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pH as Analytical Indicator for Managing Pork Meat Quality

(pH sebagai Petunjuk Analisis bagi Menguruskan Kualiti Daging Khinzir)

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ABSTRACT

In order to examine differences of meat quality traits depending on pH values post-mortem, the pH range was classified according to initial pH (pH_{45min}) and ultimate pH (pH_{24hr}) post-mortem. The differences of meat quality traits depending on sex were not changed by a number of amount, except for backfat thickness and fat content. The value of pH_{45min} was positively correlated with pH_{dif}, whereas pH_{24hr} was negatively associated with lightness (CIE L) and protein content. At pH_{45min} post-slaughter, collagen content, fat content, shear force, water holding capacity and yellowness (CIE b*) showed lower values at the higher pH range of pH>6.7 than those of other ranges, but CIE L* and redness (CIE a*) presented the lowest value at the intermediate pH range of pH6.3~6.7. Conversely, at pH_{24hr} post-slaughter, fat and moisture contents maintained the highest average values at the higher pH range of pH>6.1, but protein content showed higher value at the lower pH range of pH<5.7. Higher pH_{24hr} appeared significantly lower shear force, but higher water holding capacity. CIE L*, a*, and b* values showed significantly higher values at the lowest region of pH_{24hr}. Since meat quality characteristics seemed to be favored by consumers in rather than at the range of pH5.7~6.1, which showed significant differences of meat color, appearance, and meat juiciness, it is suggested that production of pork meat to appropriate pH value is performed by pig breeders and control measures taken during pre- and post-slaughters.*

Keywords: Berkshire; meat quality trait; post-mortem pH; pH_{45min}, pH_{24hr}

ABSTRAK

*Dalam usaha untuk mengkaji perbezaan ciri-ciri kualiti daging bergantung kepada nilai pH bedah siasat, julat pH telah dikelaskan mengikut bedah siasat pH awal (pH45min) dan pH muktamad (pH24hr). Perbezaan ciri-ciri kualiti daging bergantung kepada jantina tidak diubah oleh beberapa nilai, kecuali ketebalan backfat dan kandungan lemak. Nilai pH45min korelasi positif dengan pHdif, manakala pH24hr telah negatif dikaitkan dengan ringan (CIE L *) dan kandungan protein. Pada pH45min selepas penyembelihan, kandungan kolagen, kandungan lemak, daya ricih, air memegang kapasiti dan kekuningan (CIE b *) menunjukkan nilai yang lebih rendah pada julat pH yang lebih tinggi pH> 6.7 berbanding dengan julat yang lain, tetapi CIE L * dan kemerahan (CIE * a) menunjukkan nilai yang paling rendah pada julat pH pertengahan pH6.3 ~ 6.7. Sebaliknya, di pH24hr selepas penyembelihan, lemak dan kelembapan kandungan mengekalkan nilai purata tertinggi pada julat pH yang lebih tinggi pH> 6.1, tetapi kandungan protein menunjukkan nilai lebih tinggi pada julat pH yang lebih rendah pH <5.7. pH24hr menunjukkan daya ricih jauh lebih rendah, tetapi kapasiti pegangan air yang lebih tinggi. CIE L *, *, dan nilai-nilai * b menunjukkan nilai-nilai yang lebih tinggi di bahagian paling rendah di pH24hr. Sejak ciri-ciri kualiti daging seolah-olah digemari oleh pengguna di bukannya pada julat pH5.7 ~ 6.1, yang menunjukkan perbezaan yang signifikan pada warna daging, rupa, dan air daging, adalah dicadangkan bahawa pengeluaran daging khinzir kepada nilai pH yang sesuai perlu dilakukan oleh penternak khinzir dan bergantung kepada langkah-langkah kawalan yang diambil semasa, sebelum dan selepas penyembelihan.*

Kata kunci: Berkshire; pH bedah siasat; pH_{45min}, pH_{24h}; sifat daging berkualiti

INTRODUCTION

Meat quality is economically important because it play a critical role to the purchase intention of consumers and directly connecting to revenue of producer. Therefore, recent pork industry has focused for the production of meat to maintain the best quality and for induction of economic production. Although many researchers have pointed out the importance of pork quality (Gonzalez et al. 2014; Miar et al. 2014; Turyk et al. 2014), it is difficult to predict pork quality due to many factors affecting the quality. Thus there is no single definition for high quality meat applied in pork industry to date. Nevertheless, pork quality is classified on the basis of surface exudate, color and ultimate pH post-slaughter and the classification of pork quality is generally done by specialists through visual observation (Prieto 2007). Pork on the basis of their classification criteria has been divided into four categories such as PSE (pale, soft, exudative), RSE (reddish-pink, soft and exudative), RFN (reddish-pink, firm and non-exudative) and DFD (dark, firm and dry) (Kauffman et al. 1992; Lee et al. 2000; Warner

1994). PSE and DFD meats are identified on the basis of pH value, color (CIE L* value) and drip loss, but consumers discriminate against these meats (Adzitey & Nurul 2011; Van de Perre et al. 2010). In addition, the important factors affecting the meat quality are genetic characteristics of pig, mooring before slaughter, slaughter method and handling pre- and post-slaughters (Pearce et al. 2011; Xu et al. 2012). Therefore, meat quality is generally described as the sum of all the meat quality characteristics, and these characteristics are adjusted by function of muscular pH (Pearce et al. 2011).

Muscle of live pig has a neutral pH value of 7.0 to 7.2. As the muscle is converted to meat, the meat that has lack of oxygen supply causes anoxia, drops in pH and as a result, organic acids including lactic acid or inorganic acids accumulate in the muscle (Pearce et al. 2011). The accumulation of acidic substances is derived to acidification and pH decrease. Muscle pH post-mortem and pH decline rate affect water holding capacity and water holding capacity determines both drip loss from raw pork and cooking loss during cooking (Pearce et al. 2011). The value of pH post-mortem is generally measured within 1 h post-slaughter (initial pH or pH_{45min}) or within 24 h (ultimate pH or pH_{24h}). PIC (2003) has suggested that the preferred ranges for initial and ultimate pH are 6.3 to 6.7 and 5.7 to 6.1, respectively. If initial pH is 5.8 or less, an ultimate pH of the meat has high possibility of maintaining pH value below 5.5 and the pork is converted into PSE depending on too low pH and too rapidly pH decrease. On the other hand, a meat above ultimate pH6.1 was classified into DFD because of no decrease of pH to normal level. It was defined that PSE meat maintains pH_{45min} and ultimate pH_{24h} values of 6.0 or less and 5.3, respectively, but DFD meat has those values of 6.4 and 6.0 or more, respectively (Warriss 2000). On the other hand, normal meat maintains those values by 6.4 and 5.5, respectively (Adzitey & Nurul 2011). In addition, reducing rate of pH post-mortem is an important determinant of meat color and water holding capacity (Tomovic et al. 2014).

In this study, for entrepreneur related to production, distribution and sale of port, correlations among initial pH, ultimate pH, and pH difference between initial and ultimate pH values post-mortem were examined. Analyses on the differences of meat quality characteristics at initial and ultimate pH values post-mortem were also monitored.

Materials and Methods

Sampling and Classification

A total of 327 American Berkshire pigs (barrow; 139, gilt; 188) of approximately 180 day olds originating from the same farm (Dasan Genetics) were employed for this study. The measurements of pH_{45min} were carried out after slaughter at a commercial slaughterhouse. After that, individual *longissimus dorsi* muscles of Berkshire pigs were collected, transferred into a refrigerated condition in a laboratory and examined for meat quality traits and pH_{24h}. In this study, the values of pHs post-mortem according to classification of DFD and PSE in PIC (2003) were divided into three ranges as follows:

pH value of *longissimus dorsi* at post-mortem 45 min: <6.3, 6.3~6.7 and >6.7

pH value of *longissimus dorsi* at post-mortem 24 h: <5.7, 5.7~6.1 and >6.1

Analyses of Proximate Physical Characteristics and Chemical Composition

Berkshire pigs weighing approximately 110 kg were transported into a slaughterhouse close to an experimental station. Pigs were slaughtered by stunning with electrical tongs (300 volts for 3 s) after 12 h 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 a knife and flame. Carcasses were eviscerated and split before being placed in a chiller set at 2~4°C for 12 h.

Physical properties and chemical composition, including backfat thickness, moisture, protein, Fat, WHC, meat color, DLoss, CLoss and Coll, were measured according to methods employed in previous studies (AOAC 2000; Cho et al. 2015; Kim et al. 2016; Kristensen et al. 2001; Park et al. 2015).

Statistics Analysis

Descriptive statistics for meat quality traits were examined depending on sex and Pearson's correlation coefficients were calculated between pHs (initial and ultimate values and pH difference between initial and ultimate pHs) and various meat quality variables. Difference of meat quality in three ranges of pH_{45min} and pH_{24hr} (<6.3, 6.3~6.7 and >6.7 for pH_{45min}, <5.7, 5.7~6.1 and >6.1 for pH_{24hr}) were separately analyzed using analysis of variance (ANOVA) models. All variances in the model were considered as fixed effects except residual effect and the model was considered to be independently and normally distributed. Individual comparisons among least squares means (LSM) for significant differences were made according to multiple range test of Duncan (post-hoc test). All analyses were performed within SAS statistical software package (version 9.1, SAS Inst., Inc., USA), and differences were significantly considered at $P<0.05$.

Results

Analyses of Pork Quality Traits Depending on Sex

The pork quality attributes between fattening female (gilt) and castrated male (barrow) pigs were examined from 327 pigs of American Berkshire as shown in Table 1 through results of descriptive statistics. Carcass weight was not significantly different between barrow and gilt, but backfat thickness of barrow was significantly thicker than that of

TABLE 1. Analysis of meat quality traits and parameters measured in pork *Longissimus dorsi* of American Berkshire

Meat quality traits and parameters		Total (n=327)	Barrow (n=139)	Gilt (188)
traits	Carcass weight (kg)	84.93±5.43	84.28±5.76	85.40±5.14
	Backfat thickness (mm)	24.24±4.98	26.73±4.31^a	22.39±4.63^b
parameters	pH_{45min}[1]	6.34±0.28	6.37±0.29	6.32±0.27
	pH_{24h}[2]	5.83±0.18	5.85±0.20^a	5.81±0.16^a
	pH_{dif}[3]	0.51±0.30	0.51±0.32	0.51±0.29
	Collagen content (%)	0.89±0.13	0.87±0.14^b	0.91±0.13^a
	Fat content (%)	2.80±1.19	3.39±1.26^a	2.37±0.93^b
	Moisture content (%)	75.49±0.87	75.26±0.97^b	75.67±0.75^a
	Protein content (%)	23.88±0.73	23.60±0.69^b	24.08±0.70^a
	Warner-Bratzler shear force (kg)	2.75±0.60	2.56±0.53^b	2.89±0.62^a
	Water holding capacity	58.71±2.57	58.26±2.42^b	59.04±2.64^a
	Drip loss (%)	4.18±1.68	4.33±1.90	4.08±1.50
	Cooking loss (%)	27.36±3.90	27.47±4.10	27.27±3.75
	CIE L*[4]	48.58±2.73	49.26±2.76^a	48.08±2.60^b
	CIE a*[5]	6.15±1.02	6.18±0.99	6.14±1.05
	CIE b*[6]	3.04±1.07	3.01±1.02	3.06±1.10

[1]pH_{45min}, [2]pH_{24h}, and [3]pH_{dif} are initial pH, ultimate pH and difference between initial and ultimate pH, respectively. [4,5,6]CIE L*, a*, and b* represent meat lightness, redness and yellowness, respectively. [ab] indicates significant difference within raw at p< 0.05

gilt (p<0.05). Furthermore, ultimate pH was significantly different between barrow and gilt (p<0.05), but initial pH and pH changes (pH_{dif}) were not significantly different depending on sex. In addition, collagen content, fat content, moisture content, protein content, shear force, water holding capacity and CIE L* were significantly different between barrow and gilt. It was observed that average values of collagen content, moisture content, protein content, shear force and water holding capacity from gilt were significantly higher than those of barrow (p<0.05). According to these results, the quality characteristics associated with taste of meat from gilt showed higher average values than those of barrow. However, although various meat quality traits were significant differences between barrow and gilt, the differences were not caused by large quantities, except for backfat thickness and fat content.

RELATION BETWEEN MEAT QUALITY TRAITS AND PHS POST-MORTEM

It is well-known that pH post-mortem of pork drops a certain level after lapse of a certain time. An overall significant correlation was exhibited between pHs (initial pH, ultimate pH and pH difference between initial and ultimate pH) post-mortem and meat quality traits (Table 2). Negative correlations were observed between pH_{45min} and carcass weight, backfat thickness, CIE L*, CIE b*, water holding capacity, collagen content, fat content, drip loss, or shear force (p<0.05), but positive correlations were showed between pH_{45min} and pH_{24hr}, pH_{dif}, or protein content. The value of pH_{24hr} post-mortem was negatively correlated with CIE L*, CIE b*, protein content, drip loss and shear force, but positively associated with carcass weight, backfat thickness, water holding capacity, collagen content and fat content.

The value of pH_{dif} post-mortem was negatively correlated with carcass weight, backfat thickness, CIE b*, water holding capacity, collagen content, fat content and shear force, but positively associated with CIE L*, protein content and drip loss. From these results, the higher values of carcass weight, backfat thickness, CIE b*, water holding capacity, collagen content, fat content and shear force decreased decline rate of ultimate pH. However, the higher values of CIE L*, protein content and drip loss increased decline rate of ultimate pH.

MEAT QUALITY TRAITS IN DIFFERENT INITIAL pH RANGES

The difference of general component in pork classified into three ranges on the basis of pH_{45min} for normal meat was shown in Table 3. Collagen, fat and protein content were significantly different between the ranges of pH, but moisture content was not statistically different (Table 3). Especially, as the values of pH is high ranges, collagen and fat contents were lower and the lowest average values for the traits were found from the range of pH>6.7. However, protein content showed the lowest value in 6.3≤pH≤6.7 range which classified into the normal meat (p<0.05).

Shear force and water holding capacity in physical characteristics of pork *Longissimus dorsi* showed significant differences between pH values of the category and both the average values was the lowest in pH>6.7 (Table 3). However, drip and cooking loss were not statistically different. Meat colors in pH_{45min} ranges showed significant differences in all the applied traits such as CIE L*, a* and b* (Table 3). CIE L* and a* were the lowest at 6.3~6.7 range, but the highest at >6.7. CIE b* was the lowest at >6.7, but the highest at <6.3.

TABLE 2. Correlation coefficients between pH values post-mortem and meat quality differentiates among traits and parameters measured in pork *Longissimus dorsi* (n=327)

Meat quality traits and parameters		pH_{45min}	pH_{24h}	pH_{dif}
parameters	pH_{45min}[1]	1.000		
	pH_{24h}[2]	**0.201**	1.000	
	pH_{dif}[3]	**0.803**	**-0.423**	1.000
traits	Carcass weights (kg)	-0.133	0.056	**-0.157**
	Backfat thickness (mm)	**-0.100**	**0.204**	**-0.217**
parameters	CIE L*[4]	**-0.022**	**-0.527**	**0.301**
	CIE a*[5]	**-0.192**	**-0.248**	-0.027
	CIE b*[6]	**-0.437**	**-0.435**	**-0.139**
	Water holding capacity	**-0.294**	**0.160**	**-0.370**
	Collagen content (%)	**-0.132**	0.005	**-0.125**
	Fat content (%)	**-0.125**	**0.196**	**-0.235**
	Moisture content (%)	**0.124**	**0.151**	0.023
	Protein content (%)	0.010	**-0.518**	**0.324**
	Drip loss (%)	**-0.116**	**-0.392**	**0.132**
	Cooking loss (%)	**-0.120**	**-0.209**	0.016
	Warner-Bratzler Shear force (kg)	**-0.347**	**-0.256**	**-0.165**

[1]pH_{45min}, [2]pH_{24h}, and [3]pH_{dif} are initial pH, ultimate pH, and difference between initial and ultimate pH, respectively. [4,5,6]CIE L*, a*, and b* represent meat lightness, redness and yellowness, respectively. Significant correlations are shown in bold (p< 0.05)

TABLE 3. Analysis between pH values in the different ranges of pH_{45min} post-mortem and meat quality differentiates among traits and parameters measured in pork *Longissimus dorsi*

Parameters		<6.3 (n=80)	6.3-6.7 (n=214)	>6.7 (n=33)
Proximate chemical compositions	Collagen content (%)	0.91 ± 0.14^{a}	0.89 ± 0.13^{a}	0.85 ± 0.12^{b}
	Fat content (%)	2.87 ± 1.28^{a}	2.84 ± 1.18^{a}	2.47 ± 0.79^{b}
	Moisture content (%)	75.41 ± 0.94	75.58 ± 0.85	75.58 ± 0.63
	Protein content (%)	23.91 ± 0.75^{ab}	23.75 ± 0.74^{a}	24.07 ± 0.61^{b}
Physical characteristics	Warner-Bratzler shear force (kg)	2.92 ± 0.62^{a}	2.63 ± 0.54^{b}	2.40 ± 0.49^{c}
	Water holding capacity	59.19 ± 2.33^{a}	59.01 ± 2.75^{a}	56.23 ± 1.24^{b}
	Drip loss (%)	4.40 ± 1.61	3.90 ± 1.77	4.14 ± 1.64
	Cooking loss (%)	27.62 ± 4.15	27.27 ± 4.00	26.62 ± 2.39
Meat color characteristics	CIE L*[1]	48.71 ± 2.71^{ab}	48.17 ± 2.80^{a}	49.19 ± 2.51^{b}
	CIE a*[2]	6.34 ± 1.04^{b}	5.90 ± 0.94^{a}	6.12 ± 1.05^{ab}
	CIE b*[3]	3.37 ± 0.91^{a}	2.96 ± 1.14^{b}	2.05 ± 0.68^{c}

[1,2,3]CIE L*, a*, and b* represent the meat lightness, redness and yellowness, respectively. [abc] indicates significant difference within raw at p< 0.05

MEAT QUALITY TRAITS IN DIFFERENT ULTIMATE pH RANGES

The difference of general component classified into three ranges on the basis of pH_{24hr} was shown in Table 4. Fat, moisture and protein contents from an analyzed result of pH_{24hr} were significant differences (p<0.05), but collagen content was not statistically different. Especially, fat and moisture contents were the highest average values at pH>6.1, whereas protein content was the highest average value at pH<5.7.

According to the results of comparison between the physical properties of the pork *Longissimus dorsi* based on pH_{24hr} (Table 4), as pH_{24hr} was higher, shear force appeared significantly lower (p<0.05). As pH_{24hr} was lower, water holding capacity was significantly lower, but drip and cooking loss was significantly higher. According to the result of a comparison between the meat color properties of pork *Longissimus dorsi* based on pH_{24hr} (Table 4), the lowest range of pH_{24hr} showed significantly higher values of CIE L*, a*, and b*.

DISCUSSION

In order to investigate the effects on meat quality owing to pHs post-mortem, we classified into three pH ranges according to initial and ultimate pH values which was known to play an important role in evaluation of meat quality and then analyzed the difference in meat quality characteristics based on this category. First, we analyzed correlation between pH values and meat quality traits

TABLE 4. Analysis between pH values in the different ranges of pH_{24h} post-mortem and meat quality differentiates among traits and parameters measured in pork *Longissimus dorsi*

Parameters		<5.7 (*n*=80)	5.7-6.1 (*n*=214)	>6.1 (*n*=33)
Proximate chemical compositions	Collagen content (%)	0.89±0.14	0.90±0.13	0.88±0.14
	Fat content (%)	2.64±1.09[a]	2.76±1.20[a]	3.50±1.18[b]
	Moisture content (%)	75.28±0.85[a]	75.55±0.86[ab]	75.65±0.93[b]
	Protein content (%)	24.30±0.63[b]	23.84±0.67[c]	23.06±0.57[a]
Physical characteristics	Warner-Bratzler Shear force (kg)	2.84±0.56[a]	2.79±0.61[a]	2.23±0.42[b]
	Water holding capacity	58.48±2.41[a]	58.62±2.56[a]	59.85±2.81[b]
	Drip loss (%)	4.84±2.04[a]	4.16±1.43[b]	2.78±1.32[c]
	Cooking loss (%)	27.52±4.70[b]	27.64±3.45[c]	25.12±3.96[a]
Meat color characteristics	CIE L*[1]	50.11±2.36[a]	48.45±2.49[b]	45.78±2.61[c]
	CIE a*[2]	6.48±1.04[a]	6.10±0.99[b]	5.72±1.01[c]
	CIE b*[3]	3.78±1.02[a]	2.88±0.96[b]	2.32±0.87[c]

[1,2,3]CIE L*, a*, and b* represent the meat lightness, redness and yellowness, respectively. [abc] indicates significant difference within raw at $p< 0.05$

post-mortem depending on sex. The various meat quality traits including backfat thickness, pH_{24hr}, collagen content, moisture content, protein content, shear force, water holding capacity and cooking loss showed significant differences between barrow and gilt (Table 1). However, the differences were not caused by a large amount, except for backfat thickness and fat content. These results indicated that the total average values were suitable for evaluation of meat quality traits.

According to the results of associations between pH_{45min}, pH_{24hr}, or pH_{dif} and individual meat quality traits, correlations between initial pH and meat quality characteristics showed differential association with ultimate pH (Tables 2, 3 & 4). It is assumed that the difference of association is owed to change between initial and ultimate pHs post-mortem. As a method to prevent a high variation of pH in progress from initial pH to ultimate pH, an effective method to reduce pH decline rate of carcass was to reduce temperature immediately after slaughter (Offer 1991). This procedure reduced denaturation yield of total protein and improves water holding capacity, but extends period of rigor mortis (Maribo et al. 1988).

PSE which causes considerable variations of pH values has been internationally recognized as a major economic risk factor for fresh and processed pork (Kuo & Chu 2003; Van de Perre et al. 2010). In particular, it has been recognized for a long time that pre-slaughter stress adversely affects pork quality (Rosenvold & Andersen 2003), because the stress immediately before slaughter leads to change in pH value of muscle. Pre-slaughter stress causes more rapid pH decline and higher muscle temperatures, which results in denaturation of myofiber protein (Bond & Warner 2007; Offer 1991; Offer & Knight 1988). As a consequence, water is less firmly bound into internal structure (Offer & Knight 1988) in which this loosely bound water may be actually lost as muscle pH approaches isoelectric point of muscular proteins (pH5.0). On the other hand, low glycolytic potentials lead to higher ultimate pH, partly preventing water associated with the meat from release (Hambrecht et al. 2004).

Meat of PSE characteristics has lower initial and ultimate pH values of 6.0 or less and 5.3, respectively (Irving et al. 1989; Offer & Knight 1988) resulting in lower water holding capacity (Hedrick et al. 1994). However, the results of <pH6.3 and 6.3~6.7 ranges from initial pH post-mortem in this study showed higher water holding capacity than that of >pH6.7 (Table 3) which is different properties with PSE. It is assumed from this result that higher water holding capacities are owed to higher pH ranges than that of PSE. Water holding capacity of pork has been influenced by a number of factors including ultimate pH (Offer & Knight 1988). Meat of lower water holding capacity (low pH) is associated with lower amount of water than that of normal meat and lower ultimate pH is related with higher protein content (Kuo & Chu 2003; Van de Perre et al. 2010). In this study, we conclude that lower pH in pH_{24h} is associated with lower moisture content, but higher protein content (Table 4).

A very low ultimate pH results in paler color, but as ultimate pH increases, the meat gradually becomes darker colour (Boles & Pegg 1999). Meat colors L*, a*, and b* values are related with water holding capacity, which pork of higher water holding capacity has darker color (Kapper 2012; Mancini & Hunt 2005). CIE L* value is the best overall indicator for PSE and DFD pork (Tomovic et al. 2014). It is very meaningful which examines meat traits to suppress occurrence of abnormal meats through analysis of association between factors associated with PSE and DFD meats. As proposed by Lee et al. (2000), when classification of PSE, RSE, RFN and DFD was accurately identified for all the pork carcasses, the quality variations may be either eliminated or minimized. In addition, since these quality classes are ultimately dependent on the extent of metabolism pre- and post-slaughters within pig muscle tissue (Suckling 2012), it is suggested that pork quality characteristics preferred by consumers can be monitored using stringent management practices, taking pH parameter as a prudent consideration as shown in this study.

Conclusion

Based on the result of analysis in this study, various meat characteristics displayed different values depending on pH values post-mortem, which moisture content, water holding capacity, drip loss, cooking loss, and CIE a* were affected by change rates of initial and ultimate pH values post-mortem. Since the value above pH>6.1 in ultimate pH is a high possibility to induce DFD pork which is disliked by consumers, it is assumed that the value of pH5.7~6.1 is the most suitable pork for consumers. Therefore, we suggest that pig-breeding and managements of pre- and post-slaughters are critically important for pork production to maintain its appropriate pH at pH_{24h}. In addition, we also suggest that pH is an important criterion for evaluation of meat quality to entrepreneurs directly-faced with consumers of pork.

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