Acta Agraria Kaposváriensis (2002) Vol 6 No 2, 253-258
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Correlation between meat color and some indicators of carcass and meat quality of pigs

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ABSTRACT

In this study, carcasses of 68 pigs from one test station in eastern Croatia were used. At the weight of approximately 100 kg pigs were slaughtered and measurements on the hot carcass were collected: hot carcass weight, carcass length (a and b), meat percentage (TP), and pH_{45}. After 24 hours of cooling other quality indicators were measured: pH_{24}, w.h.c., backfat and loin muscle areas. Pig carcasses weighted 78.79 kg (hot) and after 24 hours of cooling 77.32 kg. Mean values of the carcass length were 89.43 and 104.41 cm ("a" and "b", respectively). The estimated mean leanness of pig carcasses was 54.28%, with backfat thickness of 17.25 mm and loin muscle depth 67.28. Areas of fat and loin muscle were 17.39 and 40.25 mm^2, resp., while fat/meat ratio 0.44. Meat quality indicators showed good quality of the meat in average (pH_{45} was 6.19, pH_{24} 5.71, w.h.c. 9.97, Minolta L 53.04, a* 6.89 and b* 6.24. Medium strong, negative correlation was found between Minolta L* values and carcass length (-0.41 and -0.45, "a" and "b", resp.), and backfat thickness TP (-0.34). Fat/meat surface ratio was negatively weak correlated with L* value (-0.29), while weak positive but significant r value was calculated between L* and MLD surface (0.28). The significant, weak and negative correlation was found between a* value and length "b" (-0.27). Correlations between Minolta values (L* and b*) and meat quality traits were also calculated. Strong, negative correlation was found between L* and pH_{24} values (-0.54). Between Minolta L* and pH_{45} values, the correlation was significant, medium strong and negative (-0.34). Medium strong and positive correlation was found for w.h.c. (0.44). Minolta a* value was negatively correlated with pH_{24} (-0.46) and pH_{45} (-0.33).*
(Keywords: pig, carcass traits, meat quality, color)

INTRODUCTION

The competitiveness of pork industry depends in great deal on the production of lean pigs characterized by high quality of meat. The quality of pork is described in different manners by different participants in production chain, but the most important goal to all of them is to keep the customers satisfied. One of the most important meat quality trait is color, because it is the first to be observed by the consumer. The ideal color of fresh pork is reddish pink. However, under genetic and/or environmental influences, it can turn out to be too pale or too dark. These undesirable conditions are known as PSE (pale, soft, exudative) and DFD (dark, firm, dry) meat. The incidence of poor quality pork can be reduced on the basis of the knowledge about quality traits, their relations and actions needed in order to improve them.

It is well known that the rate and extent of post mortem pH decline are the main determinants of pork quality. On the other hand, color alone does not fully describe the overall quality of meat. Measuring the color is effective only after the carcasses had enough time to cool and develop their final color. Good overview of various measures of pork quality, including color, and interactions between them is given by *Forrest* (2000). *Eikelenboom et al*. (1995) studied the significance of pH_{24} for pork quality (Minolta L* values, drip loss, water uptake, shear force etc.). He found that ultimate pH was the most predictive determinant of pork quality. The same conclusion was given by *Petersen et al*. (1996) who found no correlation between pH_{45} and Minolta L* values. On the other hand, correlation between pH_{24} and L* was significant. *Huff-Lonergan et al.* (2002) found significant correlation between color (Hunter L* values) and drip loss. Different authors found similar relations in other species. *Wulf* and *Wise* (1999), *Page et al.* (2001) in beef, *Owens et al.* (2000) in turkey meat, *Barbut* (1997) and *Fletcher* (1999) in the breast meat of broilers. The objective of this paper is to give an overview of the main carcass and meat quality traits of pigs slaughtered in slaughter houses in east Croatia. Special emphasis is given on the meat color and its correlation with other carcass and meat quality characteristics.

MATERIALS AND METHODS

This study was performed on 68 carcasses of pigs from one test station in eastern Croatia. The pigs were slaughtered at approximately 100 kg live weight in "Sotin" slaughter plant VUPIK, Vukovar. At the slaughter line, the measurements of warm carcass weight, carcass length, fat thickness and muscle depth, muscle and fat surfaces of *m. longissimus dorsi* between 13^{th} and 14^{th} rib and pH_1 values were taken on primarily processed swine carcasses. The length of the carcass was measured from *os pubis* to the 1^{st} rib (a) and from *os pubis* to *atlas* (b). The lean percentage (TP) was calculated on the basis of backfat thickness (mm) measured caudally on the place where *m. gluteus medius* gets the deepest in the subcutaneous fat, and muscle depth (mm) measured as the shortest distance between the cranial end of *m. gluteus medius* and dorsal spinal edge. After 24 hours of cooling, backfat and muscle area (cm^2), pH_2 values, water holding capacity (w.h.c.) and color of *m. longissimus dorsi* were taken. Backfat and muscle areas were measured by geometric procedure (*Comberg,* 1978) using digital planimeter "HAFF 350 E" and expressed as the fat/muscle area ratio; water holding capacity (w.h.c.) was determined using compression method by *Grau and Hamm* (1952); the color of the meat was measured by "Minolta CR-300" device at *m. longissimus dorsi* cut. The measurements of pH_{45} and pH_{24} were carried out by digital pH-meter "Mettler MP 120-B". Statistical analysis was performed using STATISTICA (5.0) for Windows program.

RESULTS AND DISCUSSION

The carcass traits of investigated pigs are presented on *Table 1*. Warm pig carcasses weighted 78.79±5.94 kg; after 24 hours of cooling their weight was 77.32±5.96 kg indicating drip loss of 1.87%. The carcass length was measured in two manners: length "a" was 89.43±2.89 and length "b" was 104.41±3.68 cm. The leanness of pig carcasses was estimated by TP method at the slaughter line and average value was 54.28±4.91%, with backfat thickness of 17.25±5.88 mm and loin muscle depth 67.28±6.58 mm.

Backfat and muscle area were 17.39±4.55 and 40.25±6.92 mm^2; fat/muscle ratio was 0.44.

Table 1

Carcass traits of investigated pigs

Trait	Mean	Min.	Max.	Standard deviation
Warm carcass weight, kg	78.79	66.00	101.50	5.94
Cold carcass weight, kg	77.32	64.00	99.00	5.96
Carcass length "a", cm	89.43	83.00	98.00	2.89
Carcass length "b", cm	104.41	97.00	115.00	3.68
Lean percentage (TP)	54.28	44.38	67.76	4.91
Backfat thickness, mm	17.25	5.00	35.00	5.88
Muscle depth, mm	67.28	55.00	85.00	6.58
Backfat area, cm^2	17.39	7.60	33.60	4.55
Loin muscle area, cm^2	40.25	27.20	63.50	6.92
Fat/muscle ratio	0.44	0.18	0.78	0.13

From the data presented in the *Table 2* it can be seen that meat quality traits of the investigated pigs had in average favorable values. The mean value of pH_{45} which indicate the velocity of postmortal glycolysis was 6.19±0.32, while those of pH_{24} 5.71±0.22. These values were, according to *Hoffman* (1994), within the boundaries of "normal" meat. The rapid fall of pH value 45 minutes post mortem is usually used as the main indicator of PSE meat. Values of pH_{45} higher than 6 are considered to be "normal"; between 5.8 and 6 are said to be suspicious to PSE; and below 5.8 are clearly PSE meat. Ultimate pH value measured after the meat rested 24 hours in cooler can also be used as a predictor of PSE meat. *Forrest* (1998) stated that when pH_{24} is 5.5 or lower, nearly 99%of the pork is PSE, and when this value is above 5.65 there will be almost no PSE meat, although the level of drip loss may be variable; van *Laack* (2000) reported pH_{24} less than 5.7 as the indicator of PSE meat. Also, the ultimate pH value higher than 6.2 is a sign of dark, firm and dries (DFD) meat (*Hoffman,* 1994). Water holding capacity of the investigated pigs was to some extent higher than expected regarding the pH values which were quite satisfactory. Other authors reported similar values of w.h.c. in the meat of pigs with noticeably lower pH_{45} (*Kralik et al*., 1996; *Petričević et al.,* 2000). Mean Minolta L* value indicating the lightness of the meat was 53.04, which suggests a normal color, having in mind that Minolta L* values above 58 are usually considered as PSE (*van Laack*, 2000). *Pettersen et al.* (1996) reported similar L* values (pH values were similar as in present study too) measured in Danish Landrace pigs *anno* 1995. Danish Landrace pigs from the year 1995 had significantly paler color than those from 1975, although the differences between pH values were insignificant. Minolta L*, a* and b* values presented here were similar to those reported by *Oksbjerg et al.* (2001). To some extent lower L* and higher a* values with similar values of b* and pH_{24} reported *Leach et al.* (1996).

Table 2

Meat quality traits of investigated pigs

Trait	Mean	Min.	Max.	Standard deviation
pH_{45}	6.19	5.44	6.97	0.32
pH_{24}	5.71	5.35	6.43	0.23
Water holding capacity	9.97	6.50	12.70	1.36
Minolta L*	53.04	43.98	61.10	3.66
Minolta a*	6.89	1.65	11.83	1.88
Minolta b*	6.24	2.19	10.02	1.70

Medium strong, negative correlation was found between Minolta L* values and carcass length (-0.41 and -0.45, "a" and "b", resp.), and backfat thickness TP (-0.34). The correlation between Minolta L* value and lean percentage was significant, very weak and positive (r=0.29). Minolta a* value, indicating the redness of the meat was negatively correlated to carcass length "b"; the correlation was very weak but significant (r=-0.17). Carcass length "a" and "b" were also correlated with Minolta b* value (r=-0.29 and r=-0.35, respectively). Weak, significant correlation was found between loin muscle area and Minolta L* and b* value (r=0.28 and r=0.29, resp.), while correlation of the same strength, only negative was determined between L* value and fat/muscle ratio (r=0.28). *Petersen et al.* (1996) reported very weak and insignificant correlations between Minolta values and carcass lean, although the correlation of Minolta L* and b* values and lean percentage in loin and ham were significant (between 0.23 and 0.28). All measured meat quality traits were found to be significantly correlated with Minolta L* values (*Table 3*). Medium strong, negative correlation was found between pH_{45} and Minolta L* value (r=-0.34); correlation of the same strength but positive was determined between water holding capacity and L* value (0.44). Correlation between pH_{24} and L* value was strong, negative (r=-0.53) which makes ultimate pH value the best predictor of muscle lightness. *Eikkelenboom et al.* (1995) reported to some extent higher correlation than in current study between pH_{24} and Minolta L*(r=-0.61) and water holding capacity (0.56). They concluded that pH_{24} was better predictor of color, w.h.c. and water uptake than pH_{45}. This was also found for some other species such as *Fletcher* (1999) for broilers breast muscle and *Page et al.* (2001) for beef. *Owens et al.* (2000) reported that L* value and pH were correlated with w.h.c. in turkey meat, but that L* had more predictive value. Minolta a* values which measure the redness of meat were correlated with both pH values; correlation coefficients were medium strong and negative. Meat yellowness expressed by Minolta b* value was significantly correlated with all measured meat quality traits. The highest correlation coefficient between b* value and meat quality traits was found for pH_{24} value; it was strong and negative (r=0.61); medium strong, negative for pH_{45}, and medium strong, positive for water holding capacity (r=-0.37 and r=0.40, resp.). *Wulf* and *Wise* (1999) found higher correlations between Minolta L*, a* and b* values and muscle pH of beef.

Table 3

Correlation coefficients between carcass and meat quality traits and Minolta L*, a* and b* values

Trait	L*	A*	B*
Warm carcass weight, kg	-0.12	0.14	0.09
Cold carcass weight, kg	-0.16	0.09	0.03
Carcass length "a", cm	**-0.41**	-0.21	**-0,29**
Carcass length "b", cm	**-0.45**	**-0.27**	**-0.35**
Lean percentage (TP)	**0.29**	-0.11	0.01
Backfat thickness (TP), mm	**-0.34**	0.12	-0.01
Muscle depth (TP), mm	0.19	0.04	0.11
Backfat area, cm^2	-0.12	0.05	0.01
Loin muscle area, cm^2	**0.28**	0.22	**0,29**
Fat/muscle ratio	**-0.29**	-0.08	-0.17
pH_{45}	**-0.34**	**-0.33**	**-0.37**
pH_{24}	**-0.53**	**-0.46**	**-0.61**
w.h.c. (cm^2)	**0.44**	0.23	**0.40**

CONCLUSIONS

From the present study, following conclusions can be drawn:

- Minolta L* value was significantly correlated with carcass length "a" and "b". Correlation was medium strong and negative (r=-0.41 and -0.45, resp.). Significant, weak and negative correlation was found between L* value and backfat thickness (r=-0.34). Very weak, but significant positive correlation was determined between L* value and lean percentage as well as loin muscle area (r=0.29 and 0.28, resp.). The correlation of the same strength but negative was found for fat/muscle ratio (r=-0.29). Carcass weights (warm and cold), muscle depth and backfat area determined by planimetry were not correlated with Minolta L* value.
- All measured meat quality traits were significantly correlated with Minolta L* value. Strong, negative correlation was found for pH_{24} value (r=-0.53). Water holding capacity and pH_{45} value were correlated with L* value by medium strong negative correlation (r=-0.44 and -0.34, resp.).
- Redness of the meat indicated by Minolta a* value was significantly correlated with carcass length "b", pH_{45} and pH_{24}. All correlation coefficients were negative. Correlations with pH_{24} and pH_{45} were medium strong (r=-0.46 and 0.33, resp.), while with carcass length "b" was weak (-0.27).
- Minolta b* value which measures yellowness of the meat was significantly correlated with carcass length "a" and "b". Both correlation coefficients were negative. Coefficient r was medium strong in case of "b" length and weak for "a" (r=-0.35 and 0.29, resp.). Loin muscle area was significantly correlated with b* value, coefficient r was positive weak (r=0.29). Positive, medium strong correlation was found between b* value and w.h.c. (r=0.40). Correlations between pH values and b* value were both significant and negative; coefficient r found for pH_{24} was strong, while that of pH_{45} medium strong (r=-0.61 and -0.37, resp.).

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