PE1.34 Availability of Blood Glucose as the Indicator for Pork Quality 238.00

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***Abstract*— The objective of this study was to examine the availability of blood glucose as an indicator of pork quality. A total of 100 crossbred pigs were assessed through blood glucose, muscle pH, pork quality traits, and protein solubility. The results showed that blood glucose levels were significantly different ($P < 0.001$) among various pork quality classes. Pale, soft, and exudative pork showed the highest blood glucose level, and reddish-pink, soft, and exudative pork showed significantly lower blood glucose level than reddish-pink, firm, and non-exudative pork ($P < 0.05$). Moreover, blood glucose level was significantly related to muscle $pH_{45\ min}$ ($P < 0.001$), $pH_{24\ h}$ ($P < 0.01$), pork quality traits (drip loss, filter-paper fluid uptake, and lightness) ($P < 0.001$), and protein solubility ($P < 0.001$). Based on these results, blood glucose level can be a useful indicator of pork quality.**

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***Index Terms*— Blood glucose, muscle pH, pork quality, quality class**

I. Introduction

Living organisms regulate their blood glucose levels for homeostasis, and thus blood glucose is maintained within a reference range. Blood glucose levels are primarily regulated by a balance between anabolic (insulin) and catabolic (glucagon, catecholamine, growth hormone) hormones [10, 15]. However, individuals who have the metabolic disorder remain in a state of high or low blood glucose [16]. Thus, assessments of blood glucose are used to diagnosis and manage the disease. Moreover, measuring blood glucose is rapid and easy.

Some studies have looked at blood metabolite concentrations in cattle, suggesting that such concentrations may be useful indicators for evaluating metabolic changes [1, 2, 11, 13]. Other research has shown the close relationships between free glucose in exudates and meat quality traits [6]. Our previous research indicated that blood glucose level measured at slaughter was related to muscle fiber type area percentage and pork quality [3]. Therefore, the objective of this study was to examine the availability of blood glucose as an indicator of pork quality.

II. Materials and Methods

1. Animals and muscle samples

A total of 100 crossbred (Landrace × Yorkshire × Duroc) pigs were evaluated. The treatment conditions for all pigs were similar both before and after slaughter, and all treatment conditions and experimental procedures were approved by the Ministry for Food, Agriculture, Forestry, and Fisheries. The pigs were fed the same commercial diet and were raised in different pens at the same farm under similar conditions. The pigs were transported to a commercial abattoir under the same conditions and handling, and were slaughtered at a similar live weight (110 ± 5 kg). Slaughter was performed during winter period in two batches (50 and 50 pigs per each slaughter batch) at the slaughter plant by standard procedures under the supervision of the Korean grading service for animal products. The slaughter plant used electrical stunning and a traditional scalding-singeing process. Following electrical stunning, while the pigs were exsanguinated, blood samples were collected to measure blood glucose levels. After evisceration, the carcasses were weighed and the loin eye area was measured at the level of the last rib. At postmortem 45 min and 24 h, muscle pH were measured directly on the carcass at the 7th/8th thoracic vertebra. After 24 h of chilling in a 4 °C cold room, samples from the pork loins (the 10th-13th thoracic vertebra) were taken to measure meat quality traits and protein solubility.

2. Blood glucose level

Blood samples were collected at the slaughter plant during exsanguination using 10.0 ml tubes treated with heparin (BD Vacutainer® sodium heparin tube, Becton Dickinson). The blood glucose levels of the samples were measured immediately using a human blood glucose checking device (OneTouch Ultra®, LifeScan, Inc.). This process involved the addition of over 1 µl of sample to a test strip that was then fed into a glucose analyzer. All measurements were completed within 10 min after exsanguination.

3. Meat quality traits and protein solubility

Muscle pH were measured in a cold room at 45 min postmortem ($pH_{45\ min}$) and 24 h postmortem ($pH_{24\ h}$) directly on the carcasses using a spear-type electrode (PH 27-SS, IQ Scientific Instruments Inc., USA) with a portable pH meter (IQ-150, IQ Scientific Instruments Inc., USA).

In order to evaluate water holding capacity (WHC), measurements for drip loss [7], and filter-paper fluid uptake (FFU) [9] were performed.

Meat color was measured with a Minolta chromameter (CR-300, Minolta Camera Co., Japan). Samples were cut from the carcasses at 24 h postmortem in a 4 °C cold room and were placed on a table for 30 min within the 4 °C cold room to expose their surfaces to air without any packaging (for bloom) prior to measuring meat color. The average of triplicate measurements was recorded and the results were expressed as Commission Internationale de l'Eclairage lightness [5].

To determine protein solubility, samples were taken from the carcasses at 24 h postmortem in a 4 °C cold room. They were promptly frozen by liquid nitrogen and then stored at -80 °C until analysis. Total, sarcoplasmic, and myofibrillar protein solubility were determined [8].

All samples were classified into pale, soft, and exudative (PSE: drip loss > 6%, lightness > 50); reddish-pink, soft, and exudative (RSE: drip loss > 6%, 43 < lightness ≤ 50); reddish-pink, firm, and non-exudative (RFN: 2% < drip loss ≤ 6%, 43 < lightness ≤ 50); and dark, firm, and dry (DFD: drip loss ≤ 2%, lightness ≤ 43) [12].

4. Statistical analysis

The General Linear Model was used to evaluate the significant differences among pork quality classes (PSE n=22, RSE n=12, RFN n=56, DFD n=10) using SAS software [14]. When significant differences ($P < 0.05$) were detected, the mean values were separated by the probability difference (PDIFF) option at a predetermined probability rate of 5%. The results for the groups were presented as least square means (LSM) together with the standard errors of LSM. Pearson partial correlation coefficients were evaluated to characterize the relationship between the blood glucose level, muscle pH, and meat quality measurements.

III. RESULTS AND DISCUSSION

To examine the availability of blood glucose level for pork quality classifications, differences in blood glucose level, muscle $pH_{45\ min}$ and $pH_{24\ h}$ were assessed within various pork quality classes, and are presented in Table 1. Muscle pH is a very useful indicator of postmortem metabolism and ultimate meat quality [4, 12]. Muscle $pH_{45\ min}$ indicates the early postmortem metabolic rate, and $pH_{24\ h}$ indicates the extent of postmortem metabolism. Hence, muscle pH levels at postmortem 45 min and 24 h are closely related to ultimate meat quality parameters, such as lightness, drip loss, and protein solubility. Moreover, muscle pH was shown to be significantly different among pork quality classes [12]. Similarly, in the present study, significant differences were found for muscle pH among the quality classes ($P < 0.001$). PSE showed the lowest $pH_{45\ min}$ and $pH_{24\ h}$. RSE had a higher $pH_{45\ min}$ value than PSE, but it was lower than RFN and DFD. RFN and DFD were not significantly different in $pH_{45\ min}$ and $pH_{24\ h}$. In addition, blood glucose levels, measured at slaughter, were significantly different among the quality classes ($P < 0.001$). PSE had the highest blood glucose level, whereas RFN and DFD had significantly lower blood glucose levels than PSE and RSE. Based on these results, blood glucose level may be useful to classify meat quality classes.

According to the results of a previous study [4], blood glucose level measured at slaughter was related to ultimate pork quality. Moreover, free glucose in exudates was closely related to pork quality [6]. Table 2 shows that blood glucose level was significantly related to muscle $pH_{45\ min}$ and $pH_{24\ h}$, and pork quality measurements. Blood glucose level was negatively related to muscle $pH_{45\ min}$ ($P < 0.001$) and $pH_{24\ h}$ ($P < 0.01$). Moreover, blood glucose level was positively related to pork quality traits, such as drip loss ($P < 0.001$), FFU ($P < 0.001$), and lightness ($P < 0.001$). Blood glucose level was also positively related to total ($P < 0.001$), sarcoplasmic ($P < 0.001$), and myofibrillar protein solubility ($P < 0.001$). From the results of present study, blood glucose level appears to be a viable indicator of pork quality.

IV. CONCLUSION

The research data indicate that there were significant differences in blood glucose level among the various pork quality classes, and PSE showed the highest blood glucose level. Furthermore, blood glucose level was significantly related to muscle pH, pork quality traits, and protein solubility. Thus, the overall results suggest that blood glucose level can be a useful indicator of pork quality.

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Table 1. Blood glucose level and muscle pH in various pork quality classes

	PSE (n=22)	RSE (n=12)	RFN (n=56)	DFD (n=10)	Level of significance
Blood glucose level (mg/dl)	229.3[a] (27.2)[1]	193.9[b] (28.0)	109.1[c] (6.28)	97.20[c] (23.1)	***
Muscle $pH_{45\ min}$	5.60[a] (0.11)	5.77[b] (0.13)	6.39[c] (0.03)	6.43[c] (0.06)	***
Muscle $pH_{24\ h}$	5.60[a] (0.05)	5.66[a] (0.06)	5.90[b] (0.02)	5.94[b] (0.03)	**

Level of significance: ** $P < 0.01$; *** $P < 0.001$.
[1] Standard error of least-square means.
[a-c] Least-square means with different superscripts in the same row differ significantly ($P < 0.05$).
PSE: pale, soft, and exudative; RSE: reddish-pink, soft, and exudative; RFN: reddish-pink, firm, and non-exudative; DFD: dark, firm, and dry.

Table 2. Correlations between blood glucose level, muscle pH, and pork quality measurements

	$pH_{45\ min}$	$pH_{24\ h}$	Drip loss	FFU	Lightness	TPS	SPS	MPS
BGL	-0.47***	-0.23**	0.60***	0.47***	0.48***	-0.51***	-0.39***	-0.41***
$pH_{45\ min}$		0.54***	-0.65***	-0.54***	-0.60***	0.58***	0.37***	0.52***
$pH_{24\ h}$			-0.68***	-0.50***	-0.49***	0.56***	0.31***	0.53***

Level of significance: ** $P < 0.01$; *** $P < 0.001$.
BGL: blood glucose level at slaughter; FFU: filter-paper fluid uptake; TPS: total protein solubility; SPS: sarcoplasmic protein solubility; MPS: myofibrillar protein solubility.