PREDICTION OF PORK QUALITY ATTRIBUTES USING METABOLIC RATE AND MUSCLE FIBER CHARACTERISTICS

Ryu, Y.C.[1], Lee, S.H.[1], Rhee, M.S.[1], Imm, J.Y.[2], and Kim, B.C.[1]
[1]Dept. of Food Science, College of Life and Environmental Sciences, Korea University, Seoul, South Korea
[2]Dept. of Food & Nutrition, College of Natural Sciences, Kookmin University, Seoul, South Korea

Background

Pork quality is varied by the combination of various intrinsic and extrinsic factors which affecting biochemical processes in the postmortem period (Klont et al., 1998). Several studies have estimated heritabilities of meat quality traits and correlation coefficients among them. Fiber type ratios are genetically defined and combination of muscle fiber composition is of moderate to high heritability in pigs (Larzul et al., 1997). Selection possibilities based on muscle characteristics have been suggested in order to improve the oxidative capacity of muscles and thereby pork quality (Maltin et al., 1997). Each muscle fiber has its own metabolic properties such as oxidative, oxido-glycolytic and glycolytic. The relative proportion of muscle fiber is one of the major factors deciding metabolic property of muscle and subsequently metabolic rate during postmortem period.

Objectives

1) to examine meat quality attributes and muscle fiber characteristics in different postmortem metabolic rate groups.
2) to investigate correlation between muscle fiber characteristics and meat quality traits.
3) to predict pork quality attributes using metabolic property of muscle and postmortem metabolic rate.

Methods

A total of 76 commercial pigs (39 gilts and 37 castrated male pigs, YLD) were evaluated. Within 45 min after slaughter, samples from M. longissimus dorsi at the last rib were taken. The piece of muscle was divided into two parts to evaluate the postmortem metabolic rate and histochemical characteristics. One part was immediately frozen in liquid nitrogen for the determination of R-value, and the other part was frozen in isopentane previously cooled in liquid nitrogen for histochemical analyses. Both muscle samples were stored at -80°C until analyses.

Muscle pH was measured at 45 min postmortem using a spear type electrode and R-value (R250, A250/A260) was determined according to the method of Honikel and Fischer (1977). To categorize myofibers, transverse serial sections (10 μm) were cut at –20°C in a cryostat and stained for myofibrillar ATPase after preincubation at pH 4.3, 4.6 and 10.3 (Brooke and Kaiser, 1970). Muscle fibers were classified into type I, type IIa and type IIb fibers. Stained sections were examined by a computerized image analysis system (Image-Pro Plus, Media Cybernetics, L.P., U.S.A.) and the percentage of myofibers, the mean cross-sectional area, and the relative areas of myofibers were determined.

Following 24 hr of chilling, ultimate pH was measured and M. longissimus dorsi was taken to evaluate the meat quality attributes. Water holding capacity was determined by bag drip method (Honikel, 1987). Surface color (CIE L*, a*, b*, chroma and hue) was determined on a cut surface after 20 min bloom time using a Minolta chromameter (CR-300, Minolta Camera Co., Japan). The solubility of the sarcoplasmic proteins was determined (Warner et al., 1997).

Results and Discussion

The postmortem metabolic rate was categorized into fast (pH_{45min}<5.9, R>1.05), intermediate (R<1.05) and slow (pH_{45min}>5.95, R>1.05) based on pH_{45min} and R-value. There were significant differences in meat quality attributes among three groups (Table 1). The fast group had higher drip loss (p<.01) and lightness (p<.01), and ultimate meat quality turned out to be RFN (15.8%) and PSE (84.2%). The intermediate group produced RFN (88.0%), PSE (10.0%), and DFD (2%), while slow group classified into only DFD meat.

There were significant differences in the relative areas of type IIa and IIb fibers among three groups. The fast group had a higher percentage of type IIb but a lower type IIa fibers than those of the slow group (p<.05). Although not significant, the mean cross sectional area of the fast group tended to be larger than that of other groups.

The present study showed that muscle fiber characteristics were moderately correlated with meat quality traits (Table 2). The drip loss was negatively related to the relative areas of type I and IIa fibers. The relative area of type IIb fibers was positively correlated with drip loss but negatively correlated with redness, pH_{45min}, and pH_{24hr}. No clear relationship was observed between lightness and relative areas.

Based on these results, the relative area of type IIb fibers was selected as a criterion to differentiate metabolic property of muscle and classified as follows: [Less glycolytic]- relative area of type IIb fibers < 89%; [More glycolytic]- relative area of type IIb fibers >89%.

Pork quality was evaluated based on the metabolic property of muscle and postmortem metabolic rate (Table 3). The relative areas of type I and IIb fibers showed significant differences (p<.01) between metabolic property groups and drip loss had a difference (p<.01) between metabolic rate groups. There were no significant differences in lightness, R-value and type IIa relative areas between [less glycolytic-fast] and [more glycolytic-intermediate] groups. Although both groups classified into normal (RFN) meat, [more glycolytic-intermediate] group had lower meat quality than [less glycolytic-intermediate] group. Furthermore, pH_{45min} showed a significant difference between these two groups.

These results suggest that reliable judgment can be possible when both metabolic property of muscle and postmortem metabolic rate are considered for the prediction of pork quality.

Conclusions

1) There were significant differences in the meat quality traits and relative areas of myofibers among different metabolic rate groups.
2) Relative areas of myofibers were moderately correlated with drip loss, redness, pH_{45min} and pH_{24hr}, respectively.
3) The variation of pork quality was better explained when both metabolic property of muscle and postmortem metabolic rate were considered together.

Pertinent literature

Brooke, M.H. and Kaiser, K.K. 1970. Muscle fiber types: how many and what kind? Archives of Neurology 23: 369-379.
Honikel, K.O. 1987. Wasserbindungsvermogen von fleisch. Fleischwirtwsch, 67: 418-421.
Honikel, K.O. and Fischer, C. 1977. A rapid method for the detection of PSE and DFD porcine muscles. J. Food Sci. 42: 1633-1636.
Klont, R.E., Brocks, L. and Eikelenboom, G. 1998. Muscle fibre type and meat quality. Meat Sci. 49: S219-S229.
Larzul, C., Lefaucheur, L., Ecolan, P., Gogue, J., Talmant, A., Sellier, P., Le Roy, P. and Monin, G. 1997. Phenotypic and genetic parameters

for longissimus muscle fiber characteristics in relation to growth, carcass and meat quality traits in Large White pigs. J. Anim. Sci. 75: 3126-3137.

Maltin, C.A., Warkup, C.C., Matthews, K.R., Grant, C.M., Porter, A.D. and Delday, M. I. 1997. Pig muscle fibre characteristics as a source of variation in eating quality. Meat Sci. 47: 237-248.

Warner, R.D., Kauffman, R.G. and Greaser, M.L. 1997. Muscle protein changes postmortem in relation to pork quality traits. Meat Sci. 45: 339-352.

Table 1. Least square means for meat quality attributes and muscle fiber characteristics in different postmortem metabolic rate groups

	Postmortem metabolic rate				
	Fast (n=19)	Intermediate (n=50)	Slow (n=7)	SE	Significance
Drip loss (%)	7.11^a	3.50^b	1.46^c	0.25	**
Lightness (L*)	50.12^a	46.97^b	42.06^c	0.40	**
pH_{45min}	5.80^a	6.08^b	6.15^c	0.05	**
pH_{24hr}	5.51^a	5.54^a	5.80^b	0.02	**
R-value	1.22^a	0.95^b	1.18^a	0.03	**
Sarcoplasmic protein Solubility (mg/g)	72.58^a	77.91^{ab}	86.77^b	2.41	*
Relative areas of myofibers (%)					
Type I	3.97^a	4.64^a	6.65^a	0.66	NS
Type IIa	6.09^a	8.04^{ab}	9.67^b	0.81	*
Type IIb	89.94^a	87.32^{ab}	83.69^b	1.15	*
Mean cross sectional area (μm^2)	4223^a	3947^a	3477^a	209	NS

* $P<0.05$; ** $P<0.01$; NS = not significant.

[a,b,c] Least square means within a row with different superscripts differ ($P<0.05$).

Table 2. Correlation coefficients between meat quality parameters and muscle fiber characteristics

	Relative areas of myofibers			Percentages of myofibers		
Meat quality parameters	Type I	Type IIa	Type IIb	Type I	Type IIa	Type IIb
Drip loss	-0.327*	-0.425**	0.468**	-0.292	-0.282	0.408*
Filter-paper fluid uptake	-0.213	-0.319*	0.336*	-0.133	-0.187	0.235
Lightness (L*)	-0.178	-0.304	0.306	-0.044	-0.189	0.181
Redness (a*)	0.260	0.266	-0.325*	0.275	-0.171	-0.376*
pH_{45min}	0.242	0.331	-0.355*	0.233	0.239	-0.328
pH_{24hr}	0.114	0.410**	-0.351*	0.028	0.388*	-0.317

* $P<0.05$; ** $P<0.01$.

Table 3. Comparison of meat quality parameters and muscle fiber characteristics in different metabolic property of muscle and postmortem metabolic rate groups

	Less glycolytic group		More glycolytic group			
	Intermediate	Fast	Intermediate	Fast	SE	Significance
Drip loss (%)	2.70^a	6.54^b	3.89^a	7.51^b	0.65	**
Lightness (L*)	46.07^a	49.90^b	47.58^{ab}	49.62^b	1.07	*
pH_{45min}	6.19^a	5.65^c	6.00^b	5.79^c	0.07	**
R-value	0.97^a	1.15^b	1.02^{ab}	1.16^b	0.05	*
Relative areas (%)						
Type I	5.65^a	5.35^a	2.61^b	2.58^b	0.80	**
Type IIa	9.26^a	7.40^{ab}	5.06^b	4.79^b	0.95	**
Type IIb	85.09^a	87.25^a	92.33^b	92.64^b	1.16	**
Meat quality	Normal (n=39)	PSE (n=10)	Normal (n=8)	PSE (n=12)		

* $P<0.05$; ** $P<0.01$.

[a,b,c] Least square means within a row with different superscripts differ ($P<0.05$).