The relationship between colour and other meat quality traits in Czech Large White pigs

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Abstract

The aim of this study was to compare the meat quality of pork meat from Czech Large White pigs divided into the different quality classes. The research was performed on chosen meat material selected from 144 pigs divided into RFN (n=74), PSE (n=66) and DFD (n=4). The focus was to study pH, electrical conductivity and drip loss in relation to colour measurements (CIELAB). PSE meat was characterised by low pH_{ult} (5.45), high electrical conductivity (10.77 mS.cm^{-1}) and high drip loss (4.13%), RFN meat statistically differed with a pH of 5.53, EC of 8.44 and drip loss of 2.87%. Lighter meat had a tendency towards PSE. Mean values of pH and conductivity were in close correlation with drip loss (r = -0.29 and r = 0.38, resp.) and lightness L* (r = -0.64 and 0.47, resp.), and also between L* and drip loss (r = 0.57). The study shows the importance of measurement for whole meat quality determination of pH, EC and drip loss, with the addition of colour, are the basis of laboratory parameters and analysis. Lightness L* was near correlated (r = 0.67) with yellowness (b*), while redness a* did not play such a significant role.

Carcass, lightness, CIELAB, overall acceptability, pork, conductivity, post mortal changes

Introduction

Pork represents more than 50% of the total amount of meat consumed in the Czech Republic, and half of this meat is sold as fresh meat for culinary purposes. It is necessary to ensure high sensory quality to meet consumers' expectations of a high-quality product. Meat quality is often described by measurements of the *m. longissimus thracis et lumborum* as template muscle, which is best suited as a reference for meat quality assessment, to eliminate unacceptable meat (Van Oeckel and Warnants 2002). One of the most important quality deviations of meat is a PSE (pale, soft and exudative) defect (Barbut et al. 2008). From a sensory point of view, PSE meat is characterised by lower colour intensity and higher lightness and drip loss in the context of lower pH values (Zelechowska et al. 2012). Higher electrical conductivity and drip loss are highly correlated with one another and with pork colour (Joo et al. 1999). Poor water binding capacity is a principal sign of PSE meat and, along with marbling, is one of the main reasons for its poor consumer acceptance (Font-i-Furnols et al. 2012). Dark, firm and dry pork (DFD) occurs very rarely and depends mainly on transport and an unsuitable degree of animal handling. There are huge visual differences in sensory quality when we compare DFD with RFN (the most common abbreviation), meat with no defects (red, firm, non-exudative). The unsuitability of DFD meat lies mainly in food safety and short storage, while the unsuitability of PSE consists of weight losses and, therefore, in economic problems. However, panellists in the case study (Nam et al. 2009) did not consider cooked PSE or DFD pork to be unacceptable overall, indicating that consumers couldn't always distinguish the quality of cooked pork sufficiently. Colour is also an indicator of meat quality (Mancini and Hunt 2005). The determination of changes in pork colour may be an indicator of its quality; most useful method for the evaluation of pork quality is the modified method by Kortz (1966) Karamucki et al. (2011). Some authors have divided pork into many quality classes,

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not merely normal (RFN) and PSE or DFD meat (Fischer et al. 2002). Sometimes is described partially PSE or DFD and acid meat (Przybylski et al. 2012). The importance of pH is undeniable; it is significant to specify a time measurement. Most scientists use measurement values early *post mortem*, others describe the importance of ultimate values, mainly for meat processes (Van der Perre et al. 2010).

Materials and Methods

Test material

The experimental material for this study was 144 samples of the *m. longissimus thracis et lumborum* of the Czech Large White (sire line), randomly selected purebred sows. All animals came from the same farm and were transported to the slaughterhouse under the same transport conditions. The pigs were kept in the same conditions and fed the same diet, and were slaughtered over a period of 3 months (5 sampling dates) in 2011. The carcasses were processed at slaughter and samples were transported after dissection the next day in ice-chilled polystyrene refrigerators at 4 °C. For general purposes and evaluation, cold carcass weight (kg) and carcass quality class (SEUROP) at slaughter were measured using a two-point scale method, and the lean meat and back fat thickness (mm) were recorded under the conditions of Council Regulation (EC) No. 1234/2007.

Decision criteria for meat classification

Based on the pH (pH_{ult}), electrical conductivity (EC_{ult}), colour lightness (L*) and red and yellow characteristics (a* and b*, resp.) in the CIELAB system, the meat was classified in the laboratory as RFN (reddish, firm, non-exudative – normal), PSE (pale, soft, exudative – defected) or DFD (dark, firm, dry – defected). From wide number were chosen 144 samples of pork, namely RFN (n=74) and PSE (n=66), and small numbers (n=4) to DFD.

Table 1. Decision criteria for meat quality classification (Matousek et al. 1997; Pospiech 2000; Szulc et al. 2012)

Meat quality (category)	pH_{ult}	EC_{ult} ($mS.cm^{-1}$)	L*	Drip loss (%)
RFN	≥ 5.5	< 10	45 – 60	1.00 – 3.00
PSE	< 5.5	≥ 10	> 60	
DFD	≥ 6.2	-	< 45	

Physical and chemical meat characteristics

Both the pH_{ult} and EC_{ult} of the meat 24 hours *post mortem* were measured in the laboratory after transport from the slaughterhouse and storage in an icebox and refrigerator (4–8 °C).

The pH was measured using a pH meter with a glass-calomel electrode and an automatic temperature compensation probe (Portamess 911 Ph, Knick, Netherlands) by inserting the electrode into the meat. The pH meter was calibrated using pH 7 and pH 4 buffers. Each measurement was performed in three places, taking the mean value as the final result. Electrical conductivity was measured by a conductometer (Fleischtester LF 191/F, Weilheim, Germany) after calibration provided with the special device and in accordance with the instructions of the manufacturer. Two values from each sample were measured and the mean calculated.

The water holding capacity was determined by drip loss (4 °C, 48 hours; Honikel 1998).

Colour evaluation of raw pork meat

The colour values of raw pork were determined using the CIELAB system and L*, a*, b* values with the use of a Minolta CM-3500d spectrophotometer (Konica Minolta, Osaka, Japan) with light source D65, observer 8°, specular component excluded (SCE), head hole 8 mm and calibration to white and black before measurement. The meat was prepared in 20-mm slices and colour was measured two times in three places on each sample and the mean calculated. CIE L* (lightness), a* (redness/greenness position data), b* (yellowness/blueness position data) values were recorded. Colour parameters and their differences through the total colour change (ΔE^*_{ab}) were calculated according to the following formulae.

$$\Delta E^*_{ab} = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

Fig. 1. ΔE^*_{ab} formulae (CIE 1976; Karamucki et al. 2011)

Statistical analysis

All values were reported as means (x) and standard deviations (S_d). The meat samples were statistically analysed using Unistat 5.1 software, by performing one-way analyses of variance (ANOVA). The significance of differences between the characteristics, as well as data, weight, fatness, pH, EC and colour, were verified using Turkey's test at a level of significance of $P < 0.05$ and $P < 0.01$, respectively. Relationships between traits were performed by Pearson correlation.

Results and Discussion

The quality of the meat of Czech Large White pigs was determined by its main quality traits such as pH_{ult}, drip loss and lightness L*, and all chosen data was divided according to Table 1 into three main groups. No statistical differences ($P > 0.05$) were found between the date or weight of the slaughter groups. Table 2 represents means and standard deviations of meat quality characteristics from RFN, PSE and DFD meat. Naturally, PSE meat had a significantly lower pH_{ult} and higher electrical conductivity, lightness and drip loss (all at a level of $P > 0.01$), however this special quality group has a higher b* value. Complete data describing differences between normal (RFN) and defected meat is given in Table 2 and corresponds with generally known results (Joo et al. 1999; Rosenvold and Andersen 2007; Fisher 2007; Ruusunen et al. 2012). Meat and back fat thickness did not differ between groups (RFN, PSE). The meat was leaner than comparable (breed, weight, lairage) meat commonly distributed from slaughterhouses 15 years ago (Matousek et al 1997).

Table 2. Meat quality characteristics in RFN, PSE and DFD meat

Meat quality category (n)	RFN (n=74)	PSE (n=66)	DFD (n=4)	P
pH_{ult}	5.53 ± 0.13^{b}	5.45 ± 0.11^{a}	6.31 ± 0.20^{c}	0.01
EC_{ult} ($mS.cm^{-1}$)	8.44 ± 1.85^{a}	10.77 ± 1.95^{b}	7.03 ± 2.56^{a}	0.01
Drip loss (%)	2.87 ± 0.67^{a}	4.13 ± 1.29^{b}	1.61 ± 0.27^{a}	0.01
Colour measurement				
L*	59.36 ± 3.46^{c}	65.17 ± 2.20^{b}	46.28 ± 1.29^{a}	0.01
a*	2.09 ± 1.73	2.03 ± 1.26	1.25 ± 0.80	NS
b*	12.20 ± 1.60^{b}	13.27 ± 1.08^{c}	6.88 ± 0.57^{a}	0.01
Carcass weight (kg)	97.6 ± 11.4	101.8 ± 11.3	95.6 ± 13.6	NS
Meat thickness (mm)	61.4 ± 8.5^{a}	65.3 ± 8.7^{b}	68.73 ± 3.2	0.05
Back fat thickness (mm)	12.3 ± 2.7	13.0 ± 3.1	12.8 ± 4.2	NS

All values were reported as means and standard deviations $\bar{X} \pm SD$

[a, b, c] Means with superscripts show significant differences in the last column (NS for $P \geq 0.05$; $P < 0.05$; $P < 0.01$)

Fischer et al. (2002), for example, divided samples into four groups (red and dry, pale and dry, pale and watery, and red and watery). Various conditions, devices and methods could lead to variations in the data. Fischer et al. (2002) provides $L*_{24} = 53.7$ value for the pale and watery meat. Results and criteria in our study are L* 65.17 ± 2.2 for PSE and 59.36 ± 3.46 for normal meat (RFN), so they are higher. Chmiel et al. (2011) includes samples to the PSE group by L* = 56.00, for RFN L* = 48.44). This shows the considerable range of values that are then presented as qualitative criteria. For the best evaluation meat quality results in the following comparison with other authors it is certainly necessary to take into account intra-vital factors such as genetics, method of feeding, housing and aspects of slaughter.

Mean values of pH and conductivity are in close correlation with drip loss. Meat drip loss of 316 samples in a study by Fischer et al. (2002) varies from 0.57 to 9.32%, with a mean of 3.39%, it shows considerable variability in entire file. In Table 3 the relationship between meat lightness L* and other meat traits is divided into the four groups.

Table 3. Relationship between meat lightness L* and other meat quality characteristics

Group (n) Lightness sorting	1 (n = 13) 55.0 ≤ L*	2 (n = 25) 55.0 < L* ≥ 60.0	3 (n = 69) 60.0 < L* ≥ 65.0	4 (n = 37) L* > 65.0	P
L*	51.07 ± 3.61^{a}	57.24 ± 1.26^{b}	62.53 ± 1.43^{c}	66.74 ± 1.28^{d}	0.01
a*	2.15 ± 2.49	1.40 ± 1.84	2.44 ± 1.09	1.70 ± 1.34	NS
b*	9.74 ± 2.41^{a}	11.22 ± 1.16^{b}	13.20 ± 1.13^{c}	13.21 ± 1.23^{c}	0.01
pH_{ult}	5.84 ± 0.37^{a}	5.55 ± 0.15^{b}	5.48 ± 0.10^{b}	5.44 ± 0.09^{b}	0.01
EC_{ult} ($mS.cm^{-1}$)	7.25 ± 2.48^{a}	8.57 ± 2.26^{b}	9.29 ± 1.77^{b}	11.19 ± 1.88^{c}	0.01
Drip loss (%)	2.38 ± 0.80^{a}	2.86 ± 0.56^{ab}	3.38 ± 1.12^{b}	4.21 ± 1.34^{c}	0.01
Carcass weight (kg)	97.9 ± 12.7	94.5 ± 12.0^{a}	102.0 ± 11.5^{b}	98.6 ± 9.7	0.05
Meat thickness (mm)	63.4 ± 10.8	61.1 ± 7.5	63.7 ± 9.9	64.5 ± 7.1	NS
Back fat thickness (mm)	12.3 ± 4.0	11.6 ± 2.9	13.2 ± 2.7	12.3 ± 2.9	NS

All values were reported as means and standard deviations $\bar{X} \pm SD$

[a, b, c] Means with superscripts show significant differences in the last column (NS for P ≥ 0.05; P < 0.05; P < 0.01)

Statistical differences in b*, pH_{ult}, EC_{ult}, drip loss (P < 0.01) and carcass weight (P < 0.05) are reported.

Table 4 represents correlations between the main meat quality parameters. The negative relationship between pH and EC is well known, we can relate to r = -0.56 (Jukna et al. 2012).

Table 4. Correlations of L*, pH_{ult} and drip loss values with other quality parameters in pork

All data (n=144)	Main meat quality parameters L*	 pH_{ult}	 Drip loss
L*	-	-	-
pH_{ult}	-0.64^{**}	-	-
Drip loss (%)	0.57^{**}	-0.29^{**}	-
a*	0.02	-0.15^{*}	-0.22^{**}
b*	0.67^{**}	-0.56^{**}	0.22^{*}
EC_{ult} ($mS.cm^{-1}$)	0.47^{**}	-0.46^{**}	0.38^{**}
Carcass weight (kg)	0.12	-0.03	-0.01

[*,**] Coefficients with superscripts show levels of significance (* P < 0.05; ** P < 0.01)

Mean values of pH and conductivity were in close correlation with drip loss (r = -0.29 and r = 0.38, resp.) and pH and conductivity with lightness L* (r = -0.64 and 0.47, resp.), and also in comparison with L* and drip loss (r = 0.57). Bidner et al. (2004) reported similar correlations between pH and L* and drip loss (r = -0.57 and -0.68). A small number of samples of DFD meat was detected (n = 4), it was included for complete view on defective meat. Table 3 shows the importance of measurement for complete meat quality determination. pH, EC and drip loss, with the addition of colour, form the basis of laboratory parameters and analysis. In Figure 2 are colour changes ΔE^*_{ab} in comparison to whole data set for RFN (2.3), PSE (3.6) and DFD meat (16.4). Difference between PSE and DFD to RFN is ΔE^*_{ab} 5.9 and 14.2, respectively.

In Figure 3 are colour differences in four groups by lightness in relation to all samples or only RFN group. The widest are second and third groups, in accord with data frequency.

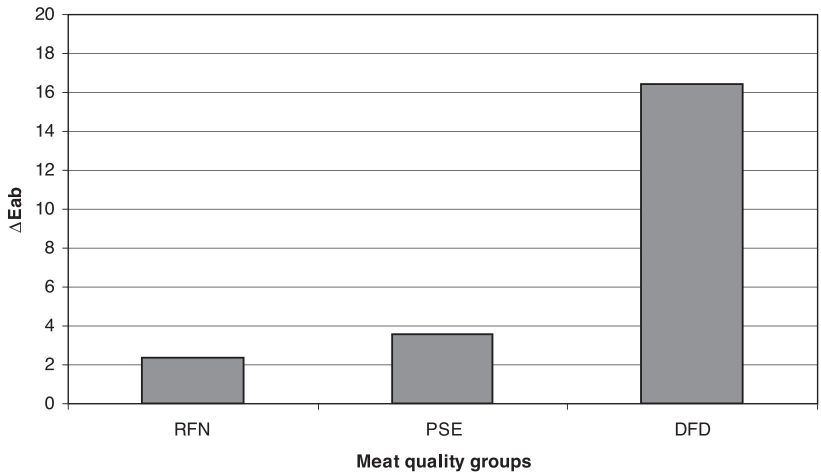

Fig. 2. Colour difference (ΔE^*_{ab}) of meat quality groups in relation to whole data set n=144

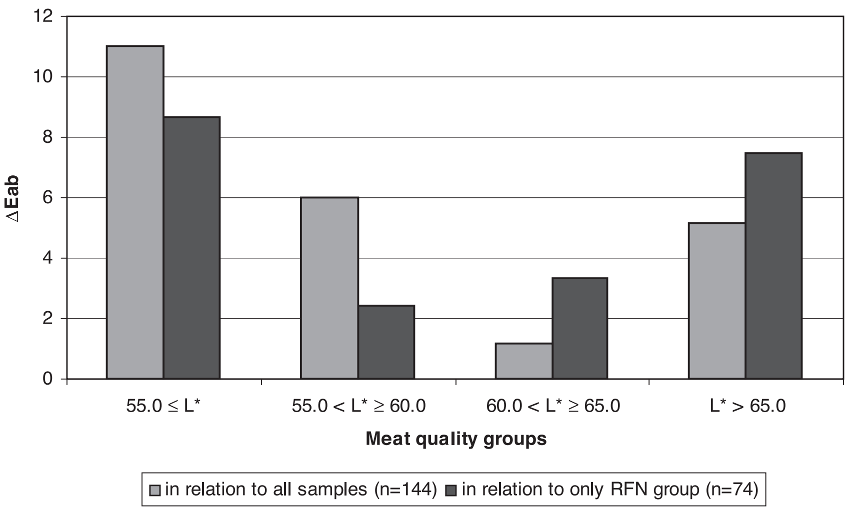

Fig. 3. Colour difference (ΔE^*_{ab}) of meat quality groups by lightness (L*)

Conclusions

This work describes the determination of changes in colour according to meat quality in Czech Large White pigs. PSE meat was characterised by low pH_{ult} (5.45), high electrical conductivity (10.77 $mS.cm^{-1}$) and high drip loss (4.13%), RFN meat statistically differed with values of 5.53 for pH, 8.44 for EC and 2.87% for drip loss. Lighter meat had a tendency towards PSE. Mean values of pH and conductivity and drip loss were in close correlation with lightness L*. The study shows the importance of measurement for complete meat quality determination. pH, EC and drip loss, with the addition of colour, forms the basis of laboratory parameters and analysis. Lightness L* was near correlated (r = 0.67) with yellowness (b*), while redness a* did not play such a significant role.

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