The effects of carcass conditioning on pH decline and glycogen content of different skeletal muscles of Malin sheep

M. Hilmi[1]*, M.H. Hussain[1] & A.Q. Sazili[1, 2]

[1]Department of Animal Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, MALAYSIA.

[2]Halal Products Research Institute, Putra Infoport, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, MALAYSIA.

*E-mail: hilmi@putra.upm.edu.my.

Introduction

Although conditioning is known to improve carcass quality, it is also proven to be costly because this practice requires more storage space and maintenance of chilling facilities and may prove to be uneconomical. The recommended conditioning period has been based on complete *rigor* development attained by the whole carcass. However, it has been well documented that the rate and extent of *rigor* development varies between individual muscles (intermuscular) and also within a muscle (intramuscular) (Warris, 2000). Besides, it may cause contamination due to prolonged exposure to environment and also due to too much handling by the operator. Longer time conditioning has also been associated with carcass weight loss and soluble nutrient loss due to evaporation in the chilling room. A possibility of reducing the conditioning period may reduce the cost of production. Therefore, this study was undertaken to investigate the effects of conditioning period on pH and glycogen content in different major skeletal muscle.

Materials and methods

Nine skeletal muscles, namely, *Supraspinatus* (SS), *Infraspinatus* (IF), *Triceps brachii* (TB), *Longgisimus dorsi* (LD), *Semimembranosus* (SM), *Semitendinosus* (ST), *Vastus lateralis* (VL), *Rectus femoris* (RF) and *Adductor femoris* (AF) from the right sides of carcasses of eighteen 1 year old male Malaysian indigenous (MALIN) sheep were used in this study. The sheep were slaughtered according to the procedure outlined in the MS 1500:2004 (Department of Standard Malaysia, 2004). Immediately after evisceration, the carcasses were subjected to conditioning at 4°C. Representative muscle samples of approximately 20g each were dissected at 3 specific periods, that is, immediately after evisceration, 24 hrs and 7 days post mortem to represent the unconditioned (pre-rigor), 1 day-conditioned and 1 week-conditioned samples, respectively. Each representative sample was assigned for pH and glycogen content determination. All samples collected were trimmed of any visible fat and connective tissue, immediately snap frozen in liquid nitrogen and stored at -80°C until subsequent analyses.

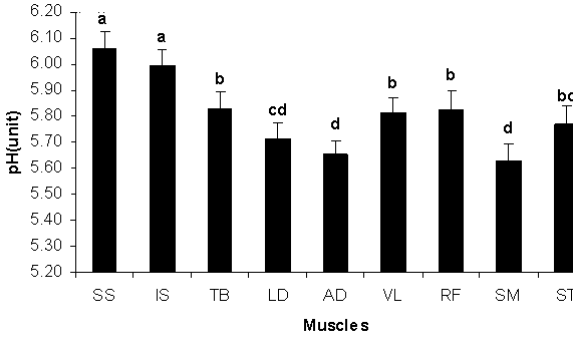
Determination of muscle pH at the 3 post mortem condition periods was carried out by first homogenizing 0.5g of each sample in deionised water in the presence of 5 mM sodium iodoacetate to prevent further glycolysis. An electrode attached to a hand held pH meter (Mettler Toledo, USA) was used to measure the pH of the resulted homogenates (Bendall, 1975). Meanwhile, the concentrations of available glycogen from the nine different muscles conditioned for 0, 1 and 7 days were enzymatically determined according to the method described by Dreiling *et al.* (1987). The data generated throughout in the present study were analysed by the Anova procedure using Statistical Analysis System (SAS, version 8, 2000). Duncan's Multiple Range Test was used to analyze the differences between means and the interaction between muscle type and conditioning period.

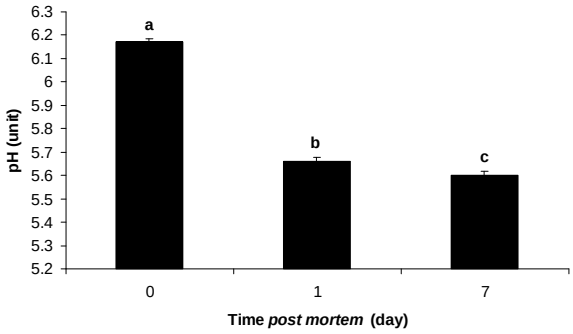
Results and discussion

There were differences in pH values (Figure 1) among those muscles investigated. Statistically, no interaction was present between conditioning period and muscle type and this indicates that the observed effects of p.m. conditioning on pH values were independent of the muscle type. Hence, the mean muscle pH of all muscles was pooled as muscle pH at 0, 1 and 7 days post mortem (Figure 2). A significantly higher ($p<0.05$) pH was observed in the unconditioned (0 day) muscle samples. In addition, the pooled muscle pH values at 7 days post mortem have significantly dropped to lower ($p<0.05$) than the pH values of the 1 day conditioned samples (Figure 2). In this study, the substantial decline of pH values of muscle from 0-day to day-1 was consistence with drop of glycogen content (Table 1) during similar period of conditioning. These changes were attributed to

postmortem glycolysis associated with the process of conversion of muscle to meat, similarly reported by Simela *et al*, 2004. However, the subsequent significant pH decline of muscle at day 7 of conditioning period could not possibly be related to the postmortem glycolysis since during this period there was no further drop of glycogen content (Table 1). This change of the pH level could be due to extrinsic factors such as protein degradation by microbial enzyme or other factors yet to be researched.

Meanwhile, the glycogen content also differed significantly across the nine different muscles but only occurred in the unconditioned (0 hr) samples (Table 1). The presence of interaction between conditioning and muscle type indicates that the differences in glycogen content across different muscles depend on the post mortem conditioning time. In the unconditioned samples, the highest glycogen level was observed in the IS muscle (19.2 mg/g ± 4.0) while the lowest level was exhibited by the ST muscle (7.24 mg/g ± 1.58). The magnitude of difference between the highest (IS) and the lowest (ST) 0 day glycogen level is 11.96 mg/g tissue, which is approximately 63.3%. From the highest to the lowest, the initial muscle glycogen levels can be ranked as follows: IS (19.20mg/g ± 4.0) >VL (14.31mg/g ± 1.87) >RF (13.98mg/g ± 0.79) >AD (12.65mg/g ± 3.55) >TB (12.23mg/g ± 3.18) >LD (11.32mg/g ± 2.36) >SM (9.07mg/g ± 3.85) >SS (8.32mg/g ± 1.15) > ST (7.24mg/g ± 1.58).





The mean pH values of 9 different skeletal muscles were pooled since there was no interaction between the muscle type and conditioning period. Pooled means with different letter differ significantly ($p<0.05$).

Figure 1. Differences in pH values among different skeletal muscles in sheep.

Figure 2. Effects of conditioning on pH of different skeletal muscles in sheep.

Table 1. Effects of post mortem conditioning on muscle glycogen content of different skeletal muscles in sheep

	Post mortem conditioning (days)					
	0		1		7	
Muscles	Glycogen (mg/g tissue)	sd	Glycogen (mg/g tissue)	sd	Glycogen (mg/g tissue)	sd
AD	12.65 ^{bcd}	3.55	5.82 ^{gh}	0.43	4.99 ^{h}	0.56
IS	19.20 ^{a}	4.00	6.15 ^{gh}	0.50	5.73 ^{gh}	1.00
LD	11.32 ^{d}	2.36	5.90 ^{gh}	0.93	5.57 ^{gh}	0.69
RF	13.98 ^{bc}	0.79	6.15 ^{gh}	0.50	5.40 ^{gh}	2.14
SM	9.07 ^{e}	3.85	5.82 ^{gh}	0.36	5.73 ^{gh}	0.75
SS	8.32 ^{ef}	1.15	6.57 ^{gh}	0.50	6.15 ^{fgh}	1.17
ST	7.24 ^{efgh}	1.58	5.40 ^{gh}	0.35	5.15 ^{gh}	0.90
TB	12.23 ^{cd}	3.18	7.40 ^{efg}	3.95	5.65 ^{gh}	0.97
VL	14.31 ^{b}	1.87	5.57 ^{gh}	0.69	5.07 ^{h}	0.71

Means within a row or a column with different superscripts differ significantly ($p<0.05$)

The differences in reactions and responses given by those muscles to the pre slaughter handling and activities could have influenced the observed glycogen content particularly at 0 day post mortem. It has been reported that muscles involved in maintaining posture are slower than those involved in locomotion in breaking down the stored muscle glycogen (Totland and Kryvi, 1991). Although the muscles were not classified in this study, the highest glycogen content present in the IS muscle suggests that it is of slow activity and this is in agreement with the previous findings in cattle (Totland and Kyrvi, 1991). Previous work in pigs also reported differences in glycogen content at post mortem between muscles of different characteristics and properties (Karlsson *et al*, 1999).

Conclusion

In general, the effects of *post mortem* conditioning on muscle pH are independent of the type of muscle or *vice versa*. The type of muscle has affected the muscle pH only at initial stage which is at 0 day *post mortem*. Unlike the 0 day *post mortem*, the type of muscle did not affect the pH of 1 day and 7 days conditioned muscles. The results suggest that the ultimate muscle pH has been reached within the 24 hours (1 day) of conditioning. The study has also demonstrated that both types of muscle and the conditioning period have affected the glycogen levels. The glycogen levels of 1 day and 7 days conditioned samples were not different. The results from these studies recommended that the optimum conditioning period for MALIN sheep carcass is 1 day since all muscle had attained their ultimate pH and glycogen level within that 24 hours. By shortening the conditioning period, it may also reduce the production cost and risk of contamination of the meat, thereby producing good quality sheep meat.

References

Bendall, J.R. (1975). Cold-contracture and ATP-turnover in the red and white musculature of the pig, post mortem. Journal of the Science of Food and Agriculture. 26(1): 55-71.

Dreiling, C.E., Brown, D.E., Casale, L. and Kelly, L. (1987). Muscle glycogen: comparison of iodine binding and enzyme digestion assays and application to meat samples. Meat Science. 20:167– 177.

Karlsson, A. H., Klont, R. E. and Fernandez, X. (1999). Skeletal muscle fibres as factors for pork quality. Livestock Production Science. 60: 255–269.

SAS Institute Inc. (2000). Statistical Analysis System User's Guide, version 8. SAS Institute North Carolina, USA.

Sazili, A.Q., Parr, T, Sensky, P.L., Jones, S.W., Bardsley, R.G. and Buttery, P.J. (2005). The relationship between slow and fast myosin heavy chain content, calpastatin and meat tenderness in different ovine skeletal muscles. Meat Science. 69: 17-25.

Simela, L., Webb, E. C. and Frylinck, L. (2004). Post mortem metabolic status, pH and temperature of chevon from South African indigenous goats slaughtered under commercial conditions. South African Journal of Animal Science. 34 (1): 204-207.

Suzuki, A. and Tamate, H. (1988). Distribution of myofibre types in the hip and thigh musculature of sheep. The Anatomical Record. 221: 494-502.

Totland, G. and Kryvi, H., (1991). Distribution pattern of muscles fibre types in major muscle of the bull (Bos taurus). Anatomy and Embryology Journal. 184: 441-450.

Warris, P.D. (2000). In Meat Science. An Introductory Text. CAB International Publishing.