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EFFECT OF THE MUSCLE BIOCHEMICAL CHARACTERISTICS ON THE TENDERNESS OF AGED MEAT IN YOUNG GOATLING (CAPRA NUBIANA) ANIMALS

Cuenca-Mendoza F[1]., C. Gonzalez[1], M. A. Ruiz-Cabrera[1], D. L. González-Navarro[1], R. González-García[1], L. González-Juárez[1], M. Gil[2]and A. Grajales-Lagunes[1]*

[1] Centro de Investigación y Estudios de Posgrado. Universidad Autónoma de San Luis Potosí, Facultad de Ciencias Químicas, 78210, San Luis Potosí, S.L.P. México; [2]Institut de Recerca i TecnologiaAgroalimentaries (IRTA)-Monells, FincaCamps i Armet s/n 17121Monells, Girona (Spain)
*Corresponding Author's email: grajales@uaslp.mx

ABSTRACT

The effect of muscle biochemical characteristics on the tenderness of goatling meat was examined in *Semimembranosus* (SM), *Semitendinosus* (ST) and *Longissimus* (L) muscles. Twelve goatling of Nubia breed were slaughtered at 55 days of age, the muscles were obtained at 1 hour *postmortem*and aged for 8 days at 4ºC.pH decline rate, metabolism, contraction rate, cathepsins B and B+L activities and tenderness (myofibrillar toughness) were evaluated at different ageing times. This study showed that in goatling muscles, the pH decline rate and metabolism type directly influencedon the activity of cathepsins B+L andtheir activity decline rate.Cathepsin B+L activity presented a quadratic correlation (R^2=0.88) with myofibrillar toughness and it was associated with the final meat tenderness.The term "goatling" refers only to young animals and it is suggests that an ageing period is necessary to improve theirtenderness.

Key words: goatling, metabolism, myofibrillar toughness, tenderness, pH, cathepsins.

INTRODUCTION

In Mexico consumption of meat from "goatling" (male kid of goat, milk-fed from 4 to 8 weeks old), has increased significantly, mainly in the states of the North of the country like Coahuila, Nuevo León, San Luis Potosí, Zacatecas and Durango (Marichal*et al.*,2003; Santos*et al.*, 2008; Siap-Sagarpa, 2006). Meat goatling play a crucial role in the rural economy in these states, because the production and marketing is the source of income for many families. However,quality of goatlingmeat is very variable because, there is not an appropriate *post mortem* control to allow the development oftheir sensory characteristics like tenderness which is one of the most important meat quality attributes appreciated by the consumer. In others species like bovine and porcine have been observed that meat tenderness is dependent of different factors as animal age, sex, species and biochemical characteristics: metabolicproperties and ageing process (Briand *et al.*, 1981; Christensen *et al.*, 2004; Ouali *et al.*, 2005). Metabolic properties of muscle have been correlated with fiber type and their distribution in the muscle, therefore the muscles that are mainly composed of oxidative type I fibers are known as red muscles, the muscles that are mainly composed of glycolytic type IIb fibers are called as white muscles. Muscles with type IIa fibers have both metabolism type, glycolytic and oxidative and are known as intermediates. Several studies have shown that metabolic properties are directly correlated with final pH (pHu) of meat, color, water-holding capacity and tenderness (Choi *et al*., 2006; Maltin *et al.*, 1998;Ryu and Kim 2005). Fiber type has an influence on proteolysis *post mortem* (ageing process) during the conversion of muscle into meatto improve the tenderness; in bovine and porcine muscle proteolytic degradation is faster in white muscle than red muscles (Koohmaraie*et al.*, 1988; Muroya*et al.*, 2010).

In goatling meat the biochemical characteristics like metabolic properties and ageing process (*rigor mortis* installation and ageing time) have not been studied and it is difficult to extrapolate the results from other studiesbecausethese characteristics vary between different muscles and among species. We consider that to improve the quality in goatling meat isnecessarytostudythese factors and also this study may help to answer many questions still controversial at present, the questions in mind are: Does meat goatling (young animals) need the ageing process to enhance the tenderness? How is metabolism type in young animal? Does metabolism type influence on enzymes responsible of the ageing process?. Therefore, this study was designed to characterize biochemically the contractile and metabolic type of goatling muscles through of myofibrillar ATPase and lactate dehydrogenase (LDH) activities respectively. Myofibrillar ATPase activity is correlated with contraction speed because it is responsible for hydrolyzing ATP during muscle contraction. LDH is a cytoplasmic enzyme that characterizes the glycolytic metabolism. Proteolytic enzymes such as cathepsins and calpains are involved in structural and biochemical changes during *post mortem* ageing process (Ouali *et al.*, 2005; Etherington *et al.*,

1990; Oualiet *al.*, 2006).The role of calpains in meat tenderness has been extensively established (Delgado *et al.*, 2001; Veiseth and Koohmaraie 2005). However, the influence of cathepsins activity to meat tenderness is not clear;because the results of several studies are controversial (Koohmaraie 1996; O'Halloran *et al.*, 1997; Hopkins and Thompson 2002)and also their role in the first hours and early days *postmortem* has not been established.

Based on the above-mentioned and with the aim of increasing the quality of the meat of this species, the objective of the present work was to evaluate the influence of muscle biochemical characteristics such as metabolism type, contraction rate and ageing process time (*rigor mortis* installation, cathepsins activities) on the tenderness of goatling meat. Also, to analyze mathematically the onset rate of the *rigor mortis* and the rate of decline of the activity of cathepsins B and B + L.

MATERIALS AND METHODS

Animals, sampling, and experimental design: Animals used in this study were obtained from the Agronomy School of the University of San Luis Potosi. All animals had the same sex (male), growth regime, feeding and slaughter procedure. Twelve goatling of Nubia breed were slaughtered at 55 days of age(this age, is the age current of slaughter to commercialize goatling meat in Mexico). Live and carcass weights were 12.651 ± 1.51 kg and 6.65 ± 0.8 kg respectively. Three muscles of each goatling carcass were used. The *Semitendinosus* (ST) and *Semimembranosus* (SM) muscles were excised immediately after slaughter from each half carcass and *Longissimus* (L) was used whole. After the trimming of the fat and connective tissue, muscles were cut in small samples (approximately 50g), vacuum packed and stored at 4°C at different ageing times (1,10, 24 hours, 6 and 8 days).Myofibrillar ATPase and lactate dehydrogenase (LDH) activitieswere determined at 1 hour of ageing time (because these enzymes exhibit activity only in the early hours *post mortem*),pH values and decline rate were measured every hour, from 1 hour up to 24 hours of ageing time, cathepsins activities were determined at 1, 10, 24 hours 6 and 8 days; after reaching the appropriate ageing times, samples for cathepsins activities were stored at -80ºC until analysis (within two weeks), myofibrillar toughness was performed only SM and ST muscles (because muscle L did not reach the thickness of 1cm required to make this determination) at 1, 6 and 8 days. A completely random design with a factorial arrangement was used; with three muscles (L, SM and ST) and five ageing times (1, 10, 14 hours 6, 8 days) with 11 replicates(Montgomery 2005).

Determination of pH decline rate:pH values were determined using a hand-held digital pH meter (Thermo Orion model 410 USA). 1 g of sample was homogenized in 10 mL of deionized water using a Polytronhomogenizer (Van Laack and Stalder, 2001). Experimental data of pH were used to calculate pH decline rate, through the exponential math model proposed by Bruce *et al.*,(2001) with some modifications, in this study the temperature was considered constant at 4°C. The exponential math model used was the following:

$$pH_s = pH_0\, e^{(-k_1 t)} + pHt_f \quad \text{.....(1)}$$

Where: pH_s is the value of simulated pH calculated by solving equation 1. pH_0 is the value of experimental pH measured in the muscle at time t, e is equal to 2.71828, which is the Euler number, $-k_1$ is pH decline rate, t is the time in hours and pHt_f is the final theoretical pH calculated by the model. The resolution of this equation and the coefficient of determination (r^2) were realized in Excel, using the Solver utility.

Determination of contraction rate and metabolism type: Myofibrillar ATPase activity (contraction rate) was measured at 1 hour *post mortem*, according to the method of Ouali and Valin, (1981). The pellet (myofibrils) were incubated in a reacting environment (0.170M KCl, 4 mM $MgCl_2$, 0.2 mM $CaCl_2$, and 4 mM ATP) and then were titrated with KOH in a total volume of 3.25mL of 10mM KOH at 30°C, pH 7.4. ATPase activity was expressed as microequivalents of KOH/min/mg of myofibrillar proteins. Concentration of myofibrillar proteins was determined by the Bradford method (1976) using BSA as standard.

Lactate dehydrogenase (LDH) activity (metabolism type) was measured at 1 hour *post mortem*, using a spectrophotometer by following the decrease of NADH concentration at 340 nm; units were expressed as the µmol of NADH per second per gram of muscle (Ansay, 1974).

Assays of cathepsins activities: Cathepsins B and B + L were assayed fluorimetrically using the method of Etherington and Wardale (1982). Cathepsin B was assayed with N-CBZ-L-arginyl-L-arginine-7-amido-4-methylcoumarin (Z-Arg-Arg-NHMec Sigma C5429). Cathepsin B+L were assayed using N-CBZ-Lphenylalanyl-L-arginine-7-amido-4 methylcoumarin (Z-Phe-Arg-NHMec Sigma C9521). The activity was measured at an excitation and emission wavelengths of 340 nm and 460 nm respectively. One unit of cathepsin activity was defined as the amount of enzyme hydrolyzing 1 nmol of substrate/minute at 37 °C. To determinate activity decline rate of these enzymes during ageing, a lineal equation (2) was used. This equation was solved through a lineal regression, using Solver in Excel.

$$Y = a + bx \quad \text{..... (2)}$$

Where: a, represents the initial enzymatic activity (1h post mortem) and b, represents the decline rate of the enzymatic activity regarding with time. The

parameters a and b were analyzed with variance analysis to evaluate the effect that factors (muscle and ageing time) have on decline rate of cathepsins.

Tenderness measurement: Raw meat tenderness (myofibrillar toughness) was measured at 1, 6 and 8 days of ageing time in 1x1x3cm samples, using compression test in an Instron machine (Model 3365) up to 20% strain at speed of 50 mm/min, the probe surface used was of 1 cm^2 (Lepetit and Buffiere, 1993), compression test was carried out at room temperature (20±2°C), the average of 5 measurements for each animal and ageing time was reported.

Statistical Analysis: Analysis of variance (ANOVA) was performed multiple lineal regression (MLR) using Modde 7.0 (Umetrict AB Inc. USA) Statistical package. When F-tests were significant, means were compared using LSD tests. For the response variables that were not measured during all ageing times comparison of means was performed. Differences were considered significant at $p<0.05$. All measures were done in triplicate, except myofibrillar toughness which was indicated above.

RESULTS AND DISCUSSION

Determination of pH decline rate: The results regarding to pH decline are illustratedin Fig.1, these results showed that ST muscle have higher value of initial pH (1 hour*postmortem*) than the SM and L muscles ($p<0.05$). The three muscles followed monophase kinetics of pH decline without existing overlapping among their values such as that observed in muscles of other species. Oualiet *al*., (2006) observed different stages of stabilization during pH drop in the L muscle of young charolais bull (19 months) and charolais cull cow (54 months) during the first hours *post mortem*.

Table1. Speed of pH decline and decline rate of the cathepsins activity and myofibrillar toughness in *Longissimus* (L), *Semimembranosus* (SM) and *Semitendinosus* (ST) of goatlingmuscles.

	L	SM	ST
Speed of pH decline (pH unit/hour)	0.174±0.0193a r^2 =0.987	0.132±0.0145b r^2= 0.989	0.110±0.0131c r^2=0.983
Speed of change Cathepsins B+L activity (Cathepsins Unit/hour)	2.74E-04±1.14E-05a	3.18E-04±8.69E-06b	2.37E-04±1.32E-05c
Myofibrillar toughness (N/cm^2)			
1 day	-	16.17±1.59a	29.05±3.02d
6 days	-	13.97±0.88b	26.93±2.60e
8 days	-	11.76±0.85c	21.71±2.72f

The values of the parameters in the same rows and columns with the same letter does not differ ($p>0.05$).

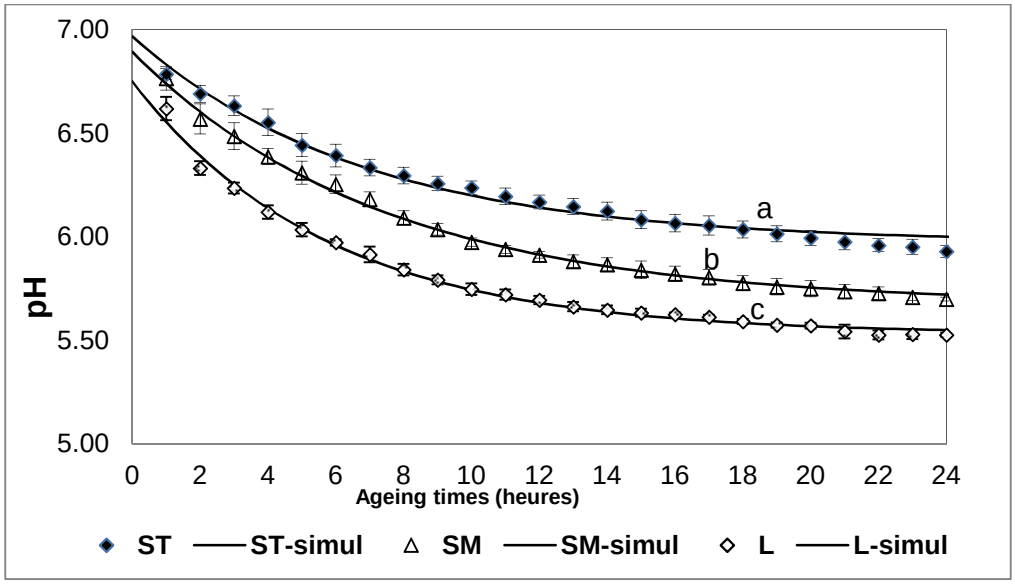
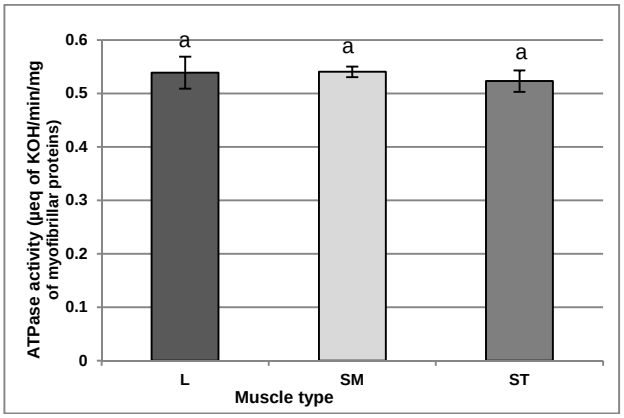


Figure1. pH evolution in the *Longissimus* (L), *Semitendinosus* (ST), and *Semimembranosus* (SM) muscles. Each point is the mean of three independent determinations for each animal. Means with same letters are not significantly different ($p>0.05$).

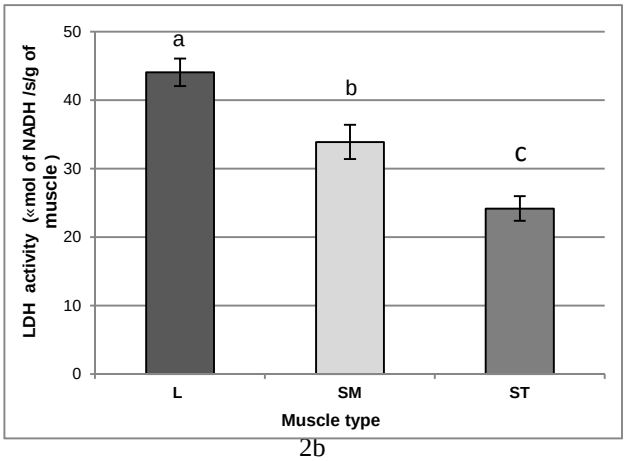
For charolais bull a first pH stability step was observed between 1 and 3 hours followed by a second step between 4 and 8 hours, in charolais cullonly one pH stability step was observed between 1 and 3 hours. Discontinuity of pH drop observed for these authors may be related with age of the animal because in this study did not show this behavior. The pHu value (24 hours post mortem) of the ST (5.9±0.05) muscle was higher ($p<0.05$) than the pHu value of the SM and L muscles, no significant differences between the pHu values of L and SM muscles were apparent. Similar pHu values for the SM muscle of goatling of Majorera breed were reported by Arguello *et al.,* (2005), the value for L muscle (5.68±0.19) was higher than that reported in this study. Kadhim *et al.* (2003) reported pHu values for the SM and ST muscles of 5.83 and 6.08 respectively for 1 year old female goats. Although values differ, behavior of muscles is similar because ST has the highest value. These differences that exist between pHu value in animals of the same or different species, can be explained based on age, pre-slaughter and slaughter conditions, post-slaughter processing, type of muscle metabolism and glycogen content at slaughter (Ngapo and Gariepy 2008; Christensen *et al.,* 2004; Arguello *et al.,* 2005). In the present study we were able to detect differences in the rate of pH decline between ST, SM and L muscles during *rigor mortis* development, pH (k) decline rate, between 1 and 24 hours *post mortem* varies between 0.11 to 0.174 pH unit/hour (Table 1). In a descending order, the muscle that presented the highest decline rate of pH was L, SM and ST, this difference observed can be attributed mainly of metabolism type, due to the L and SM muscle presented a glycolytic metabolism and ST an intermediate metabolism. In the literature, there are no reports of decline rate of pH regarding this species; in pigs muscles Henckel *et al.*,(2000) reported that SM muscle displayed a slower rate of pH decrease than LD, these results are in agreement with those reported in this study, but these authors did not report pH decline rate values. It was considered in the present study that *rigor mortis* in the three muscles began to set in between 18-20 hours *post mortem* approximately, because pH decrease was minimal from this time and up to 24 hours.

Contraction rate and metabolism type: Fig. 2a.shows the values of myofibrillar ATPase activity, which correspond to the speed of contraction of the muscle. The ATPase myofibrillar activity did not vary between the three muscles L, SM and ST ($p>0.05$); therefore, these muscles exhibit the same speed of contraction. In the available literature it was difficult to find results regarding contraction rate and type of muscle metabolism in goatling; due to this fact, the discussion concerning metabolic and contractile activities refers to the results reported for other species. Our results of myofibrillar ATPase activity were similar to those observed in pig muscles, (Laborde *et al.*,1985). In bovines between 2 and 10 years old, Talmant*et al.*,(1986) and Zamora *et al.*, (2005) reported lower values of ATPase activity than those reported in this study.

The results of LDH activity in L, SM and ST muscles are shown in Fig. 2b. Significant differences ($p<0.05$) were observed between the three muscles studied, muscles showing the greater and the lower average in LDH activity were L and ST, respectively. The activity of this enzyme for the three muscles varies from 23.75 to 44.29 µmoles of NADH /s/g of muscle. The values of LDH activity of this study were lower than those reported by Talmant *et al.,* (1986) for bovines between 2 and 10 years old (90, 85 and 75 µmoles of substrate /s/g of muscle for the SM, LD and ST muscles respectively)but higher that those reported by Zamora *et al.,* (2005) for LD muscle from Charolais of 19 months of age (36 µmoles of NADH /s/g of muscle).



2a



2b

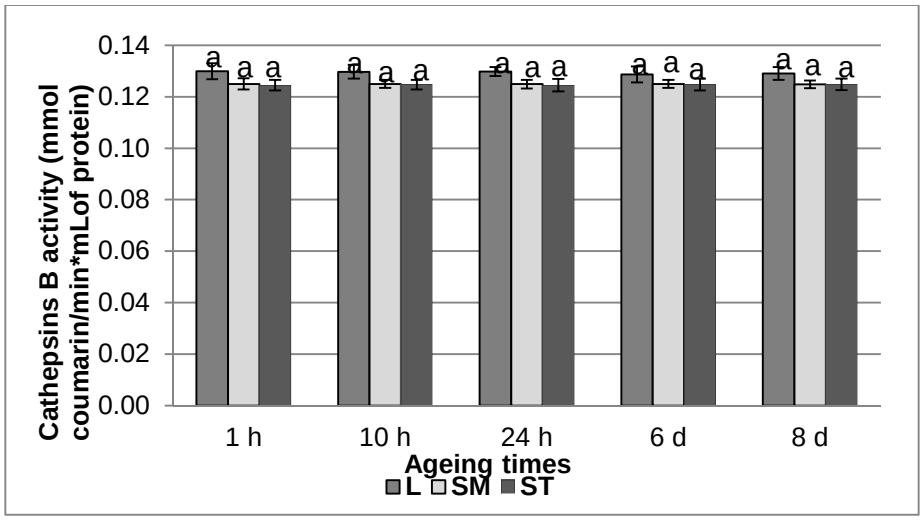
Figure 2.a) ATPase activity and b) Lactate dehydrogenase activity in *Semitendinosus* (ST), *Semimembranosus* (SM) and *Longissimus*(L), Each point is the mean of three independent determinations for each animal Means with same letters are not significantly different ($p>0.05$).

Our results and those reported in the literature suggest that there is a great difference between the values of LDH activity in muscles of the same species and in different species; these are not clear, because some authors have indicated that LDH activity decrease with animal age and others indicated that this activity increase with animal age (Talmant *et al.,* 1986; Jurie *et al.,*1995; Lefaucheur 2010). Regarding the relation between pHu values with the activity of these enzymes, the present results support and extend the conclusions of Monin *et al.,*(1987) who observed that in pig muscles pHu value is lower when LDH activity increases. In this study we also found that ultimate pH was lower when LDH activity increases. With respect to the speed of contraction, it was not related with pHu values because all muscles showed similar values of ATPase activity. Opposite results were found by Talmant*et al.,* (1986) who indicate that the ultimate pH was lower when ATPase activity increases. According to our results, activity LDH would be related with ultimate pH, because their function is to convert pyruvate into lactic acid, which is the final product of anaerobic glycolysis and responsible of muscle acidity. Based in the ATPase, citrate synthase and LDH activities in the literature, there is awell-defined classification of metabolism type and speed of contraction in different species as pig (Laborde *et al.,* 1985) bovine (Ansay 1974), sheep (Briand *et al.,* 1981), and guinea pig (Peter *et al.,*1972). Based on these classifications and according to the enzyme activities and the pHu obtained in our work, goatling muscles could be classified as follows: L and SM as "fast white" muscles because both have high ATPase and LDH activities and therefore their metabolism is mainly glycolytic with fast contraction rate, ST is a "fast intermediate" muscle due to that LDH activity value is considered as metabolism oxidative-glycolytic with high contraction rate.

Cathepsins B and B+L activities: The activity of cathepsins (cysteine-proteinases) B and B+L are presented in Fig. 3a and 3b,respectively. The activity of cathepsin B was unaffected by muscle type and ageing time($p>0.05$). In addition, it was observed that the activity of this enzyme remained constant during the time of storage in the three muscles studied, this results are in according with Cuenca-Mendoza *et al.,* (2014). This behavior has already been observed in other species (Etherington*et al.,* 1990; Gil *et al.,* 1998). Toldrá and Etherington (1988) reported a decrease of 70% in fresh pork muscle stored at 4°C for 20 days. Nagaraj *et al.,*(2002) reported that the activity of this enzyme exhibits significant changes at 20 days of storage; indicating that the activity decreased between 9-17% in LD, SM and ST muscles of adult goats (1 year). In this work these changes were not observed, may be because the maximum time of ageing was 8 days. Cathepsins B is associated with the *post mortem* proteolysis during ageing process; however, this enzyme may require more time for its activation and is dependent of muscle type (Nagaraj *et al.,* 2002).

Cathepsins B+L activity (Fig. 3b.), was affected by muscle type and ageing time, significant differences ($p<0.05$) between cathepsins B+L activity values of L, SM and ST muscles were observed, but not between SM and ST ($p>0.05$). Higher activity of cathepsins B+L was observed in L muscle ($p<0.05$) than in SM and ST muscles. It was also detected in the three muscles studied that cathepsins B+L activity was constant between 1-24 hours *post mortem* ($p>0.05$) at 6 days, this activity was reduced to 8 and 10% approximately, with respect of the first hours of ageing ($p<0.05$) and continued to drop during the time of storage. These results are in accordance with those reported by Cuenca-Mendoza *et al.,* (2014) when used two different age of animal. Nagaraj *et al.,* (2002) reported that cathepsins B+L activity for the adult goat decreased after 6 days of storage, and observed a greater drop (17-35%) after 20 days of storage. In pig meat have been reported by Toldrá and Etherington (1988) that 79% of activity of this enzyme decreases after 20 days of storage. Etherington *et al.,*(1987) and Whipple and Koohmaraie (1992) reported that the cathepsins B + L activity was higher in young animals than in adult animals.

These studies described above only report the percentage of decrease in enzymatic activity regarding the time of storage, because at present there are not reports that indicate the rate of decline of the cathepsins B and B+L activity with respect to time. In our study, we calculated the rate of decline of enzymatic activity in both enzymes, and it was found that for cathepsins B, the change of the speed was constant in the three muscles studied. The values were relatively small and similar in the three muscles 2.52E-06±2.04E-06, this behavior can help to understand why the activity of this enzyme constant. For cathepsins B+L the muscles ordered highest to the lowest change of speed were the SM, L and ST respectively, values oscillate between 2.37 to 3.18E-04cathepsin activity Unit/hour (Table 1). The highest rate of decline was observed for glycolytic muscles (L and SM), suggesting that the rate of decline may be dependent of metabolism type. The higher rate of activity loss can be positively related to meat tenderness indicating that when the activity loss is fast and its contribution to muscle proteolysis shorter, the meat is softer (Zamora *et al.,* 2005).



3a.

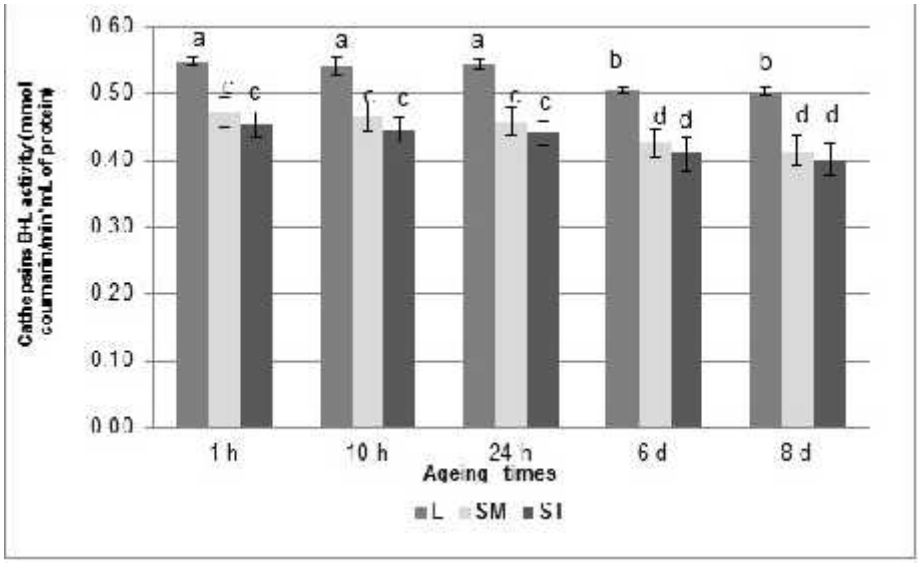
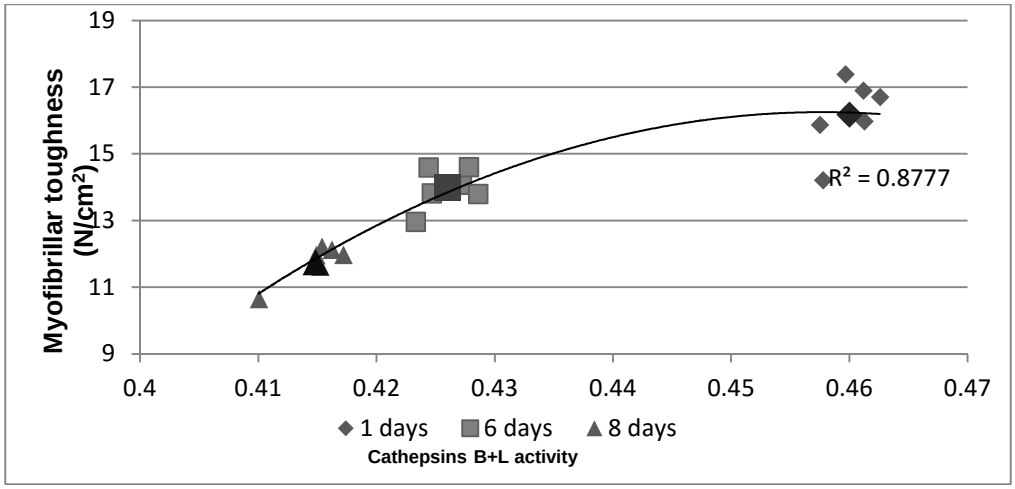


Fig. 3b.

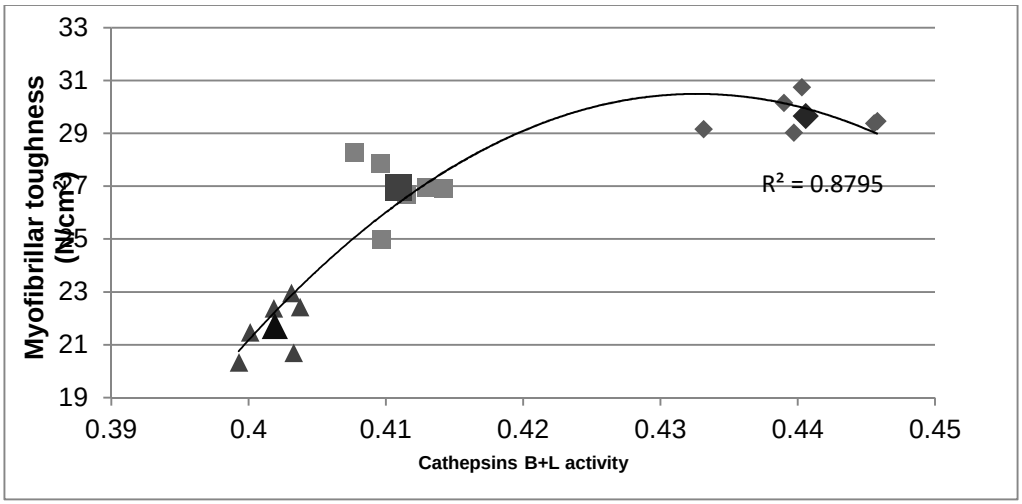
Figure 3.*Postmortem*cathepsins activities a) cathepsins B and b)cathepsins B+L in three goatling muscles *Semitendinosus* (ST), *Semimembranosus* (SM) and *Longissimus* (L) during 8 days of ageing. Each point is the mean of three independent determinations for each animal. Means with same letters are not significantly different (p>0.05).

Tenderness measurement: When the tenderness ofraw meat is determined using a compressive test at 20% of deformation the force measured correspond to myofibrillar toughness (Lepetit and Buffiere, 1993).Myofibrillar structure is the main structure that presents the greatest changes during ageing and its resistance indicates if the muscle is mature or no. Muscle is considered mature (conversion of muscle into meat) when values of myofibrillar resistance are lower than 10N/cm^2 (Lepetit and Buffiere, 1993). Table 1 shows myofibrillar toughness results for SM and ST muscles, results clearly indicate that myofibrillar toughness was lower ($p<0.05$) for the SM muscle than for the ST. It was observed that at 24 hours, the average toughness for ST muscle was twice higher than SM muscle; the value of myofibrillar toughness at 24 hours *post mortem* is correlated with the onset of *rigor mortis* since toughness of muscle is maximum (Lepetit *et al.*,1986). After 24 hours, was observed a significant ($p<0.05$) reduction of myofibrillar toughness in both muscles; this has also been observed by Lepetit and Buffiere (1993), and Zamora *et al.*, (2005) in muscles of other species. At 8 days of ageing myofibrillar toughness for SM and ST muscles was approximately of 12.0 and 22.0 N/cm^2 respectively ($p<0.05$). These results suggest that in both muscles is necessary more time of storage to reach 10N/cm^2 or less.

SM muscle could be considered mature at 10 days of storage as we have observed in others species; however, for ST muscle it would be necessary to increase storage time in order to obtain a resistance of 10N/cm^2. Zamora *et al.,* (2005) indicate that when toughness is greater than 10N/cm^2 the meat must be considered as tough and is not acceptable for the European consumer. With respect of muscle L, it was not possible to determine directly myofibrillar toughness, for that an SDS-PAGE electrophoresis was performed to determine myofibrillar degradation (data not shown). In the current study we found that for this muscle, a 30kDa band appeared after 24 hours *post mortem*, which is related with proteolysis due to the degradation of the T troponin (Cuenca *et al.,* 2014). These results coincide with those reported by Christensen *et al.,* (2004) who observed that in LD pig muscle, this band appears after one day post mortem; for SM muscle it was observed after 3 days and for ST muscle it was yet not observed after 8 days of ageing. The differences in meat toughness have been attributed at pHu value and the rate of pH decline; a negative relation has been observed when pH drop is very fast as in PSE (pale, soft, exudative) muscles the meat is tougher (Monin and Ouali 1990; Ouali 1991). We clearly observed that pHu value and the rate of decline are related with meat tenderness during ageing time, because muscles that presented the lower pHu value and highest decline rate were softer. LDH activity also has been correlated with toughness meat, but it is considered that the correlation could be positive or negative (Maltin *et al.,*2003). In the present study we observed that meat toughness in Nubia goatling is also associated with LDH activity, and therefore with the metabolism type; it was indicated in preceding paragraphs that ATPase and LDH activities were higher for the SM muscle than for the ST, suggesting a glycolytic metabolism with a fast contraction speed for the SM muscle, which indicates that the predominant glycolytic muscles would present less myofibrillar toughness in Nubia goatling. In contrast, Zamora *et al.,* (2005) found that the least glycolytic and slow contracting bovine muscles tenderize as much as muscles with higher glycolytic potential and higher contraction speed. This same behavior was found by Oual*iet al.,*(2005), who indicated that the difference in toughness between glycolytic and oxidative beef muscles after 8 days ageing was not significant, these differences confirms that it is not possible to extrapolate the results between different species. Meat toughness also depends of the activity of proteolytic enzymes like cathepsins (Koohmaraie 1994), in this study we found that cathepsins activity depends of muscle type and their activity is directly related with meat toughness. Relationship between toughness and cathepsins B+L activity is shown in Fig. 4a and b for SM and ST muscles, respectively. In these figures we can observe that there is a quadratic correlation (R^2 0.877-0.8795) between toughness and cathepsins B+L activity, this is, when enzymatic activity decreases toughness also decreases. Respect to SM muscle (Fig. 4a.) it can be observed that at one day postmortem exists more dispersion between toughness values and cathepsins B+L activity and this dispersion decreases as ageing time increases, this suggests that when proteolysis increases there is a closer relation between toughness and cathepsins B+L activity. Respect to ST muscle (Fig. 4b.) it is observed that results present more dispersion and this one does not decreases respect to ageing time.



4a.



4b.

Figure 4. Plot of myofibrillar toughness versus cathepsins B+L activity and the correlation between these variables, a) SM muscle and b) ST muscle during 8 days of ageing.

These differences in dispersion between these muscles could be due to that SM muscle is more homogenous because it presents a predominant glycolytic metabolism and ST is a more heterogeneous muscle due to that it shows both types of metabolism, glycolytic and oxidative. These results suggest that the tenderness of muscles SM and ST is correlated with metabolic type, because both muscle presented the same values of contracted rate. In addition, it is clear that SM and ST muscle of goatling require of ageing process to reduce the toughness of meat. According to Ouali *et al.*, (2006) storage of muscles for a reasonable period of time is a prerequisite for the development of the organoleptic qualities to the final product, namely meat. In Europe, this storage is approximately between 8 and 10 days *post mortem*. In Mexico consumption of meat from the different species is generally done 24 hours *post mortem* when the organoleptic characteristics have not yet developed and the muscle toughness is at its maximum. Unfortunately it was not possible to determine the instrumental tenderness in L muscle and we cannot correlate the tenderness with cathepsins B+L activity, we suggests that the behavior of the L tenderness could be similar to the SM muscle because both muscle presented a glycolytic metabolism.

Conclusions: According to the enzymatic activity of LDH and myofibrillar ATPase, pHu and the rate of pH decline, the SM and L muscles of this species presented a predominantly glycolytic metabolism and a fast rate of contraction, so they may be considered as "fast white muscles". The ST muscle presented both glycolytic and oxidative type of metabolism and a fast rate of pH decline, so they may be considered as "fast intermediate muscles". The metabolism type directly influenced on the activity of cathepsins B+L and their rate of decline activity. In SM and ST muscles there is a correlation between cathepsins B+L activity and tenderness. Another important conclusion is that although the term "goatling" is refers only to young animals, a tenderizing/ageing period would be necessary because it is during this period of storage when the main organoleptic characteristics of the muscle are developed such as: taste, color, but mainly tenderness.

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