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Comparison among meat quality classes according to the criteria of post-mortem pH_{24hr}, drip loss and color in Berkshire pigs

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ABSTRACT

This study was performed to analyze the difference between the meat properties classified into 5 ranges depending on Berkshire meat quality traits. Post-mortem pH_{24hr} was positively correlated with water holding capacity, but negatively correlated with meat color, protein content, drip loss, and cooking loss. Berkshire gilt was discovered by higher population of RFN (reddish pink, firm, non-exudative), a normal meat class when compared to barrow, whereas DFD (dark, firm, and dry) was not detected and PSE (pale, soft and floppy, exudative) and RSE (reddish pink, soft and floppy, exudative) were found by a low number of individuals. It was assumed that Berkshire gilt is less susceptible to stress when compared with barrow. Therefore, from the results of this study, we suggest that Berkshire gilt is high possibility for production of good meat due to a forming ability for better meat quality than that of Berkshire barrow.

Key words: Drip loss, Meat color, Meat quality class, Pigs, Post-mortem pH.

INTRODUCTION

Quantity and quality of meat are critically important in the pork industry. Although pig farmers often don't focus attention to quality but on quantity, both factors might influence each other for economic benefits (Sima *et al.*, 2013). Pork quality plays a critical role as more important indicator for meat purchase to an astute consumer, which consumer's purchasing power is an important factor to induce the activation of modern pork industry (Suckling, 2012). Therefore, recently pork industry has been focusing in order to produce better meat quality, and many researchers have pointed out the importance of pork quality (Gonzalez *et al.*, 2014; Miar *et al.*, 2014; Turyk *et al.*, 2014). However, it is very difficult to predict pork quality due to many of factors to affect the quality. Fresh meat quality is the result of post-mortem muscle metabolism, which is influenced by various management conditions such as transport, pre-slaughter handling, stunning, and processing and cooling conditions for carcasses (Rosenvold and Anderson, 2003; Pearce *et al.*, 2011; Xu *et al.*, 2012; Marija *et al.*, 2014). Thus there is no single definition for high quality meat applied in the pork industry to date.

In order to classify pork depending on meat quality, fat composition, nutritional value, yield and eating quality are also frequently referred in the literature (Prieto, 2007; Suckling, 2012). Pork quality is generally classified on the base of surface exudate (or drip loss), color and ultimate pH post-slaughter (Prieto, 2007). Drip loss, color and pH are the most important parameters to technically describe pork quality (Sima *et al.*, 2013). Pork based on variations of ultimate pH, color and drip loss is initially divided into three quality categories; normal (or RFN: reddish-pink, firm, and non-exudative), PSE (pale, soft and exudative) and DFD (dark, firm and dry). Recently, new two quality categories have been added for more reliable quality assessment via consideration of the variation in color or drip loss, namely RSE (reddish-pink, soft and exudative) and PFN (pale, firm and exudative) (Kocwin-Podsiadla *et al.*, 2006; Weschenfelder, 2013).

In this study, we examined relationships among meat quality traits analyzed from *longissimus dorsi* of pure Berkshire. In addition, we analyzed the difference of meat quality traits among five meat quality classes depending on post-mortem pH_{24hr}, L* and drip loss for entrepreneurship related with pork.

MATERIALS AND METHODS

Sampling and classification of samples: A total of 236 pigs (barrow=103, gilt=133) were employed for statistical analysis of meat quality traits in this study, which fattened about 6 months old at the same farm in South Korea (Dasan Genetics). The measurements of carcass weight and backfat thickness were carried out after slaughter at a commercial

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slaughterhouse. Individual *longissimus dorsi* muscles of pig were collected, transferred into a refrigerated condition in a laboratory and examined for meat quality traits.

In this study, pork quality classification according to criteria of post-mortem pH_{24hr} (or ultimate pH), drip loss and color (L*) were divided into five meat quality classes; PSE, PFN, RSE, RFN and DFD (Weschenfelder, 2013; Dokmanovic *et al*., 2014).

Technological quality measurements: Pigs with live weights between 105 and 125 kg were transported to a slaughterhouse near the experimental station. They were slaughtered by stunning with electrical tongs (300 volts for 3 sec) after 12 hour of feed restriction. The stunned pigs were exsanguinated while being hanged. Carcasses were then placed in a dehairer at 62°C for 5 min and remaining hair was removed by using a knife and flame. Carcasses were eviscerated and split before being placed in a chiller set at 2~4°C for 12 hour.

Physical property and chemical composition, including moisture content (MC), protein content (PC), fat content (FC), water holding capacity (WHC), drip loss (DL), cooking loss (CL), collagen content (CC) and meat color (L*, a*, b*), were measured according to methods employed in the previous studies (AOAC, 2000; Kristensen *et al*. 2001; Cho *et al*. 2015).

RESULTS AND DISCUSSION

Carcass and meat quality traits: Berkshire gilts reveal a tendency of higher economic efficiency than that of Berkshire barrows (Cho *et al*., 2015). However, an accurate assessment in accordance with Berkshire pork quality has not been classified by a statistical analysis. Therefore, in this study, in order to examine meat quality of Berkshire and classify pork depending on meat quality, we analyzed descriptive statistics for characteristics of carcass and meat quality from the investigated 236 samples in Berkshire (Table 1). The carcass weight did not exhibit significant difference between barrow and gilt. However, collagen content, moisture content, protein content, and shear force of the gilt have significantly higher value than those of the barrow (P<0.05). On the other hand, backfat thickness, lightness (L*), fat content and drip loss were vice versa (P<0.05). Therefore, the gilt appeared better than the barrow in the quality characteristics associated with taste of meat. These results have revealed in our previous study to maintain better meat quality in Berkshire gilt than the barrow (Cho *et al*., 2015).

Relationship between meat quality traits: In this study, the employed pork was divided into five classes according to pH_{24hr}, L* and drip loss (data not shown). The meat quality traits pH_{24hr}, L* and drip loss referred for the classification were examined for association with the other meat quality traits via correlation coefficients. As a result, post-mortem pH_{24hr} was positively correlated with backfat thickness, water holding capacity and moisture content (Table 2). On the contrary, pH_{24hr} was negatively associated with L*, redness (a*), yellowness (b*), drip loss, protein content and cooking loss. From the latter, the higher pH value was maintained, the lower their values induced (P<0.05). L* has significantly positive correlations with drip loss, b*, fat content and cooking loss, but negative correlations with moisture content and shear force (P<0.05). Drip loss was negatively correlated with water holding capacity, but positively associated with a*, b*, protein content, cooking loss and shear force (P<0.05).

It is well-known that post-mortem pH_{24hr} is negative correlations with drip loss or lightness, but positive correlation with water holding capacity (Chmiel *et al*., 2014; Kapper, 2012). The higher values of lightness, redness and yellowness are caused by higher content of oxymyoglobin, which this pattern appears well in PSE meat than RFN meat

Table 1: Mean±SD for the carcass and meat quality analyzed from Berkshire

	Total (n=236)	Barrow (n=103)	Gilt (n=133)
Carcass weight (kg)	84.64±5.51	84.50±5.65	84.76±5.42
Backfat thickness (mm)	24.06±4.81	**26.58±4.34[a]**	**22.11±4.23[b]**
pH_{24hr}	5.78±0.13	5.79±0.14	5.78±0.12
L*	49.10±2.78	**49.90±2.62[a]**	**48.47±2.75[b]**
a*	6.35±1.12	6.27±1.05	6.41±1.17
b*	2.91±1.01	3.01±0.95	2.83±1.05
Water holding capacity (%)	57.57±2.10	57.55±2.04	57.59±2.15
Collagen content (%)	0.90±0.13	**0.87±0.14[a]**	**0.92±0.13[b]**
Fat content (%)	2.74±1.25	**3.28±1.35[a]**	**2.33±0.99[b]**
Moisture content (%)	75.45±0.91	**75.22±1.03[a]**	**75.63±0.76[b]**
Protein content (%)	23.91±0.67	**23.68±0.58[a]**	**24.08±0.68[b]**
Drip loss (%)	4.87±1.72	**5.04±1.81[a]**	**4.73±1.65[b]**
Cooking loss (%)	28.97±2.68	28.94±2.72	28.99±2.65
Shear force (kg)	2.91±0.60	**2.70±0.51[a]**	**3.06±0.62[b]**

L*, a*, and b* represent the meat lightness, redness and yellowness, respectively. pH_{24hr} is pH value measured at 24 hours post-mortem. Significant differences between barrow and gilt are indicated with different superscript lowercase letters according to Duncan’s test (P< 0.05).

Table 2: Pearson correlation coefficients between meat quality traits (n=236)

	pH_{24hr}	L*	Drip loss
L*	**-0.414****	-	-
Drip loss	**-0.339****	**0.458****	-
Carcass weight	0.074	0.048	0.046
Backfat thickness	**0.203****	0.084	-0.012
a*	**-0.182****	-0.013	**0.144***
b*	**-0.260****	**0.449****	**0.214****
Water holding capacity	**0.209****	-0.076	**-0.271****
Collagen content	-0.007	-0.080	0.082
Fat content	0.107	**0.287****	-0.054
Moisture content	**0.130***	**-0.357****	-0.024
Protein content	**-0.326****	0.089	**0.230****
Cooking loss	**-0.294****	**0.270****	**0.276****
Shear force	-0.035	**-0.175****	**0.254****

* Meat quality traits were indicated by the same parameters with Table 1.

(Karamucki *et al.*, 2013). In addition, in this study, positive correlation with pH_{24hr} was shown in meat quality trait such as water holding capacity, which an increase of the trait is associated with maintenance of intact form for meat tissue. However, negative correlation with pH_{24hr} was exhibited in drip loss, cooking loss and meat colors by a phenomenon in the opposite. When post-mortem pH decreases, water holding capacity is reduced due to partial denaturation of protein (Chmiel *et al.*, 2014). Meat which has a lower pH_{24hr} value results in a higher protein content (Kuo and Chu, 2003; van de Perre *et al.*, 2010). Therefore, it is assumed that the accumulation of larger amount of protein in tissue accelerates the decrease of pH owing to increase of the amount for protein degradation, as well as quantitative increase of partial denaturation accelerates the decrease of water holding capacity.

Taken together, since post mortem pH_{24hr}, drip loss and color were significantly correlated with meat qualities except for carcass weight and collagen content, it is considered to have a rationale to distinguish the meat category based on these factors.

Meat quality traits in different pork quality classes: The applied meats were included into five classes by numbers in the order such as RFN (107) > PSE (56) > RSE (38) > PFN (33) > DFD (2) (Table 3). Meat quality characteristics owing to pork quality classification of the examined pigs were significant differences on pH_{24hr}, L*, a*, b*, fat content, moisture content, protein content, drip loss, cooking loss and shear force. Since DFD meat maintained high ultimate pH, the low values of drip loss and lightness occurred. However, since DFD meat was displayed as a low number (n=2), pork to satisfy the conditions of DFD appeared to be not readily formed. RFN of a normal meat occupying the most amount maintained the intermediate values for pH_{24hr}, lightness and drip loss in the classification. Although PSE meat showed a value of the lowest pH, lightness and drip loss were similar with the values of PFN and RSE, respectively. PFN had a value of higher pH_{24hr} than that of PSE meat, but was vice versa for drip loss. RSE meat was similar pH_{24hr} and lightness with RFN, but was a similar pattern with PSE for drip loss.

The occurrence of PSE and DFD has been internationally recognized as a major economic risk factor for fresh pork (van de Perre *et al.*, 2010; Adzitey and Nurul, 2011). Furthermore, a major cause of PSE and DFD has been evaluated as stress due to pre-slaughter handlings which can adversely affect the quality of pork. Long-term stress mainly leads to meat quality associated with DFD meat, while short-term stress mainly leads to quality associated with RSE or PSE meat (Rosenvold and Andersen, 2003). Therefore, since pork used in this study displayed the low DFD numerical, it is assumed that the long-term stress hardly

Table 3: Comparison among meat quality classes according to pH_{24hr}, L* and drip loss values in Berkshire

	DFD(n=2)	PFN(n=33)	PSE(n=56)	RFN(n=107)	RSE(n=38)
Carcass weight	89.00±4.24	84.15±5.12	85.57±5.43	84.27±5.73	84.53±5.38
Backfat thickness	23.50±12.02	24.79±4.61	24.50±4.77	23.79±4.61	23.61±5.37
pH_{24hr}	**6.21±0.26^{a}**	**5.77±0.14^{b}**	**5.71±0.10^{b}**	**5.81±0.12^{b}**	**5.80±0.11^{b}**
L*	**41.76±0.06^{c}**	**51.44±1.20^{a}**	**52.21±1.68^{a}**	**47.33±1.71^{b}**	**47.82±1.43^{b}**
a*	6.91±0.24	6.04±1.16	6.46±1.21	6.28±0.95	6.60±1.34
b*	**1.95±0.72^{b}**	**3.37±1.11^{a}**	**3.35±1.09^{a}**	**2.65±0.87^{ab}**	**2.62±0.81^{ab}**
Water holding capacity	58.48±0.63	57.93±2.14	57.06±1.88	58.04±2.09	56.65±2.06
Collagen content	0.82±0.19	0.87±0.14	0.88±0.15	0.90±0.12	0.92±0.13
Fat content	**2.88±1.03^{ab}**	**3.82±1.74^{a}**	**2.81±1.34^{ab}**	**2.50±0.91^{b}**	**2.39±0.95^{b}**
Moisture content	**76.47±1.56^{a}**	**74.73±1.23^{c}**	**75.27±0.95^{bc}**	**75.61±0.63^{b}**	**75.83±0.77^{ab}**
Protein content	**23.07±0.59^{b}**	**23.57±0.67^{ab}**	**24.16±0.62^{a}**	**23.88±0.64^{a}**	**23.95±0.68^{a}**
Drip loss	**1.93±0.04^{c}**	**4.12±0.62^{b}**	**6.66±1.45^{a}**	**3.68±0.80^{b}**	**6.35±1.20^{a}**
Cooking loss	**24.72±2.14^{b}**	**29.01±2.96^{a}**	**29.85±2.55^{a}**	**28.27±2.51^{a}**	**29.81±2.39^{a}**
Shear force	**3.08±0.95^{a}**	**2.51±0.49^{b}**	**2.96±0.67^{ab}**	**2.87±0.51^{ab}**	**3.27±0.59^{a}**

* Meat quality traits were indicated by the same parameters with Table 1.

Table 4: Comparison among meat quality classes according to pH$_{24hr}$, L* and drip loss values in barrow and gilt pigs

	Barrow (n=103)					Gilt (n=133)			
	DFD (n=2)	PFN (n=22)	PSE (n=29)	RFN (n=33)	RSE (n=17)	PFN (n=11)	PSE (n=27)	RFN (n=74)	RSE (n=21)
Carcass weight	89.00±4.24	84.32±5.61	85.97±5.15	82.64±6.15	85.29±5.01	83.82±4.21	85.15±5.78	85.00±5.42	83.90±5.71
Backfat thickness	23.50±12.02	26.00±4.06	26.31±4.12	27.39±4.85	26.59±3.10	22.36±4.86	22.56±4.73	22.18±3.47	21.19±5.65
pH$_{24hr}$	**6.21±0.26^{a}**	**5.79±0.14^{b}**	**5.72±0.09^{b}**	**5.82±0.13^{b}**	**5.80±0.12^{b}**	**5.72±0.12^{b}**	**5.70±0.10^{b}**	**5.81±0.11^{a}**	**5.80±0.11^{a}**
L*	**41.76±0.06^{c}**	**51.58±1.35^{a}**	**52.12±1.66^{a}**	**48.14±1.42^{b}**	**48.31±1.52^{b}**	**51.17±0.80^{b}**	**52.31±1.72^{a}**	**46.97±1.71^{c}**	**47.42±1.24^{c}**
a*	**6.91±0.24**	**5.99±1.05**	**6.52±1.06**	**6.06±0.95**	**6.55±1.14**	6.16±1.39	6.40±1.36	6.38±0.94	6.65±1.51
b*	**1.95±0.72^{b}**	**3.32±1.13^{a}**	**3.21±0.95^{a}**	**2.84±0.85^{ab}**	**2.69±0.70^{ab}**	**3.49±1.09^{a}**	**3.50±1.23^{a}**	**2.57±0.87^{b}**	**2.55±0.89^{b}**
Water holding capacity	58.48±0.63	57.69±2.16	56.97±1.67	58.20±2.06	57.01±2.28	**58.42±2.09^{a}**	**57.17±2.11^{ab}**	**57.97±2.12^{a}**	**56.36±1.88^{b}**
Collagen content	0.82±0.19	0.86±0.14	0.83±0.13	0.90±0.12	0.89±0.16	0.90±0.13	0.94±0.15	0.90±0.12	0.95±0.09
Fat content	2.88±1.03	4.20±1.83	3.27±1.35	2.93±0.82	2.86±0.97	**3.06±1.30^{a}**	**2.32±1.16^{b}**	**2.31±0.89^{b}**	**2.00±0.76^{b}**
Moisture content	**76.47±1.56^{a}**	**74.58±1.30^{b}**	**75.15±1.00^{b}**	**75.48±0.74^{ab}**	**75.53±0.79^{ab}**	**75.03±1.09^{c}**	**75.41±0.89^{bc}**	**75.67±0.57^{ab}**	**76.08±0.68^{a}**
Protein content	**23.07±0.59^{b}**	**23.40±0.65^{ab}**	**23.88±0.47^{a}**	**23.65±0.56^{ab}**	**23.81±0.56^{a}**	**23.91±0.59^{b}**	**24.45±0.63^{a}**	**23.98±0.65^{b}**	**24.06±0.75^{ab}**
Drip loss	1.93±0.04	4.05±0.59	6.61±1.71	3.79±0.67	6.48±1.38	**4.27±0.69^{b}**	**6.72±1.14^{a}**	**3.64±0.85^{c}**	**6.25±1.05^{a}**
Cooking loss	**24.72±2.14^{b}**	**28.53±3.18^{a}**	**29.09±2.52^{a}**	**28.98±2.70^{a}**	**29.59±2.28^{a}**	**29.97±2.30^{a}**	**30.66±2.38^{a}**	**27.95±2.38^{b}**	**29.99±2.52^{a}**
Shear force	**3.08±0.95^{a}**	**2.39±0.39^{b}**	**2.71±0.62^{ab}**	**2.72±0.35^{ab}**	**3.02±0.46^{a}**	**2.74±0.60^{c}**	**3.23±0.62^{ab}**	**2.93±0.56^{bc}**	**3.47±0.62^{a}**

* Meat quality traits were indicated by the same parameters with Table 1.

received. However, since a relatively large number of PSE and RSE meats displayed, we suggest that the short-term stress is given in the slaughter process.

Comparison of meat quality classes depending on gender: As shown in Table 4, the barrow from the component ratio of Berkshire gilt and barrow according to meat quality classification, except for DFD, was shown by a relatively uniform distribution in PFN, PSE, RFN and RSE. However, the gilt was not DFD meat, but RFN meat was accounted by the relatively high percentage when compared to PFN, PSE and RSE. Therefore, when compared between the gilt and barrow, PFN and PSE meats exhibited relatively high percentages in the barrow, whereas the frequency of RFN meat in the gilt appeared very high. RSE meat was a similar in both sexes. Meats with reddish- and pink-attributes, which consumers are generally preferred over the analysis of the distribution through meat quality classification depending on the gender, were relatively large number of population in the gilt. However, pale- and exudative-attributes, which consumers hate the meat type, were detected by a relatively high percentage in the barrow. Therefore, as described at characteristics of meat associated with stresses (Rosenvold and Andersen, 2003), it was displayed that the barrow is more sensitive to long- and short-term stresses than those of the gilt. For this reason, as economic production ratio of female pigs is higher than that of male pigs (or barrow), producer is able to increase the economic benefits by rearing a large number of female pigs. Fallowing sows have different gender production ratio depending on the nutritional status (Foxcroft *et al*., 2007). In other words, when the sows are well-maintained for nutritional status, a new born ratio of female pig is relatively higher than that of male pigs. Therefore, producer is necessary to systematically manage the nutrition of sow.

Taken together, it is suggested that the gilt produces more favorite meat for consumers than the barrow (or boar) in the characteristic that consumers prefer the pork with reddish- and non-exudative- attributes. In addition, it is assumed that the gilt is less susceptible to relative effect on stress, because DFD and PSE meats with dark- and pale- attributes to be repellent from consumers are caused by stress.

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