COMPARISON OF HISTOCHEMICAL CHARACTERISTICS AND MEAT QUALITY TRAITS IN DIFFERENT JEJU PIG BREEDS

S.H. Hwang, K.B. Ko, K.H. Kim, Y.C. Ryu*

Division of Biotechnology, Jeju National University, 66 Jejudaehakro, Jejusi, 690-485, South Korea

*Corresponding author (phone: +82-64-754-3332; fax: +82-64-725-2403; e-mail: ycryu@jejunu.ac.kr)

***Abstract*—This study was to investigate the histochemical characteristics and meat quality traits among commercial Jeju black pigs (JBP), native Jeju black pig×Duroc (JD) and Jeju Landrace×Yorkshire×Duroc (JLYD). A total of 188 pigs were evaluated. JD contained a significantly lower mean area percentage of type IIb fibers than those of other breeds ($P < 0.05$). The muscle pH_{45min} and pH_{24h} were significantly higher in JD. Drip loss and color parameters were signficantly different between the breeds ($P < 0.001$). JD showed the highest muscle pH and lowest drip loss and L* values than the other breeds. These results imply that the *longissimus dorsi* muscle of Jeju black pig×Duroc pig is better meat quality than that of other breeds. Based on these results, we conclude that muscle fiber composition can explain in parts the variation of meat quality across and within breeds.**

Index Terms— **Histochemical characteristics, *longissimus dorsi*, meat quality, pig breeds.**

I. INTRODUCTION

Mechanisms controlling pork quality development are often associated with altered postmortem muscle metabolism. Specifically, changes in the rate of glycolysis can create unfavorable muscle pH. A high rate of pH decline and a low ultimate pH result in muscle protein denaturation and diminish quality parameters (Ryu *et al*., 2005). One of the main factors determining muscle biochemical pathways is fiber type composition: skeletal muscle is composed of different types of fibers, which are the results of co-ordinated expression of distinct sets of structural proteins and metabolic enzymes (Chang *et al*., 2003). Because muscle fibers contain different myosin heavy chains, which are responsible for their different ATPase activity (Picard *et al*., 1999), it is possible that fiber type composition may be associated with postmortem changes in the conversion of muscle to meat, and subsequently meat quality (Ryu and Kim, 2006). Therefore, the variation in fiber type characteristics can explain part of the variation in some meat quality traits.

Some recent studies found correlations between muscle fiber characteristics and meat quality traits in beef (Ozawa *et al*., 2000) and in pigs (Ryu and Kim, 2005). For the practical application of this knowledge to improve and control meat quality, more information of the effects of the fiber type characteristics on meat quality is necessary. Therefore, this research focuses on comparing muscle histochemical characteristics between Berkshire, Landrace, Yorkshire, and crossbred pigs.

II. MATERIALS AND METHODS

This study involved 188 pigs from three different breeds as follows: commercial Jeju black pigs (JBP); native Jeju black pig×Duroc (JD); Jeju Landrace×Yorkshire×Duroc (JLYD). Pigs were slaughtered according to standard commercial procedures in a Korean abattoir. Within 45 min postmortem, muscle samples for histochemical analysis were taken from the *longissimus* muscle at the 8th *thoracic vertebrae*. Samples were cut into 0.5 × 0.5 × 1.0 cm pieces, promptly frozen in liquid nitrogen, and stored at -80℃ until subsequent analyses. Serial transverse muscle sections (10 μm) were obtained from each sample with a cryostat at -20℃ and mounted on glass slides. The myosin adenosine triphosphatase activities were detected after acid (pH 4.7) preincubation (Brooke and Kaiser, 1970). About 300 fibers per sample were examined by an image analysis system and the muscle fibers were divided into type I, IIa, and IIb according to the nomenclature of Brooke and Kaiser (1970).

Muscle pH was measured directly on carcass at the 7th/8th *thoracic vertebrae* using a spear type electrode at 45 min (pH_{45min}) and 24 h postmortem (pH_{24h}). Following 24 h of chilling, *M. longissimus dorsi* was taken to evaluate the meat quality traits. Drip loss was determined by suspending muscle samples standardized for surface area in an inflated plastic bag for 48 h at 2℃. The color of the meat was measured at the 8th/9th *thoracic vertebrae* at 24 h postmortem with a chromameter after exposing the surface to the air for 30 min at 2℃. The average of triplicate measurements was recorded and the results were expressed as C.I.E. L*, a*, and b*. The texture was measured after cooking, parallel to the longitudinal orientation of the muscle fibers, were taken from each steak for Warner–Bratzler shear force (WBS) measurements, and 2.0 × 2.0 × 2.0 cm^3 pieces were cut for texture profile analysis (TPA). The samples were sheared perpendicular to the long axis of the cores. Three pieces for each sample were measured for TPA. The data were analyzed statistically using the SAS program. The differences between the breeds were studied using analysis of variance and Duncan's test was used to locate the differences.

III. RESULTS AND DISCUSSION

There were no significant differences in carcass weight and backfat thickness among groups. Table 1 showed the differences in meat quality measurements among the JBP, JD, and JLYD breeds. The muscle pH_{45min} and pH_{24h} were significantly higher in JD (P < 0.001). Meat color and sensory evaluation value was closely related to postmortem metabolic rate and pH value. The muscle color and sensory evaluation value was positively related to pH value. The L^* value ,a^* value. and b^* value of the JD group was the highest at 24h postmortem (P < 0.001). However, the a^* value of the JLYD group was the lowest at 24h postmortem (P < 0.001). NPPC color value and NPPC marbling value of the JD group were highest in the breed groups (P < 0.001). The water-holding capacity and texture were significantly dependent on breed (Table 2). For the water-holding capacity measurements, the JD group had significantly highest values of FFU, drip loss, and cooking loss (P < 0.001). The JD group had the highest value of hardness (P < 0.001), cohesiveness (P < 0.01), and springiness (P < 0.1). Ryu and Kim (2005) reported that the percentage of type IIb fibers was negatively related to the pH at 45 min postmortem and positively related to drip loss and lightness. Solomon *et al.* (1998) also suggested that high proportion of type IIb fibers may be more prone to PSE pork because of its anaerobic nature, higher glycogen content, and lower ultimate pH. In this study, JD group, which showed the highest muscle pH, the lowest drip loss, and L* values contained a significantly lower mean area percentage of type IIb fibers than those of other breeds (Table 3).

Table1. Muscle $pH_{45min,}$ muscle $pH_{24h,}$ $temperature_{24h,}$ $lightness_{24h}$ (L^*), $redness_{24h}$ (a^*), $yellowness_{24h}$ (b^*), NPPC color, NPPC marbling (means± s.d.) of *longissimus dorsi* muscle in different breeds

	breed			
	JBP	**JD**	**JLYD**	**Significance**
Muscle pH_{45min}	$5.96±0.28^b$	$6.28±0.11^a$	$5.98±0.29^b$	***
Muscle pH_{24h}	$5.59±0.19^b$	$5.94±0.20^a$	$5.64±0.11^b$	***
$Temperature_{24h}$	$5.32±1.57^{ab}$	$5.42±0.64^a$	$4.42±1.13^b$	***
$Lightness_{24h}$ (L^*)	$51.09±3.37^a$	$41.78±5.38^b$	$50.66±3.11^a$	***
$Redness_{24h}$ (a^*)	$6.93±1.27^b$	$14.15±3.66^a$	$5.82±1.49^c$	***
$Yellowness_{24h}$ (b^*)	$5.13±1.09^b$	$6.13±1.74^a$	$4.47±1.11^b$	***
NPPC color	$3.06±0.68^b$	$5.00±0.60^a$	$2.82±0.62^b$	***
NPPC marbling	$1.69±0.76^b$	$3.90±1.25^a$	$1.82±0.63^b$	***

Levels of significance: NS = not significant; *** P < 0.001.

$^{a\text{-}c}$Means with different superscripts in the same row significantly differ (P < 0.05).

Table2. Meat quality traits (means ± s.d.) of the porcine *longissimus dorsi* muscle in different breeds

	breed			**significance**
	JBP (N=121)	**JD (N=7)**	**JLYD (N=60)**	**(P-value)**
FFU (mg) [1]	$70.14±44.25^a$	$7.28±3.98^b$	$61.68±34.74^a$	***
Drip loss (%)	$5.53±1.40^a$	$0.95±0.25^b$	$5.07±2.49^a$	***
Cooking loss (%)	$26.21±4.01^a$	$18.84±4.63^b$	$26.03±3.65^a$	***
Hardness (N/g)	$41.51±6.73^a$	$31.58±4.94^b$	$37.62±4.09^a$	***
Cohesiveness	$0.40±0.12^a$	$0.26±0.18^b$	$0.42±0.10^a$	**
Springiness	$0.62±0.20^a$	$0.48±0.26^b$	$0.62±0.15^a$	†

Levels of significance: NS = not significant; † P < 0.1; *** P < 0.001.

$^{a\text{-}b}$Means with different superscripts in the same row significantly differ (P < 0.05).

[1] FFU = filter-paper fluid uptake.

Table3. Muscle fiber characteristics of *longissimus dorsi* muscle in different breeds

	breed			**significance**
	JBP (N=52)	**JD (N=6)**	**JLYD (N=15)**	**(P-value)**
Area percentage (%)				
TypeI	11.88±8.85[a]	12.83±5.16[a]	8.91±2.89[b]	*
TypeIIa	6.53±5.97[a]	8.66±2.70[a]	5.62±1.69[a]	NS
TypeIIb	83.01±9.98[a]	78.51±5.48[b]	85.55±3.92[a]	*
Number percentage (%)				
TypeI	16.07±4.98[a]	14.46±4.92[a]	13.85±4.33[a]	NS
TypeIIa	9.23±3.02[a]	8.88±2.56[a]	10.15±2.94[a]	NS
TypeIIb	74.86±5.55[a]	76.46±5.95[a]	75.82±5.87[a]	NS

Levels of significance: NS = not significant; * $P < 0.05$.
[a-b]Means with different superscripts in the same row significantly differ ($P < 0.05$).

IV. CONCLUSION

Comparing the fiber type composition and meat quality traits observed from the different breeds, the results imply that the *longissimus dorsi* muscle of native Jeju black pig×Duroc group is better meat quality trait than that of other breeds. JD group, which showed the highest muscle pH, the lowest drip loss, and L* values contained a significantly lower mean area percentage of type IIb fibers than those of other breeds.

ACKNOWLEDGEMENT

This work was supported by a grant from Jeju special self-governing province and the Research Institute for Subtropical Agriculture and Biotechnology in Jeju National University, Korea.

REFERENCES

1. Brooke, M. H., and K. K. Kaiser. (1970). Three myosin adenosine triphosphatase system: the nature of their pH liability and sulphydryl dependence. Journal of Histochemystry and Cytochemystry, 18: 670−672.
2. Chang, K. C., N. Da Costa, R. Blackley, O. Southwood, G. Evans, G. Plastow, J. D. Wood, and R. I. Richardson. (2003). Relationships of myosin heavy chain fibre types to meat quality traits in traditional and modern pigs. Meat Science, 64: 93−103.
3. Ozawa, S., T. Mitsuhashi, M. Mitsumoto, S. Matsumoto, N. Itoh, K. Itagaki, Y. Kohno, and T. Dohgo. (2000). The characteristics of muscle fiber types of longissimus thoracis muscle and their influences on the quantity and quality of meat from Japanese Black steers. Meat Science, 54: 65−70.
4. Picard, B., C. Barboiron, M. P. Duris, H. Gagniere, C. Jurie, and Y. Geay. (1999). Electrophoretic separation of bovine muscle myosin heavy chain isoforms. Meat Science, 53: 1−7.
5. Ryu, Y. C., and B. C. Kim. (2005). The relationship between muscle fiber characteristics, postmortem metabolic rate, and meat quality of pig longissimus dorsi muscle. Meat Science, 71: 351−357.
6. Ryu, Y. C., and B. C. Kim. (2006). Comparison of histochemical characteristics in various pork groups categorized by postmortem metabolic rate and pork quality. Journal of Animal Science, 84: 894−901.
7. Ryu, Y. C., Y. M. Choi, and B. C. Kim. 2005. Variations in metabolite contents and protein denaturation of the longissimus dorsi muscle in various porcine quality classifications and metabolic rates. Meat Science, 71: 522−529.
8. Solomon, M. B., R. L. J. M. van Laack, and J. S. Eastridge. (1998). Biophysical basis of pale, soft, exudative (PSE) pork and poultry muscle: A. review. Journal of Muscle Foods, 9: 1−12.