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RESEARCHES REGARDING THE EVOLUTION OF OVINES MEAT QUALITY DURING REFRIGERATION STORAGE CONDITION

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Abstract

The purpose of this paper is to present the evolution of the pH values during ovine meat refrigeration/maturation. In order to achieve the proposed objectives, investigations were carried on a total number of 104 ovines (52 lambs and 52 adults) taken from the farm of Horleşti, located in the north-east of Romania, in proximity of the Iaşi municiple. The analyzed muscles are characterized by oscillatory amplitude of recorded values, following a descending trend during the first 48 h, then an ascending trend within the time span of 48-120 h, when meat maturation is stimulated. At the end of the rigidity period it is found that in muscle samples taken from the Karakul breed, the highest glycogen values are found in the Longissimus dorsi, as for Ţurcană they are found in Trapezius pars thoracica. pH values during meat maturation fit within qualitative standards for meat, avoiding undesired effects such as PSE or DFD.

Key words*: quality, meat acidity, ovines, NE Region, Romania.*

INTRODUCTION

Quality has a particularly important role in the social and economic challenge, being demanded and imposed by the saturation of agri-foods markets, due to the high efficiency of modern agriculture and zootechnical sector (Crăciun et al., 2011; 2012; Murariu et. al., 2018; Rațu et al., 2018). This is one of the reasons why the quality of meat has occupied a significant place in the research agenda, many years ago, at worldwide level. The structure of the skeletal muscle and its biochemical components influence the transformation of the muscle into meat and sensitively perceptible quality of it including tenderness, color, flavor and succulence (Murariu et al., 2013a;b;c; Lazăr et al., 2011; Frunză et al., 2019a;b). The acidity of the meat is given by the concentration of organic acids from meat (Simeanu et al.2015; Simeanu et al., 2017; 2018), including acidic substances, being measured by the pH value. Knowing the evolution of muscle acidity in post mortem period has a particular importance because it influence the physical properties of the meat, of the water retention capacity and on the product self life (Byrne et al., 2000; Boișteanu, 2002). The most important meat quality index is pH. It reflects the biochemical processes that are taking place in the transformation of muscle into meat (Lup et al., 2018; Murariu et al., 2012). In lambs alive, the pH of the muscle is between 7.1 and 7.3 values. After slaughter, blood circulation stops. Consequently, the intake of oxygen and nutrients is stopped. From this moment on, skeletal muscles are happening a series of irreversible physicochemical and biochemical changes (anaerobes and lactic acid formation) that produce cadaveric rigidity. One of the consequences of this phenomenon is the decrease of the pH values that passes from 7.1 – 7.3 values to values that varies between 5.6 to 6.4 depending on the muscle region. Changes on the pH values during the post-mortem period depend on the glycogen concentration of the muscle after slaughter (Dragomir, 2005). The pH values in *post mortem* stage found in the literature indicate that the ovines species is less sensitive to slaughtering stress than suine and bovine species (Petrescu et al., 2011; Vergara et al., 1999).

Immediately after slaughter, the meat of slaughterhouse animals has an almost neutral reaction. The first enzymes that act are calpaines, the proteolytic enzymes contained in

muscle fiber, that have similar properties to cathepsins, but who act in a neutral and slightly alkaline environment. As the muscular rigidity is installed, the reaction becomes acidic. The main consequence of the accumulation of lactic phosphoric acids is the decrease of the pH to about 5.6.

MATERIALS AND METHODS

In order to characterize the evolution of meat quality stored in refrigerate condition by its acidity through this paper it aimed to present the evolution of the pH values during ovine meat refrigeration for 120 hours. These assessments are necessary given the pattern of modern consumers model who are increasingly concerned about safe meat production and marketing without adverse effects on their health.

In order to achieve the proposed objectives, investigations were carried on a total number of 104 ovines (52 lambs and 52 adults), respectively 26 lambs of Karakul breed and 26 lambs of Ţurcană breed, 26 adult ovines of Ţurcană breed and 26 ovines of Karakul breed, taken from the farm of Horleşti, located in the north-east of Romania, in proximity of the Iaşi municiple. Harvesting and sampling was made for three muscular tissue, as follows: *Longissimus dorsi, Triceps brachii and Trapezius pars thoracica*.

The determination of the pH values was performed after 6; 12; 24; 48; 72 and 120 hours *postmortem*, according to the analysis principle described by SR ISO 2917:2007. To perform the examinations it was prepared the aqueous meat extract for each sample. For this purpose, the meat sample was cleansed by connective and fatty tissues and finely chopped. From the minced sample it was taken 10 grams with 100 cm^3 distilled water in a 250 cm^3 Erlenmeyer flask. The mixture was left about 15 – 20 minutes during which it was stirred several times. It was filtered and after the filtrate was subjected to the examination. The Hanna digital pH-meter reads automatically the pH value and the temperature. Measurement was carried out after calibration with 4.01 and 7.01 buffers. After the device balancing, the reading electrode was introduced into the filtered extracts prepared and the values were readed automatically.

RESUTS AND DISCUSSIONS

Before slaughter stress has significant influences on the ultimate pH value of the muscle, so the tenderness differs between muscles with free shortening and those immobilized from the shortening (Murariu et al., 2014*)*. Stress may be due to the animal transport to the slaughter house, narsh way handling, unfavourable temperature, starvation, and any other factor that could affect the development of glycogen stores before animal slaughter (Muchenje, 2007; Ghimpeteanu et al., 2016).

Muir et al. (1998) found that green – fed animals are more sensitive to stress before slaughter, in association with depletion of glycogen stores compared with animals feed with dietary supplements. In green – fed animals are found higher pH values in relation to animals feed with concentrated feed.

Muscle acidity presents changes during muscle conversion in meat. The evolution of acidity value and its oscillation amplitude have specific influences on the physical properties of meat. Berge et al. (2003) found a direct dependence between the weight of the carcass, with a higher predisposition for cold shortening for muscles from lambs. They recommend to prevent the risk of cold shortening to keeping the carcass at 15 ^oC for 6 hours *post mortem*. Thus, is attempted a slower decrease of temperature, without increasing the rate on fall in *rigor mortis* phase (McGeehin et al., 2001). The ultimate pH value, measured at 24 hours after slaughter is influenced by glycolytic potential, namely the amount of glycogen content that could be converted in lactic acid.

In the *prerigor* phase, at 6 hours after slaughter, the muscles collected from Ţurcană breed revealed very significant differences ($p>0.001$) reported on the age category at slaughter, with the mean values ranging from 6.16 (in *Trapezius pars thoracica muscle*) and 6.45 (in *Triceps brachii muscle* and for the muscles samples collected from Karakul ovines there were significant differences ($p>0.05$) at Triceps brachii muscles and distinctly significant differences ($p>0.01$) for *Trapezius pars thoracica muscle* with the mean values ranged between 6.27 (in *Triceps brachii*) and 6.5 for *Trapezius pars thoracica muscle.* This

differences are influenced by the energy reserves (glycogen and phosphocreatine) present in the muscles, the amount of the lactic acid founded in the muscle mass, the health and fatigue states of the ovines, the effect of animal stress and the contraction state of the muscle before slaugter (Strugaru et al., 2010). The moment of muscle rigidity installation at 5 – 6 hours after slaughter is favored by the decreasing of pH values trend and the increasing of actin and myosin atractivness. Therefore, the animals age at slaughter does not show a factor of interest in *rigor mortis* phase, as evidenced by insignificant differences ($p<0.05$), until is reached the meat maturation threshold. This downward trend was recorded up to 48 hours, at which moment the pH values began to increase. These results are in accordance with those fouded in the literature, by Mc Geehin et al. (2001) and Berge at al. (2003) who following a comparative study of muscles composition and meat quality from six different European countries, reported that is no evidence that the age of animals influences the rate of *postmortem* pH decrease in lambs meat. The pH decrease is direct proportional with ATP hydrolysis actvity, being determined by glycogen stores at the moment of animal slaughter. Thus, it take place the formation of actomizinic complex with the actin and myosin accumulate in non contractile mass. Primary statistical estimates calculated do the researches data, which characterize the degree of dispersion of ovines meat acidity values during meat maturation, were low. Thus, the standard error of the average values have oscillated between 0.004 and 0.05, and by coefficient of variation calculating it were express values below 5% limit (0.21 – 2.88%), with one exception of 6.28%, values which evidence a very good homogeneity within the age of ovines and breed (Table 1).

Whereas the weight of carcass is directly dependent on the age of animals, these aspects creating a higher predisposition for cold shortening of the lamb muscles (Berge et al. 2003), in this work reserches it were been taken precautions measures to prevent the risk of cold shortening. Thus, the carcasses were kept at 14^{o}C for 6 hours in *post mortem* phase, to perform the wounding, in order to prevent cold shortening of the muscles by a low temperature decrease.

The mean values of ultimate pH ranged from 5.6 to 5.7 beeing generally accepted as normal for ovines meat with a slow entry in rigidity phase.

The ultimate pH values obtained for muscles sampled collected from Karakul breed ranged between 5.65 (*Trapezius pars thoracica*) and 5.71 (*Triceps brachii*) and for muscles collected from Țurcană breed the values ranged from 5.62 (*Triceps brachii*) and 5.67 (*Longissimus dorsi*). These values fall within the normal limits presented in the literature (Harss and Shorthose, 1988; Berge et al., 2003). The meat maturation began to be established in this researches at 48 hours after slaughter, being favored by the pH values increased. This phase is characterized by a low degradation of actomyosin in actin and myosin and of sarcoplasmic proteins, by an increse of hydration capacity and water retention capacity and an improve of sensorial characteristics of ovines meat (tenderness, succulence and flavor). Instead, the muscles collected from Țurcană breed carcasses revealed significant statistical differences ($p>0.05$) for *Longissimus dorsi* muscle at 72 hours after slaughter, distinctly significant differences for *Longissimus dorsi* after 120 hours after slaughter and very significant differences ($p>0.001$) for *Triceps brachii* muscles at 72 and 120 hours after slaughter with the mean values ranging from 5.9 (*Longissimus dorsi*, from adult ovines) and 6.14 (*Triceps brachii*, adult ovines). These results fall within the limits presented in the literature 5.8 – 6.2 (Georgescu et al., 2000). In the maturation phase of the meat, the samples collected from Karakul breed carcasses revealed significant statistical differences ($p>0.05$) for *Longissimus dorsi* muscle and distinctly significant differences for *Triceps brachii* muscles ($p>0.01$) related to age at 120 hours after slaughter, with the mean values ranging from 5.84 (*Longissimus dorsi* muscle from adult ovines) and 6.12 (*Triceps brachii* muscles from adult ovines). At all muscular regions evaluated, collected from the both age groups (*Karakul* and *Țurcană* breeds), the acidity highlight a decrease of the mean values between 0 and 48 hours post mortem, reaching the minimum limit of 5.39 value, being followed by an evolution of the means

values that ranged in the 48 – 120 hours interval, with the final mean values ranged from 5.84 to 6.14 (Figure 1).

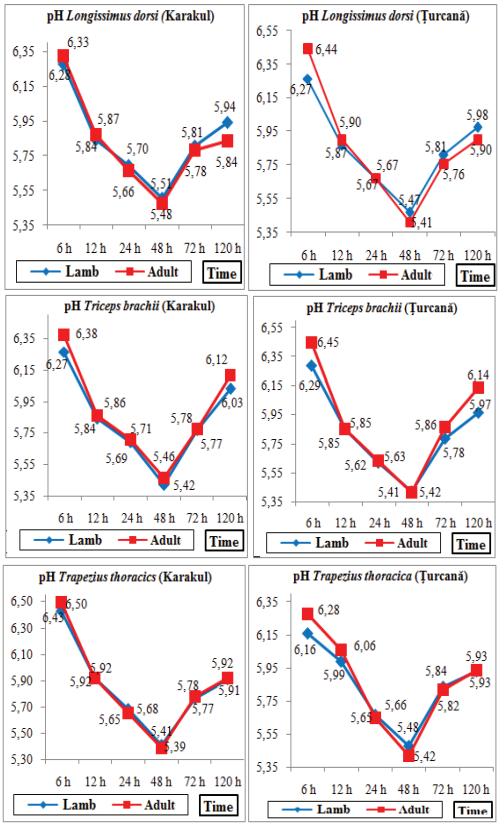

Figure 1. The acidity dynamics of L*ongissimus dorsi, Triceps brachii and Trapezius pars Thoracica* muscles during maturation, depending on age

The pH mean values presented by age groups for the ovines breed analysed highligted variations in the *pre rigidity* phase, uniforming themselve in the same intervals of decrease, thus at 12; 24 and 48 hours the most values have intersected except for those measured at 12 hours for *Trapezius pars thoracica* collected from Ţurcană ovines. In the maturation phase, at 72 hours of slaughter, the upward trend maintains the uniformity of variation except the mean values obtained for the (*Longissimus dorsi* and *Triceps brachii* muscles from Ţurcană breed whose values ranged from 5.76 to 5.81 and 5.78 to 5.86. Therefore, the dynamic of acidity between the two ovines age groups for each breed revealed curvilinear relations within the same areas of variations of the mean values (Figure 1).

The quality of ovines meat according to it's acidity is mainly influenced by intrinsic factors (breed, gender, muscular growth rate, energy reserve) as well as extrinsic ones (intensive exploitation of animals associated with slaughter and marketing methods or slaughtering season).

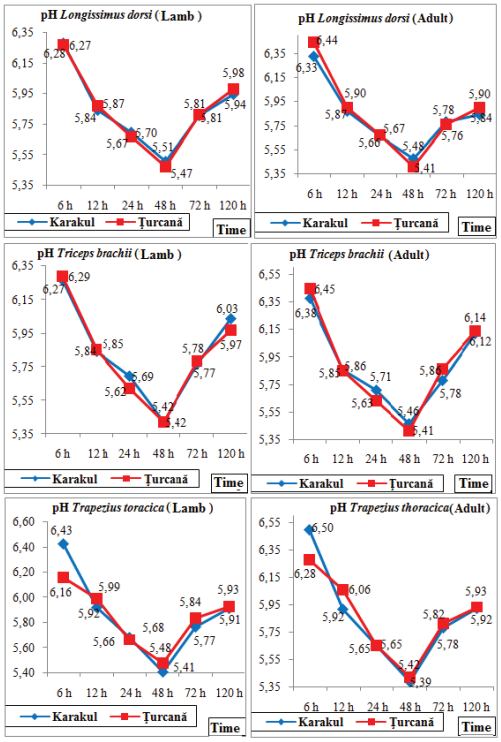

Figure 2. Dynamic of ovines meat mean values for acidity (derived from lambs and adult ovines) during maturation, depending on breeds

The statistical analysis of the pH dynamic for each age group according to breed revealed the recording of significant differences ($p>0,001$) for *Triceps brachii* muscle at the final pH for both age groups and at 72 hours after slaughter when talking about the acidity of the samples collected from *Turcana* ovines (Table 1). The statistical analysis of the *Trapezius pars thoracic* value of muscular acidity showed significant differences according to breed for both age groups in the previous phase and 12 hours after slaughter. Unlike adults, the lambs recorded significant distinct differences ($p>0.01$) at 48 hours after slaughter according

to breed and very significant differences (p>0.001) during maturation (at 72 hours) (Table 1). These differences can be observed in the charts for both age categories of ovines studied comparatively between breeds (Figure 2). Thus, at lambs, the curvilinear relationship between the two breeds fits within very uniform areas of variation for *Longissimus dorsi* and *Triceps brachii* muscles, while mean pH values for the *Trapezius pars thoracic* muscle revealed variations in the *pre-rigor* phase (6.16 - 6.34), which were uniform throughout the rigidity and maturation of the meat (Figure 2). The acidity dynamic of the evaluated meat for adult sheep showed the uniformity of the variation ranges for most of the phases except for *Longissimus dorsi* and *Trapezius pars thoracic* muscles which at the time of *pre-rigidity* showed variations in the range of 6.33 ÷ 6.44 and 6.28 ÷ 6.5 when the rigidity was installed at 12 hours *post mortem* (Figure 2).

Table 1. Statistial estimators and statistical differences between lambs and adult ovines and between Karakul and Țurcană breeds of ovines meat acidity during its maturation

Muscle region		Age categ.	Karakul breed		ANOVA		Țurcană breed		ANOVA
			$\bar{X} \pm s_{\bar{x}}$	V%	K vs Ț	T vs A	$\bar{X} \pm s_{\bar{x}}$	V%	T vs A
Longissimus dorsi	6 h	L	6.28 ± 0.04	2.25	i.s.	i.s.	6.27 ± 0.01	0.81	***
		A	6.33 ± 0.05	2.88	*		6.44 ± 0.01	0.41	
	12 h	L	5.84 ± 0.02	1.11	i.s.	i.s.	5.87 ± 0.01	0.78	i.s.
		A	5.87 ± 0.02	1.04	i.s.		5.9 ± 0.02	0.94	
	24 h	L	5.7 ± 0.01	0.88	i.s.	i.s.	5.67 ± 0.01	0.57	i.s.
		A	5.66 ± 0.02	1.03	i.s.		5.67 ± 0.01	0.58	
	48 h	L	5.51± 0.02	1.3	i.s.	i.s.	5.47 ± 0.01	0.77	i.s.
		A	5.48 ± 0.02	1.08	**		5.41 ± 0.01	0.94	
	72 h	L	5.81± 0.01	0.56	i.s.	i.s.	5.81 ± 0.01	0.69	*
		A	5.78 ± 0.01	0.84	i.s.		5.76 ± 0.02	1.02	
	120 h	L	5.94± 0.01	0.56	i.s.	*	5.98 ± 0.01	0.9	**
		A	5.84 ± 0.01	0.8	*		5.9 ± 0.02	1.28	
Triceps brachii	6 h	L	6.27 ± 0.03	1.6	i.s.	*	6.29 ± 0.02	1.24	***
		A	6.38 ± 0.04	2.42	i.s.		6.45 ± 0.02	0.95	
	12 h	L	5.84 ± 0.01	0.21	i.s.	i.s.	5.85 ± 0.01	0.57	i.s.
		A	5.86 ± 0.01	0.57	i.s.		5.85 ± 0.04	2.44	
	24 h	L	5.69 ± 0.01	0.75	***	i.s.	5.62 ± 0.02	1.07	i.s.
		A	5.71 ± 0.01	0.76	***		5.63 ± 0.01	0.83	
	48 h	L	5.42 ± 0.01	0.74	i.s.	*	5.42 ± 0.01	0.94	i.s.
		A	5.46 ± 0.01	0.9	*		5.41 ± 0.01	0.98	
	72 h	L	5.77 ± 0.01	0.67	i.s.	i.s.	5.78 ± 0.02	1.1	***
		A	5.78 ± 0.01	0.91	***		5.86 ± 0.01	0.51	
	120 h	L	6.03 ± 0.02	1.3	**	**	5.96 ± 0.004	0.27	***
		A	6.12 ± 0.02	0.95	i.s.		6.14 ± 0.02	1.06	
Trapezius thoracica	6 h	L	6.43 ± 0.02	0.94	***	**	6.16 ± 0.01	0.69	***
		A	6.5 ± 0.02	0.99	***		6.28 ± 0.02	1.27	
	12 h	L	5.92 ± 0.01	0.81	***	i.s.	5.99 ± 0.01	0.8	***
		A	5.92 ± 0.02	1.25	***		6.06 ± 0.01	0.85	
	24 h	L	5.68 ± 0.01	0.82	i.s.	i.s.	5.66 ± 0.02	1.02	i.s.
		A	5.65 ± 0.02	1.1	i.s.		5.65 ± 0.01	0.85	
	48 h	L	5.41 ± 0.02	1.26	**	i.s.	5.48 ± 0.02	1.03	i.s.
		A	5.39 ± 0.01	0.94	i.s.		5.42 ± 0+.01	0.6	
	72 h	L	5.77 ± 0.02	1.03	***	i.s.	5.84 ± 0.01	0.48	i.s.
		A	5.78 ± 0.01	0.78	i.s.		5.82 ± 0.01	0.9	
	120 h	L	5.91 ± 0.1	0.53	i.s.	i.s.	5.93 ± 0.02	1.13	i.s.
		A	5.76 ± 0.1	6.28	i.s.		5.93 ± 0.01	0.76	

[1] h – hours from slaughter; [2] A – adult ovines; L – lambs; [3]V% - coefficient of variation

[4] i.s – insignificant statistical differences (p<0.05); * - semnificative differences (0.01>p>0.05); ** - distinct semnificative differences (0.001>p>0.01); *** - very significant differences (p>0.001)

CONCUSIONS

Varying age or weight at slaughter is one of the most important factors for ovine meat acidity, during the *prerigor mortis* phase. Resulted statistical differences in pH values between the two age categories for muscle samples from the two breeds taken into presented researches (Karakul and Ţurcană) are justified by the level of energetic resources present in muscles due to age, with higher glycogen quantities in adult ovines.

The main consequence of the accumulation of lactic phosphoric acids is the decrease of the pH to about 5.6. When the meat enters in the resolution phase, the reaction tends to neutral again. It is appreciated that there is a strong correlation between the chemical reaction (expressed by pH) and the state of meat tenderness.

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