MEAT QUALITY AND SENSORY EVALUATION OF DIFFERENT PIG BREEDS: RELATIONSHIPS BETWEEN MHC ISOFORMS AND SENSORY EVALUATION

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Abstract—**The goals of this study were to compare postmortem meat quality measurements, sensory evaluation of cooked meat and myosin heavy chain (MHC) isoform contents of different porcine breeds. In addition, the relationships between MHC isoform content and sensory evaluation were examined. Berkshire pig, with the highest $pH_{24\ h}$ value had greater water holding capacity than the other breeds. Also, in sensory evaluation of cooked meat from the different breeds, Berkshire pig meat was more tender and juicier. Though the content of MHC isoforms did not differ significantly among breeds, we found significant relationships between the fast/slow ratio of isoforms and sensory evaluation in all pigs, with the exception of the flavor intensity and mouth coating. Therefore, the content of MHC isoforms is associated with the sensory evaluation of cooked meat in Berkshire breed.**

Index Terms—**myosin heavy chain isoforms, meat quality, pig breeds, sensory evaluation**

I. INTRODUCTION

Eating quality is an important aspect of meat quality, and it is affected by several factors, especially breed. Sheard, Nute, Richardson and Wood (2005) reported that sensory characteristics of cooked meat differ among various pig breeds. Differences in meat quality and sensory characteristics both across and within pig breeds are explained, in part, by variation in muscle fiber characteristics (Maltin et al., 2001; Ryu et al., 2008). Myosin heavy chain (MHC) isoforms are often used as molecular markers to identify fiber types (Bottinelli & Reggiani, 2000). The contents of MHC isoforms can also influence metabolic rate during the postmortem period and, in turn, affect meat quality (Choi et al., 2010; Choi, Ryu & Kim, 2007). However, the effects of MHC isoform content on sensory evaluation of cooked meat are unclear. To address this issue, we compare postmortem meat quality mesurements, sensory evaluation of cooked meat and MHC isoform content of different pig breeds. We also examine the relationships between MHC isoform content and sensory evaluation.

II. MATERIALS AND METHODS

A. Animals and muscle samples

A total of 134 pigs were evaluated (Berkshire, n = 67; Duroc, n = 38; Yorkshire, n = 29). All pigs were raised on the same farm and slaughtered at the same slaughterhouse using electrical stunning during the spring. The similar weight pigs (110 ± 5 kg) were slaughtered. At 45 min postmortem, muscle samples were taken from the *longissimus dorsi* muscles at the 8th *thoracic vertebra*, promptly frozen in isopentane cooled by liquid nitrogen, and stored at -80 °C until subsequent analysis, which included MHC isoform content. After chilling for 24 h in a 4 °C cold room, the pork loins were removed and evaluated for meat quality measurements and sensory traits of cooked meat.

B. Meat quality measurements

Muscle pH at 24 h postmortem ($pH_{24\ h}$) was measured directly on the *longissimus dorsi* muscle of carcasses using a portable pH meter (HM-17MX, TOADKK, Japan). Drip loss (Honikel, 1998), filter-paper fluid uptake (FFU) (Kauffman, Eikelenboom, Wal, Merkus & Zaar, 1986) and cooking loss (Honikel, 1998) were measured for water holding capacity (WHC) measurements. Warner-Bratzler shear force (WBS) was determined using an Instron Universal Testing Machine (Model 1011, Instron Corp., USA) equipped with a Warner-Bratzler shearing device. Lightness (L^*), redness (a^*) and yellowness (b^*) were measured with a Minolta chromameter (CR-300, Minolta Camera Co., Japan).

C. Sensory evaluations

Samples were cut into 2-cm thick steaks. Steaks were roasted in an oven set at 180 °C and turned every 3 min until cooked to an internal temperature of 71 °C. Cooked steaks were cut into 1.3 cm^3 pieces that were randomly given to minimize bias. Ten trained panelists were assigned separate sensory booths at Korea University to evaluate the sensory quality of 134 pork samples. Panelist training was performed according to published sensory evaluation procedures

(Meilgaard, Civille & Carr, 1991), and the 10 panelists were trained to assess pork samples over 4 weeks. A total of 34 sessions were performed with eight samples per session. Sensory quality of the cooked meat were evaluated for softness (1 = very soft; 9 = very hard), initial tenderness (1 = very tender; 9 = very tough), chewiness (1 = very tender; 9 = very chewy), rate of breakdown (1 = very fast; 9 = very slow), juiciness (1 = extremely juicy; 9 = not juicy), flavor intensity (1 = full pork flavor; 9 = no pork flavor), off-flavor intensity (1 = very weak; 9 = very strong), mouth coating (1 = none; 9 = very high), and amount of perceptible residues (1 = none; 9 = abundant). The entire experiment of sensory evaluation was repeated, and the average value of the two replications was used.

D. Myosin heavy chain isoforms

MHC isoforms were analyzed using sodium dodecyl sulfate-polyacrylamide gel electrophoresis (Talmadge & Roy, 1993). MHCs were separated into slow and fast isoforms. Bands were visualized with Coomassie Brilliant Blue staining. Each MHC band was examined with an image analysis system for quantitative analysis (Kodak 1D image analysis software, Eastman Kodak Co., USA). The percentages of each MHC isoforms were derived from the ratio of the density of each MHC band to the density of the total MHC band (slow and fast), and the MHC fast/slow ratio was expressed as the ratio of the density of the fast MHC bands to the density of the slow MHC bands within each sample.

E. Statistical analysis

Meat quality, sensory evaluation of cooked meat and MHC isoform content among breeds (Berkshire, Duroc and Yorkshire) were analyzed using SAS PC software (SAS Institute, 2004). Pearson correlation coefficients were evaluated using partial correlation coefficients (SAS Institute, 2004) to determine relationships between MHC isoform content and sensory evaluation of cooked meat in all pigs.

III. RESULTS AND DISCUSSION

Meat quality measurements for the different pig breeds are shown in Table 1. All meat quality measurements were significantly different among pig breeds. The muscle $pH_{24\,h}$ value ($P < 0.001$) was significantly higher in the Berkshire breed than in other breeds. Duroc pigs exhibited the highest lightness ($P < 0.001$) in comparison to other breeds. The measurements of WHC were significantly different among breeds; Berkshire pigs had the lowest drip loss ($P < 0.001$) and FFU ($P < 0.001$), and cooking loss ($P < 0.001$) than the Duroc and Yorkshire pigs. Also, Berkshire pigs had significantly lower WBS values ($P < 0.001$) than the Duroc and Yorkshire pigs. Sensory evaluations of cooked meat are shown in Table 2. The panelists gave significantly lower softness ($P < 0.001$), initial tenderness ($P < 0.001$), juiciness ($P < 0.001$) and chewiness ($P < 0.001$) scores to the Berkshire pigs relative to the Duroc and Yorkshire pigs. In other words, Berkshire pig meat was softer, more tender and juicier than that of other breeds. On the other hand, Yorkshire pigs scored higher in rate of breakdown ($P < 0.01$) and amount of perceptible residues ($P < 0.01$) than the other breeds.

No significant differences were observed in the content of MHC isoforms among pig breeds (Table 3). However, there were significant relationships between the content of MHC isoforms, especially for the fast/slow ratio of isoforms, and sensory evaluation in all pigs (Table 4). The content of the MHC slow isoform was negatively correlated with flavor intensity, off-flavor intensity, and amount of perceptible residues (r = –0.22, –0.18 and –0.22, respectively). By contrast, the fast/slow ratio was positively correlated with sensory evaluation characteristics, such as softness (r = 0.22), initial tenderness (r = 0.21), juiciness (r = 0.18), off-flavor intensity (r = 0.22), chewiness (r = 0.22), rate of breakdown (r = 0.23), and amount of perceptible residues (r = 0.35). Flavor intensity and mouth coating were not significantly correlated with this ratio.

Table 1. Meat quality measurements of the *longissimus dorsi* muscle from various pig breeds

	Berkshire (*N = 67*)	**Duroc (*N = 38*)**	**Yorkshire (*N = 29*)**	**Level of significance**
Muscle $pH_{24\,h}$	5.89^{a} (0.03)[1]	5.60^{b} (0.03)	5.59^{b} (0.04)	***
Lightness (L^{*})	45.00^{b} (0.31)	48.99^{a} (0.41)	45.37^{b} (0.46)	***
Redness (a^{*})	6.95^{b} (0.13)	6.04^{c} (0.17)	7.61^{a} (0.19)	***
Yellowness (b^{*})	2.32^{b} (0.09)	2.90^{a} (0.12)	2.70^{a} (0.13)	***
Drip loss (%)	1.83^{b} (0.16)	3.40^{a} (0.21)	3.82^{a} (0.24)	***
Filter-paper fluid uptake (mg)	18.07^{b} (1.54)	33.36^{a} (2.04)	28.20^{a} (2.34)	***
Cooking loss (%)	25.81^{c} (0.54)	29.46^{b} (0.75)	31.78^{a} (0.82)	***
Warner-Bratzler Shear force (N)	46.22^{b} (1.59)	58.91^{a} (2.10)	60.04^{a} (2.41)	***

[1]Standard errors of least square means.
Level of significance: *** $P < 0.001$.
[a-c]Least square means with different superscripts in the same row differ significantly ($P < 0.05$).

Table 2. Sensory evaluation of cooked meat from various pig breeds

	Berkshire	**Duroc**	**Yorkshire**	**Level of significance**
Softness	4.76^{b} (0.14)[1]	5.32^{a} (0.17)	5.71^{a} (0.20)	***
Initial tenderness	4.97^{b} (0.15)	5.71^{a} (0.19)	6.09^{a} (0.22)	***
Juiciness	4.89^{b} (0.11)	5.51^{a} (0.14)	5.47^{a} (0.16)	***
Flavor intensity	5.02^{b} (0.05)	5.04^{b} (0.07)	5.30^{a} (0.08)	**
Off-flavor intensity	5.46 (0.08)	5.76 (0.10)	5.60 (0.11)	NS
Chewiness	4.89^{b} (0.14)	5.60^{a} (0.17)	5.86^{a} (0.19)	***
Rate of breakdown	5.32^{b} (0.12)	5.68^{ab} (0.15)	6.08^{a} (0.17)	**
Mouth coating	5.16 (0.07)	5.01 (0.08)	4.88 (0.10)	NS
Amount of perceptible residues	5.50^{b} (0.07)	5.57^{b} (0.08)	5.93^{a} (0.10)	**

[1]Standard errors of least square means.
Level of significance: NS, not significant; ** $P < 0.01$; *** $P < 0.001$.
[a-b]Least square means with different superscripts in the same row differ significantly ($P < 0.05$).

Table 3. Myosin heavy chain (MHC) isoform content of the *longissimus dorsi* muscle from various pig breeds

	Berkshire	**Duroc**	**Yorkshire**	**Level of significance**
MHC slow isoform (%)	6.23 (0.35)[1]	5.51 (0.51)	5.45 (0.64)	NS
MHC fast isoform (%)	93.77 (0.35)	94.49 (0.51)	94.55 (0.64)	NS
Fast/slow ratio	21.47 (1.74)	21.26 (2.52)	19.71 (3.18)	NS

[1]Standard errors of least square means.
Level of significance: NS, not significant.

Table 4. Correlation coefficients (*R*) between myosin heavy chain (MHC) isoform content and sensory evaluation of cooked meat in porcine *longissimus dorsi* muscle

	MHC isoform		
	Slow isoform	**Fast isoform**	**Fast/slow ratio**
Softness	–0.08	0.08	0.22^{*}
Initial tenderness	–0.10	0.10	0.21^{*}
Juiciness	–0.10	0.10	0.18^{*}
Flavor intensity	$–0.22^{*}$	0.22^{*}	0.16
Off-flavor intensity	$–0.18^{*}$	0.18^{*}	0.22^{*}
Chewiness	–0.10	0.10	0.22^{*}
Rate of breakdown	–0.11	0.11	0.23^{*}
Mouth coating	–0.00	0.00	–0.07
Amount of perceptible residues	$–0.22^{*}$	0.22^{*}	0.35^{***}

Level of significance: * $P < 0.01$; *** $P < 0.001$.

IV. CONCLUSION

In general, Berkshire pig has a higher percentage of muscle fiber type I and a higher fat content in comparison to other breeds, such as Duroc, Landrace and Yorkshire (Ryu et al., 2008). For this reason, Berkshire pig has several traits of good quality (Suzuki, Shibata, Kadowaki, Abe & Toyshima, 2003). In this study, Berkshire pig meat was the tenderest and juiciest of the breeds considered. Though the content of MHC isoforms was not significantly different among pig breeds, we found significant relationships between content of MHC isoforms, especially the fast/slow ratio of isoforms, and sensory evaluation in all pigs. Our data implied that the content of MHC isoforms can affect sensory evaluation of cooked meat.

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