THE CORRELATIONS AMONG CHANGES IN METABOLITE CONTENTS, MUSCLE FIBER CHARACTERISTICS, AND PORK QUALITY TRAITS

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Introduction

In living animals, energy production has two main alternative routes: the oxidative and glycolytic pathways (Pösö and Puolanne, 2005). Glycogen, the branched polymer of glucose, is the main energy reserve in muscle. Glucose derived from glycogen is converted into lactate by glycolytic metabolic mechanisms. And lactate is either converted back to pyruvate to be used oxidatively via the tricarboxylate acid cycle, or transported out of the muscle fiber if there is a lack of oxygen and/or mitochondria (Pösö and Puolanne, 2005). After slaughter, when blood circulation is stopped, lactate accumulates in the muscle tissue (Pösö and Puolanne, 2005). This lactate accumulation causes a rapid decline in pH, and subsequently affects meat quality (Ryu et al., 2005). Muscle fiber types have different metabolic, biochemical, and biophysical characteristics, and can affect postmortem (PM) changes during the conversion of muscle to meat (Ryu et al., 2005). Therefore, the purpose of this study was to examine the relationships among the changes in metabolite contents, including glycogen and lactate, muscle fiber type composition, as well as meat quality traits and protein denaturation.

Materials and Methods

A total of 51 crossbred (Landrace × Yorkshire × Duroc) pigs (32 females and 19 castrated males) were evaluated. The treatment conditions for the animals were the same both before and after slaughter. At 45 min PM, muscle samples were obtained from the *longissimus dorsi* muscle at the 8th *thoracic vertebra* for histochemical (Brooke and Kaiser, 1970), biochemical (glycogen and lactate contents), *R*-value, and protein solubility analyses (Choi et al., 2007). At 24 h PM, muscle samples were again taken to measure biochemical characteristics, protein solubility, and meat quality traits (Choi et al., 2007). Finally, the Pearson correlation coefficients were evaluated using the partial correlation coefficients (SAS institute, 2001).

Results & Discussion

The mean values, standard deviations, and overall ranges for glycogen and lactate contents at the early and ultimate PM periods are given in Table 1. Lactate content at 45 min PM was negatively associated with muscle fiber type I composition, while positively related to the area composition of type IIB fibers (Table 2). The 24 h/45 min ratio of lactate showed an opposite tendency to lactate content at 45 min PM in the composition of muscle fiber. For the meat quality traits, glycogen and lactate contents at 45 min PM, and the 24 h/45 min ratio were highly correlated with *R*-value (Table 3). Moreover, glycogen content at 45 min PM was positively associated with $pH_{45\,min}$, and glycogen content at 24 h PM was positively related with drip loss and filter-paper fluid uptake (FFU). The 24 h/45 min ratio of glycogen had negative relationships with $pH_{45\,min}$ and L^* values, and positive relationship with $pH_{24\,h}$. Lactate content at 45 min PM was inversely related to $pH_{45\,min}$, however, it was positively related to drip loss and FFU. Glycogen content at 45 min PM and the 24 h/45 min ratio of lactate were positively correlated with the total protein solubility at 24 h PM. On the other hand, the 24 h/45 min ratio of glycogen and lactate content at 45 min PM had a negative correlation with the total protein solubility at 24 h PM.

Table 1. Means, standard deviations (SD) and ranges for glycogen and lactate contents (mg/g tissue wet weight) in porcine *longissimus dorsi* muscle

	Means	SD	Minimum	Maximum
Glycogen content (mg/g)				
45 min PM	1.00	0.79	0.11	3.51
24 h PM	0.25	0.12	0.08	0.69
24 h/45 min Ratio	0.41	0.27	0.04	0.98
Lactate content (mg/g)				
45 min PM	5.49	1.88	2.56	10.53
24 h PM	8.01	0.99	6.72	10.80
24 h/45 min Ratio	1.61	0.51	1.01	2.98

Table 2. Correlation coefficients (r) between glycogen, lactate contents and fiber type composition in porcine *longissimus dorsi* muscle

	Glycogen content			Lactate content		
	45 min PM	24 h PM	24 h/45 min Ratio	45 min PM	24 h PM	24 h/45 min Ratio
Muscle fiber area percentage						
Type I	.34*	.09	-.19	-.58***	.02	.63***
Type IIA	-.45**	-.16	.45**	.13	-.08	-.20
Type IIB	.05	.04	-.16	.35*	-.03	-.34*
Muscle fiber number percentage						
Type I	.19	.04	-.16	-.46**	.05	.48**
Type IIA	-.46**	-.13	.50**	.22	-.05	-.29
Type IIB	.22	.08	-.28	.17	-.01	-.13

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Table 3. Correlation coefficients (r) between glycogen, lactate contents and meat quality measurements in porcine *longissimus dorsi* muscle

	Glycogen content			Lactate content		
	45 min PM	24 h PM	24 h/45 min Ratio	45 min PM	24 h PM	24 h/45 min Ratio
Meat quality traits						
Muscle $pH_{45\ min}$	.46**	-.01	-.49**	-.51***	.07	.65***
Muscle $pH_{24\ h}$	-.35*	-.11	.39*	.02	-.17	-.04
R–value	-.53***	-.05	-.52***	.79***	.16	-.80***
Drip loss	.06	.36*	-.01	.29*	.20	-.37*
FFU	.08	.45**	.02	.31*	.26	-.33*
Lightness (L^{*})	.25	.06	-.35*	.19	.27	-.12
Redness (a^{*})	-.01	-.03	.10	-.09	-.06	.06
Yellowness (b^{*})	.41**	.03	-.34*	-.18	.34*	.40**
Protein solubility at 45 min PM						
Sarcoplasmic protein	.10	-.07	-.17	-.34*	-.26	.27
Myofibrillar protein	.31*	-.06	-.39**	-.06	.09	.18
Total protein	.27	-.06	-.39**	-.21	-.06	.27
Protein solubility at 24 h PM						
Sarcoplasmic protein	.03	-.20	.06	-.17	-.01	.22
Myofibrillar protein	.35*	-.02	-.40**	-.34*	-.13	.29
Total protein	.32*	-.10	-.32*	-.35*	-.11	.33*

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.
Abbreviation: FFU, filter-paper fluid uptake.

Conclusions

Early PM metabolite contents, including glycogen and lactate, were related to muscle fiber type composition, especially type I, IIB fibers, and the meat quality measurements, particularly $pH_{45\ min}$, water-holding capacity, and protein denaturation. Especially, muscles with a higher 24 h/45 min ratio of lactate had a tendency toward slower metabolic rate, higher water-holding capacity, and lower degree of protein denaturation.

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