MEAT CHARACTERISTICS AMONG FOUR MUSCLE TYPES OF CROSBRED BOER GOAT

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Abstract – The objective of this study was to determine the effect of muscle types on biochemical and meat quality traits among four goat muscles. *Infraspinatus* (IF), *Longissimus dorsi* (LD), *Psoas major* (PM) and *Supraspinatus* (SS) from 10 crosbred boer goats were used in this study. The results showed that muscle types of crosbred boer goats had variations in meat characteristics as differences in muscle fiber size, sarcomere length, glycogen content, pH and shear force value among different muscle types. In terms of meat quality, PM was the best followed by IF, LD and SS, respectively. Because PM had the longest in sarcomere length, the smallest size of muscle fiber, and the lowest shear force value ($P < 0.01$). There were significant correlation ($P < 0.05$) between pH and glycogen level and also between sarcomere length, glycogen content, pH and shear force value.

Key Words – Crosbred boer goat, Meat characteristics, Muscle type

- INTRODUCTION

Goats are considered to be important for a meat-producing animal as their meat are becoming more accepted by consumers. Goat meat could become an excellent choice for health-conscious consumers because of its low fat content compared with other red meat and chicken [1, 2]. Goat meat not only low in fat and cholesterol but also an excellent source of protein, vitamin B, iron and zinc [3]. Nevertheless, some of important factors that make the goat a successful meat-producing animal, especially under extensive systems, are the ability to graze and utilize poor forages; short generation intervals and high reproductive rates; the feasibility of herding by children and women due to the flock instinct; and their ability to stand droughts [4]. Meat quality is commercially important, as it may be possible to manipulate quality to meet particular market requirements. Due to goat has a potential to become an important meat-producing animal but there is a limit information of goat meat quality. For this reason, the present study was to investigate the basic knowledge of goat meat quality by comparing meat quality among different muscle types in crosbred boer goats as well as evaluate the relationship among meat characteristics in this study.

- MATERIALS AND METHODS

Animals

Ten male crosbred boer goats (7-10 months of age) were raised on a concentrate diet for three months. The animals (body weight 26.5 ±3.5 kg) were hold overnight without feed but had free access to water before slaughter in a slaughterhouse at Kasetsart university Kumpangsan campus, Nakorn Prathom. Carcasses were dressed and splited longitudinally. Muscle samples of *Infraspinatus* (IF), *Longissimus dorsi* (LD), *Psoas major* (PM), and *Supraspinatus* (SS) were removed from each carcass within approximately two hours post mortem. Each muscle from left side carcass was trimmed of all visible fat and was divided in tripicate for measuring sarcomere length, muscle fiber diameter and glycogen content. Muscles from the right side carcass was measured pH at 2 h post mortem before vacuum packing and keeping at 1 °C for 7 days then storing at -20 °C until shear force measurement.

Meat characteristics

The pH of all muscles was measured at 2 and 24 h post mortem using a pH-meter with a puncture electrode (Mettler Toledo, Switzerland). Muscle fiber diameter was measured using protocol from Tuma et al. (1962) [5]. . Sarcomere length was evaluated using an adapted protocol from Cross et al. (1981) [6]. From each sample, sarcomere length of thirty fiber samples were measured by helium neon laser (Research electro-optics, USA). Glycogen content was determined using an adapted protocol from Adamo and Graham (1998) [7]. Shear force values were determined using an instron Universal Testing Machine (Model 1011, Instron Corp., USA). A 7 days chops were cooked in vaccum-sealed bags in a water bath at 80 ºC until they reached an internal temperature of 70 °C. Samples were cooled by put in running tab water for 30 min. Samples were cut in parallel to the alignment of the muscle fibers into approximately 1-cm-thick and 5-cm-long slice before measuring shear force value.

Statistical analysis

Differences between muscle types for all traits were analysed with the mixed procedure in SAS software (SAS Institute Inc., Cary, NC, USA). The model used included muscle types as fixed effect. Least square means were separated using PDIFF option ($P < 0.05$). The relationships among meat characteristics from four muscle types of crosbred boer goats were evaluated by Pearson correlation coefficients.

- RESULTS AND DISCUSSION

Results of meat characteristics of crosbred boer goat in this study are given in Table 1. Muscle fiber diameter was the longest in SS followed by IF, LD and PM ($P < 0.01$). Sarcomere length at 2 h post mortem was significantly longer in PM than in LD while was the shortest in SS and IF ($P < 0.01$). Sarcomere length at 24 h post mortem was significantly different ($P < 0.01$) among four muscles as PM > LD > SS > IF. Glycogen content at 2 h post mortem was significantly highest in LD ($P < 0.01$). LD and PM had higher pH_{2h} value than IF and SS ($P < 0.05$). pH_{24h} was the lowest in LD ($P < 0.01$). Shear force value was the lowest ($P < 0.01$) in PM followed by IF while was the highest ($P < 0.01$) in LD and SS (2.60, 3.29, 4.00 and 4.02 kg, respectively).

In this experiment, muscle fiber size was evaluated from muscle fiber diameter. This study found a significant variation in size of muscle fiber. The reason might be muscles have different metabolic types as they contain different proportion of muscle fiber types. Which can be classified into three major types: the red (type I), intermediate (type IIA), and white (type IIB). Type I fibers are the smallest in diameter while type IIB fibers are the largest in diameter [8]. Sarcomere length reflects the extent of post mortem muscle contraction. Several researches showed the relationship between sarcomere length and meat tenderness as the increase in sarcomere length with the concomitant increase in tenderness in lamb [9], and in beef [10]. From this study, there was a significant different in sarcomere length among muscles at both 2 h post mortem and 24 h post mortem. Nagaraj et al. (2006) [11] reported the variation of sarcomere length among different muscles of goat as different percentage decrease of sarcomere length during 20 days of storage as follows: *Semitendinosus* (18.68), *Longissimus dorsi* (17.97), *Semimem-branosus* (17.48) and *Bicep femoris* (16.85). In agreement with Olsson et al. (1994) [12] that reported the lower level of shortening in *Semimembranosus* than in *Longissimus dorsi* of beef, the reason might be the latter has significantly more oxidative fibers therefore it has a higher level of shortening.

Glycogen content varied among different muscles in this study. In agreement with Lefaucheur and Gerrard (1998) [13] that reported higher glycogen content in fast glycolytic muscle fibre (type IIA and IIB) than slow oxidative fibre (type I). In ovine, glycolytic activity was highest in LD followed by PM, IF and SS, respectively and oxidative activity was also highest in LD followed by IF, SS and PM, respectively [14]. The variation of glycogen content among muscle types might be associated with pH value in this study as the highest glycogen content in LD had the lowest pH_{24h}. Bee et al. (2006) [15] suggested that the muscle glycogen concentration affect the rate of pH decline and ultimate pH. PM in this study was the most tender muscle as it had the lowest shear force value. That might be associated with its smallest muscle fiber size and longest sarcomere length at both 2 h post mortem and 24 h post mortem.

Table 1 Meat characteristics of four muscle types of crosbred boer goat

Trait	Muscle types (LSMeans)			
	IF	LD	PM	SS
MFD[1] (μ)	97.25^{b}	84.39^{c}	70.73^{d}	101.64^{a}
SL_{2h}[2] (μ)	1.65^{c}	1.74^{b}	1.98^{a}	1.62^{c}
SL_{24h}[3] (μ)	1.36^{d}	1.55^{b}	1.90^{a}	1.46^{c}
Gly[4] (μmol/g)	2.83^{b}	6.90^{a}	1.81^{b}	3.64^{b}
pH_{2h}[5]	6.23^{e}	6.00^{f}	5.96^{f}	6.21^{e}
pH_{24h}[6]	6.06^{b}	5.75^{a}	6.04^{b}	6.11^{b}
SF (kg)[7]	3.29^{b}	4.00^{a}	2.60^{c}	4.02^{a}

^{abcd} Values in the same row with different superscripts differ ($P < 0.01$), ^{ef} Values differ ($P < 0.05$)
[1]MFD = muscle fiber diameter; [2]SL_{2h} = sarcomere length at 2 h post mortem; [3]SL_{24h} = sarcomere length at 24 h post mortem; [4]Gly = glycogen content at 2 h post mortem; [5]pH_{2h} = pH at 2 h post mortem; [6]pH_{24h} = pH at 24 h post mortem; [7]SF = shear force value at 7 day post mortem

Correlations among meat characteristics from four muscle types in this study was presented in Table 2. Muscle fiber diameter negatively correlated ($P < 0.05$) with sarcomere length at both 2 h post mortem ($r = -0.60$) and at 24 h post mortem ($r = -0.43$). There was a positive correlation between sarcomere length at 2 h post mortem and at 24 h post mortem ($r = 0.69$, $P < 0.01$). Sarcomere length at 2 h post mortem was not significantly correlated with shear force value ($r = -0.18$, $P > 0.05$). While there was a highly negative correlation between sarcomere length at 24 h post mortem and shear force value ($r = -0.48$, $P < 0.01$). Glycogen content at 2 h post mortem positively correlated with pH_{2h} ($r = 0.33$, $P < 0.05$) while negatively correlated with pH_{24h} ($r = -0.39$, $P < 0.05$). A shear force value positively correlated with glycogen ($r = 0.38$, $P < 0.05$) and pH_{2h} ($r = 0.35$, $P < 0.05$) while negatively correlated with pH_{24h} ($r = -0.32$, $P < 0.05$).

Table 2 Relationship among meat characteristics of crosbred boer goat

Trait	SL_{2h}	SL_{24h}	Gly	pH_{2h}	pH_{24h}	SF[7]
MFD[1]	-0.60*	-0.43*	-0.06	0.13	0.10	0.11
SL_{2h}[2]		0.69**	0.09	-0.17	0.01	-0.18
SL_{24h}[3]			-0.04	-0.26	0.13	-0.48**
Gly[4]				0.33*	-0.39*	0.38*
pH_{2h}[5]					-0.06	0.35*

pH_{24h} [6]	-0.32*

* $P < 0.05$, ** $P < 0.01$

[1]MFD = muscle fiber diameter; [2]SL_{2h} = sarcomere length at 2 h post mortem; [3]SL_{24h} = sarcomere length at 24 h post mortem; [4]Gly = glycogen content at 2 h post mortem; [5]pH_{2h} = pH at 2 h post mortem; [6]pH_{24h} = pH at 24 h post mortem; [7]SF = shear force value at 7 day post mortem

The biochemical changes occurring in muscle after animals die are very important parts of the conversion of muscle into meat. Glycogen depletion during post mortem produces a lactic acid buildup and, therefore, a pH decline. In the present study, glycogen content had a positive correlation with pH_{2h} while had a negative correlation with pH_{24h}. These indicated that the higher initial glycogen level, the lower ultimate pH that was similar to Bee et al. (2006). The low glycogen level in accordant with the high ultimate pH was reported herein and by Kannan et al. (2003) [16]. The results obtained from this study describe a close relationship between muscle sarcomere length at 24 h post mortem, glycogen content, pH and shear force value of different goat muscles. Several publish researchs showed a positive correlation between sarcomere length and meat tenderness in beef (Rhee et al., 2004), in goat [17]. In Contrast to the results in this experiment, Simela (2005) reported a positive correlation between pH_{24h} and shear force value in *Semimembranosus* but no significant correlation in LD of Chevon.

- CONCLUSION

In this study, muscle types of crosbred boer goats had variations in meat characteristics as differences in muscle fiber size, sarcomere length, glycogen content, pH and shear force value among different muscle types. There are close relationship between pH and glycogen level and also between sarcomere length, glycogen content, pH and shear force value.

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