^*a^*b^*$) but not significant on pHu and cooking loss. The lairage time had a highly significant influence on PQMu, CIE b^*, drip loss but for the other parameters it had negligible or no influence. There was a highly significant effect of the slaughtering plant on pH_1, PQM_1, PQMu and color parameters (CIE $L^*a^*b^*$) and a significant influence ($p<0.01$) on the variability of drip loss and cooking loss. By contrast, the fasting time had no effect on most meat quality properties except on drip ($p<0.01$) and cooking loss ($p<0.001$). These results are in accordance with those of De Smet *et al.* (1996) whose found no effect of feed withdrawal on most meat quality traits. As indicated by the regression coefficient, an increase of offals/hot carcass weight seems to be related to an increase of drip or cooking loss.

The halothane genotype Least Squares Means and their standard errors (SE) for all parameters are listed in Table 3. Meat quality was negatively affected by the presence of the halothane gene. Drip loss differed significantly between genotypes with the TT pigs having the highest drip loss (6.8%) while that of the CC (5.5%) was the lowest and that of CT intermediate (6.1%). Cooking loss was also significantly higher in TT pigs indicating lower water holding capacity. Significant differences between CC and TT genotypes ($P< 0.05$) were observed in terms of pH_1 (6.12 *vs* 5.69), PQM_1 (4.9 *vs* 6.4) and PQMu (9.7 *vs* 12.7). The CIE L^* and b^* values (56.9% and 16.6) were significantly higher in homozygous stress positive animals (TT) comparatively to CC (55.0% and 15.8) or CT pigs (54.6% and 15.4). The higher L^* value of the TT genotypes indicated paler meat. The WBPSF was the lowest for CT pigs with no significant difference observed between the CC and TT genotypes.

The abattoir Least Squares Means and their standard errors for all parameters are listed in Table 4. The slaughterhouse 1 had lower pH_1, pHu, higher PQM_1 and CIE L^* values compared with slaughterhouses 2, 3 ,4 and 5. Cooking loss, drip loss and PQMu means were the highest for the meat originating from slaughterhouse 5. Although it would be necessary to determine the reasons for abattoirs differences, the small and old structure of the abattoir 1 with no training of the staff could partially explain the results.

Conclusions

From these results, it can be concluded that the halothane genotype is the most important factor determining organoleptic and technological properties of pork meat. A significant proportion of TT stress-susceptible pigs which can develop PSE meat was found in this Belgian study. Additional efforts to reduce halothane gene in pig population have to be realized to improve meat quality. Slaughterhouse and lairage time are significant factors influencing quality attributes of pork. The influence of the fasting time (assessed by offals/hot carcass weight) was low except on drip and cooking loss.

Further research is needed to evaluate the interaction terms slaughterhouse x genotype and lairage time x genotype and to identify slaughtering factors which could explain slaughterhouse differences in terms of meat quality.

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This work is part of a project supported by the Direction Générale de l'Agriculture, Direction de la Qualité des Produits, Région Wallonne, Belgium.

Table 1. Number, mean, standard deviation, minimum and maximum of the measured parameters

Parameter	Number	Mean	Standard Deviation	Minimum	Maximum
pH_1	497	6.00	0.35	5.30	6.85
pHu	403	5.40	0.10	5.10	5.95
PQM_1 (mS/cm)	418	5.1	2.4	2.8	22.4
PQMu (mS/cm)	372	10.9	3.4	2.8	19.2
CIE L∗(%)	512	54.6	4.4	41.6	66.4
CIE a∗	512	6.3	2.0	0.9	12.4
CIE b∗	512	15.5	1.8	10.5	20.1
Drip loss (%)	396	6.5	2.0	1.2	11.4
Cooking loss (%)	490	30.2	2.5	20.2	39.2
WBPSF (N)	490	37.5	7.8	21.0	71.7

Table 2 : Proportion of variation explained by the GLM models (R^2), the significance level (Pr > F) of the influencing factors and the regression variable of the 'white offals'/hot carcass weight on the parameter in the case of significance.

Parameter	R^2	Genotype Pr > F	Lairage time Pr > F	Slaughterhouse Pr > F	Offals / hot carcass weight	
					Pr > F	Regres./%
pH_1	0.56	0.0001^{***}	0.0272^{*}	0.0001^{***}	0.3822	-
pHu	0.16	0.2117	0.1164	0.0489^{*}	0.1648	-
PQM_1	0.34	0.0001^{***}	0.8760	0.0001^{***}	0.6925	-
PQMu	0.33	0.0001^{***}	0.0001^{***}	0.0001^{***}	0.5816	-
CIE L∗(%)	0.46	0.0001^{***}	0.0111^{*}	0.0001^{***}	0.1384	-
CIE a∗	0.26	0.0001^{***}	0.0138^{*}	0.0001^{***}	0.7278	-
CIE b∗	0.35	0.0001^{***}	0.0001^{***}	0.0001^{***}	0.7448	-
Drip loss (%)	0.22	0.0224^{*}	0.0001^{***}	0.0080^{**}	0.0016^{**}	0.27
Cooking loss (%)	0.17	0.0519	0.0132^{*}	0.0017^{**}	0.0004^{***}	0.33
WBPSF (N)	0.11	0.0012^{**}	0.4696	0.2406	0.2047	-

Table 3 : Halothane genotype least squares means ± SE of meat quality traits

Parameter	CC			CT			TT		
	Number	Means	SE	Number	Means	SE	Number	Means	SE
pH_1	57	6.12b	0.04	210	6.03b	0.02	87	5.69a	0.03
pHu	52	5.44a	0.02	190	5.42a	0.01	49	5.43a	0.02
PQM_1 (mS/cm)	50	4.9a	0.3	185	4.5a	0.2	70	6.4b	0.3
PQMu (mS/cm)	50	9.7a	0.6	175	12.5b	0.4	47	12.7b	0.6
CIE L∗(%)	59	55.0a	0.5	214	54.6a	0.3	87	56.9b	0.5
CIE a∗	59	6.4b	0.3	214	5.6a	0.2	87	6.9b	0.2
CIE b∗	59	15.8a	0.2	214	15.4a	0.1	87	16.6b	0.2
Drip loss (%)	52	5.5a	0.4	173	6.1ab	0.3	49	6.8b	0.4
Cooking loss (%)	59	30.5ab	0.4	205	30.2a	0.2	74	31.1b	0.3
WBPSF (N)	59	38.6b	1.3	205	35.8a	0.8	74	40.3b	1.1

Results followed by the same letter are not significantly different ($p<0.05$)

Table 4 : Slaughterhouse least squares means ± SE of meat quality traits

Parameter	Slaughterhouse 1			Slaughterhouse 2			Slaughterhouse 3			Slaughterhouse 4			Slaughterhouse 5		
	n	Means	SE	n	Means	SE	n	Means	SE	n	Means	SE	n	Means	SE
pH_1	78	5.71a	0.04	153	6.11c	0.03	71	6.13c	0.04	27	5.90b	0.05	25	5.90abc	0.11
pHu	79	5.41a	0.02	155	5.46b	0.02	-	-	-	27	5.41a	0.02	30	5.44ab	0.05
PQM_1 (mS/cm)	55	7.3b	0.4	137	5.1a	0.3	57	4.5a	0.3	27	4.7a	0.4	29	4.7a	0.8
PQMu (mS/cm)	73	9.4a	0.6	142	8.2a	0.5	-	-	-	27	13.5b	0.6	30	15.5b	1.4
CIE L∗(%)	79	59.3c	0.6	153	53.0a	0.5	71	52.8a	0.5	27	55.9b	0.7	30	56.3abc	1.5
CIE a∗	79	7.0c	0.3	153	5.9b	0.2	71	5.8b	0.3	27	4.7a	0.4	30	8.1c	0.8
CIE b∗	79	16.2b	0.3	153	14.7a	0.2	71	15.1a	0.2	27	15.0a	0.3	30	18.7c	0.7
Drip loss (%)	79	5.4a	0.4	138	5.0a	0.3	-	-	-	27	5.8a	0.4	30	8.4b	0.9
Cooking loss (%)	79	30.0b	0.4	155	29.1a	0.3	47	30.0b	0.4	27	30.8b	0.5	30	33.1c	0.1
WBPSF (N)	79	37.2ab	1.4	155	35.9a	1.1	47	37.7ab	1.4	27	40.2b	1.6	30	40.0ab	3.6

Results followed by the same letter are not significantly different ($p<0.05$)