CLASSIFICATION OF PORK SAMPLES ACCORDING TO DRIP LOSS

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SUMMARY

The present research was conducted in 119 randomly chosen carcasses of barrows slaughtered at approximately 100 kg of live weight in three slaughterhouses in east Croatia. Main meat quality traits were measured: pH_{45}, pH_{24}, CIE-L and drip loss by compression and bag method. Among the investigated drip loss indicators of drip loss the highest significance was found for WHC and pH_{24} ($p<0.05$), while the values of pH_{45} and CIE-L* were not statistically significant. Meat samples were classified in „exudative" and „non-exudative" groups by two discriminant analyses. Overall accuracy of the first analysis was not high (approximately 62%). When dependent variables were grouped according to cluster analysis of drip loss, overall accuracy was increased by approx. 77%. When the first discrimination analysis was used, statistically significant ($p<0.05$) differences between „exudative meat" and „non-exudative meat" groups were found only for two parameters of drip loss: pH_{24} and WHC. When the second discriminant analysis was used, statistically significant differences ($p<0.05$) between the two groups were found only for pH_{45}.*

Key words: pork, meat quality traits, indicator, discriminant groups

INTRODUCTION

Unfavourable water-holding capacity or drip loss causes major problems in pig production and processing due to its negative impact on both the appearance of meat and yield in further processing. Another undesirable characteristic of such meat is unnaturally pale colour that consumers notice first when judging the acceptability of meat. Since drip loss and colour are both affected by post-mortem glycolysis in the muscle, the initial and final pH values are considered as meat quality indicators enabling fair predicting of these traits. Colour measurements are effective only after a period of time needed for meat to cool (24 hours) and to develop a final hue on the cut surface (blooming time). Commonly used methods for measuring water loss in pork are the compression method after Grau and Hamm (1953) and the bag method developed by Honikel (1987). However, results of these methods are known relatively late. For this reason it is of special importance to differentiate the meat into different classes of drip loss on the basis of measurements of quality parameters as early as possible. Different criteria for sorting pork in meat quality groups have been suggested. Kauffman et al. (1992) and Warner et al. (1997) suggested drip loss of >5% as threshold for differentiation of watery from "normal" meat; Joo et al. (1999) set the threshold for excessive drip loss to 6%. Regarding the pH values, the criteria are not clear either. Selier and Monin (1994) used the initial pH value less than 5.8 and final pH less than 5.5 to predict pale, soft and exudative (PSE) pork. For the same purpose, Forest (1998) used the final pH value of 5.5 or lower; while van Laack (2000) used the final pH value lower than 5.7. Final pH value of 5.69 was interpolated as threshold value differentiating exudative from "normal" *longissimus dorsi* muscle.

The aim of this paper was to investigate the significance of pork quality indicators predicting final drip loss and determined by bag method and to set up a model for discrimination of meat samples according to excessive and "normal" drip loss.

MATERIAL AND METHODS

The study was carried out in 119 randomly selected carcasses of barrows slaughtered at approximately 100 kg of live weight in three slaughterhouses in east Croatia. At the slaughter line, 45 minutes after sticking, the initial pH values (pH_{45}) and temperature were measured at *m. longissimus dorsi* of primarily processed swine carcasses. After 24 hours of cooling, final pH values (pH_{24}), temperature and colour of *m. longissimus dorsi* were measured at the same place where the initial pH was measured. Water-holding capacity was measured after the method of Grau and Hamm (Grau and Hamm, 1952) and by bag method

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Table 1. Descriptive statistics of investigated meat quality traits

Variable	Mean	Standard deviation	Minimum	Maximum
pH_{24}	6.09	0.276	5.43	6.62
pH_{48}	5.63	0.176	5.38	6.46
CIE-L*	46.79	4.898	35.65	59.40
WHC, (cm^2)	8.31	1.432	4.30	12.50
Drip loss, (%)	5.55	2.754	0.98	14.79

as described by Kauffman et al. (1992); the former method being termed in this paper as WHC, and the latter as drip loss. Meat samples for WHC and drip loss were taken from *longissimus dorsi* muscle after 24 hours of cooling; the former were compressed on filter paper for planimetry, while the latter were weighed, placed in plastic bags and stored at 6°C for 48 h and then weighed again. The colour of meat was measured by Minolta CR-300 device on cut of *m. longissimus dorsi* after 15 minutes of blooming and presented as CIE L* values. The measurements of pH_{45} and pH_{24} were carried out by digital pH-meter Mettler MP 120-B. All the data were processed using STATISTICA (7.0) for Windows program. Statistical methods applied were descriptive statistics, cluster analysis and traditional discrimination analysis.

RESULTS AND DISCUSSION

The main parameters of meat quality are presented in Table 1. According to Hofmann et al. (1994), limit value of the initial pH indicating PSE condition of pork is 5.8; L* value exceeding 53 and drip loss value less than 5% suggest the same meat quality condition as well. As regards final pH values, different values for differentiation between "normal" and PSE meat were suggested: e.g. 5.5 by Forrest (1998) and 5.7 by van Laack (2000). Water-holding capacity (WHC) measured by the compression method higher than 9 cm^2 is also an indication of PSE condition (Blendl et al., 1991). The ability of meat to withhold water, measured by bag method, was expressed as drip loss. Having in mind the above-mentioned threshold values, the meat quality of hogs included in the study was satisfactory. The exception was drip loss measured the bag method, which was too high according to Kauffman et al. (1992) and Warner et al. (1997), but acceptable according to Joo et al. (1999). Variations of measured parameters are similar to those published in expert literature (Ryu and Kim, 2005; Kušec et al., 2005).

The significance of meat quality indicators predicting drip loss is presented in Table 2. The highest significance ($p<0.05$) was found for water-holding capacity (WHC) determined by compression method and final pH values, while initial pH values were on the very limit of statistical significance. The WHC measured by compression was considered in this study as an indicator because its results are known 48h earlier than results of drip loss determination by bag method. Meat paleness expressed by CIE-L* value was not statistically significant ($p>0.05$) as a predicting indicator of drip loss. Ability of muscles to withhold water was the topic of many discussions in literature (Kušec et al., 2005, Otto et al., 2004). Relationship between meat quality indicators were investigated by Kušec et al. (2005) and Kralik et al. (2002). Significant correlation was found between final pH values, water-holding capacity determined by compression method and drip loss determined by bag method.

Traditional discriminant analysis model was applied in order to classify meat samples into groups with high and favourable drip loss on the basis of investigated indicators of meat quality (pH_{45}, pH_{24}, CIE-L* and WHC). Drip loss limit value of 5% was used in the first analysis (as suggested by Warner et al., 1997) for differentiation of quality groups by dependent variable, whilst in the second analysis meat samples were classified according to cluster analysis (Table 3). Results of both discriminant analysed are presented in Table 4.

From Table 4 it can be seen that classification functions for exudative and non-exudative classes had different accuracy. With the use of the first discriminant method, in the classes with excessive and "normal" drip loss, 58.93% and 65.08% of investigated meat samples respectively, were accurately differentiated. Overall discrimination accuracy was also not high (~62%). The second discriminant analysis (classes determined by cluster analysis) provided better differentiation; almost 99% of samples in

Table 2. Results of univariate tests of significance for drip loss prediction with meat quality indicators as independent variables

	SS	D.F.	MS	F	P
Intercept	52.6429	1	52.64288	7.964613	0.005630
pH_{45}	25.7736	1	25.77363	3.899425	0.050720
pH_{24}	27.7851	1	27.78514	4.203756	0.042628
CIE-L*	3.4150	1	3.41504	0.516679	0.473733
WHC (cm^2)	31.9173	1	31.91729	4.828932	0.030008
Error	753.4941	114	6.60960	-	-

Table 3. Descriptive statistics of drip loss clusters (exudative and non-exudative meat)

	Mean	Standard deviation	Minimum	Maximum	N
Exudative	9.15	1.87	6.78	14.79	34
Non-exudative	4.11	1.40	0.98	6.5	85

the class "normal" meat were accurately differentiated, so that overall accuracy was higher (~77%) in comparison with accuracy of the first discriminant analysis. Accuracy of discrimination in the exudative class was quite low; only 24% of samples were accurately differentiated. Two classes of samples were formed with each discriminant analysis; their principal meat quality traits are presented in Table 5.

When the first discriminant analysis was used, the group of exudative samples had significantly lower final pH values and higher water-holding capacity (p>0.05), while the differences between groups in the initial pH and CIE-L* values were not statistically significant (p>0.05). When the second discriminant analysis was used, significant differences between groups were found only in the initial pH and WHC values (p<0.05).

CONCLUSION

Based on the study results, following can be concluded:

- Among the selected indicators of drip loss assessed by bag method, the highest significance was found for water-holding capacity (WHC) obtained by compression method and final pH values (p<0.05), while the initial pH values were on the very limit of statistical significance. Paleness of meat expressed as CIE-L* value was not statistically significant (p>0.05).

- Classification of meat samples into exudative and non-exudative groups by discrimination functions showed different levels of accuracy. When the drip loss value of 5% was used as criterion for division of samples into quality groups, the overall discrimination percentage was not high, but it was increased when the meat quality groups were formed according to cluster analysis of drip loss.

- When the first discriminant analysis was used, the exudative and non-exudative meat groups showed statistically significant differences only in pH and WHC values. When the second discriminant analysis was used, statistically significant differences were found only in pH_{45} values, but not in other indicators of drip loss.

ZUSAMMENFASSUNG

KLASSIFIZIERUNG DER SCHWEINEFLEISCHMUSTER IN BEZUG AUF DIE AUSSCHEIDUNG DER FLEISCHFLÜSSIGKEIT

Die Untersuchung wurde auf 119 zufällig ausgewählten Schweinehälften durchgeführt, die Schweine waren aus dem Kastratursprung, geschlachtet bei ungefähr 100 kg Lebensmasse in drei Schlachthöfen auf dem Gebiet Ostkroatiens. Es wurden die wichtigsten Eigenschaften der Fleischqualität gemessen: $pH_{45,}$ pH_{24} , CIE-L* und die Ausscheidung der Fleischflüssigkeit gemessen durch die Methode der Kompression (WHC) und "die Methode des Säckchens" (Austropfen). Beim Prüfen der statistischen Bedeutsamkeit der Perdiktor(en) für Ausscheidung von Fleischflüssigkeit wurde die Bedeutsamkeit für WHC und pH_{24} des Wertes (p<0.05) festgestellt, während für die Werte pH_{45} und CIE-L* keine statistische Bedeutsamkeit festgestellt wurde. Die Fleischmuster wurden in Gruppen "normales" Fleisch und "wässeriges" Fleisch mittels zwei Diskriminantanalysen geteilt. Die gesamte Genauigkeit der ersten Analyse war nicht hoch (etwa 62 %), aber nach der Gruppierung abhängiger Variablen nach Cluster-Analyse für Prozente der Ausscheidung von Fleischflüssigkeit stieg die gesamte Genauigkeit auf etwa 77 %. Durch die Anwendung der ersten Diskriminantanalyse des statistisch bedeutenden Unterschieds (p<0.05) wurden unter der Gruppen "wässeriges" Fleisch und "normales" Fleisch Werte für pH_{24} und WHC festgestellt. Bei der Anwendung der zweiten Diskriminantanalyse wurde der statistisch bedeutende Unterschied (p<0.05) unter diesen zwei Gruppen nur für pH_{45} festgestellt, die anderen Prediktor(en) der Ausscheidung von Fleischflüssigkeit unterschieden sich untereinander nicht bedeutend (p>0.05).

Schlüsselwörter: Schweinefleisch, die Eigenschaften der Fleischqualität, Indikatoren, Diskriminantgruppen

Table 4. Classification matrix obtained by discriminant analysis

	Exudative meat		Non-exudative meat		Correctly classified (%)	
	Analysis 1 (p=0.471)	Analysis 2 (p=0.286)	Analysis 1 (p=0.529)	Analysis 2 (p=0.714)	Analysis 1	Analysis 2
Exudative	33	8	23	26	58.93	23.53
Non-exudative	22	1	41	84	65.08	98.82
Total	55	9	64	110	62.18	77.31

Table 5. Class means and standard deviations (in brackets) of the meat quality traits used in discriminant analyses

	Discriminant analysis 1				Discriminant analysis 2			
	pH_{45}	pH_{24}	CIE-L*	W.H.C	pH_{45}	pH_{24}	CIE-L*	W.H.C
Exudative meat	6.06 (0.291)	5.59[a] (0.140)	46.76 (4.219)	8.65[a] (1.261)	6.01[a] (0.288)	5.59 (0.154)	46.91 (4.293)	8.85[a] (1.138)
Non-exudative meat	6.12 (0.261)	5.67[b] (0.198)	46.82 (5.465)	8.01[b] (1.515)	6.13[b] (0.265)	5.65 (0.182)	46.74 (5.143)	8.19[b] (1.485)

Numbers in columns with different exponents are statistically different ($p<0.05$)

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BACTERIOCINOGENIC STARTER CULTURES VS. *LISTERIA MONOCYTOGENES*

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SUMMARY

In this paper the use of bacteriocinogenic lactic acid bacteria and bacteriocins in food is presented, in particular regarding their antilisterial activity. Results of most studies are affirmative to the standardisation of the use of bacteriocinogenic starter cultures, since they enhance

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