Evaluating the Quality of the Rabbit Meat (Flemish Giant Breed) During Storage by Refrigeration Following the Evolution of the pH

Gabriela Tărnăuceanu (Frunză)[1], Cecilia Pop[1], Paul Corneliu Boişteanu[1]

University of Agricultural Sciences and Veterinary Medicine Iasi, 700490-Iasi, Mihail Sadoveanu, 3, Romania

Abstract

The acidity evolution in muscle during the period after slaughter, to its maturation, it has direct links with the sensory quality characteristics of meat (tenderness, firmness, aroma) and influences the water holding capacity and suitability for storage. The purpose of this paper was to determined the pH evolution of rabbit meat (Flemish Giant breed) after slaughter, during maturation, to autolysis and alteration, from 27 individuals (15 males and 12 females). The rabbits had an average body weight of 11.5 kg being at the age of reproductive maturity (11-12 months). The pH evolution of meat (refrigerated at 2^0C) was monitored during of 18 days after slaughter. There have been sampled different muscle groups (*Longissimus dorsi, Psoas major, Triceps brachi, Biceps femoris, Semimembranosus, Intercostalis, Cervicalis* muscles). The pH value of the meat varies, depending primarily on the different metabolic type of muscle, the lowest pH level, at 24 h after slaughter, it has been found in *Longissimus dorsi* muscles (5.7) and the highest values in *Intercostalis* muscles (6.1). Starting with the 14th day of storage the meat was altered, the pH being close to 7 (for males and females, on the average 6.49 for *Longissimus dorsi* muscles, 6.57 for *Psoas* muscles, 6.56 for *Semimembranosus* muscles, 6.66 for *Intercostalis* muscles, 6.73 for *Triceps brachi* muscles, 6.75 for *Biceps femoris* muscles, and the highest value 6.81 for *Cervicalis muscles*). The pH evolution had an ascending trend, quite similar for females and males, presenting preponderant insignificant differences by gender.

Keywords: evolution, females, males, meat, rabbits

1. Introduction

Meat quality depends on a large number of factors often related with muscular pH. [1]. However, few studies have been made on the pH of rabbit meat. Differences among rabbit strains with a different adult size, and at a different degree of maturity, have been found in *Longissimus dorsi* muscle. Other authors have also found differences between muscles in a strain, depending on the type of metabolism of the muscle. Many factors such as genotype, age, weight, gender, maternal effect, rearing system and temperature can influence growth and change the relative growth of organs and tissues, leading to modifications of carcass traits of rabbits, meat quality [1, 2] and energy metabolism [3-12]. Determinations of rabbit meat pH evolution over a longer period of time have not been found yet. The purpose of this paper was to determine the rabbit meat quality (Flemish Giant breed) by pH evolution of after slaughter, during maturation, to autolysis and alteration. This paper is part of a broader study aimed to make a comparative characterization of rabbit (Flemish Belgian breed) and hares (*Lepus europaeus* Pallas) meat quality.

* Corresponding author: Gabriela Frunză
Tel: 0758922082, Email:
frunza.gabriela27@gmail.com

2. Materials and methods

The biological material was composed from 27 individuals (15 males and 12 females).

The rabbits had an average body weight of 11.5 kg being at the age of reproductive maturity (11-12 months). They were fed without fodder and water restrictions. The slaughter of rabbits was made in summer (June). The pH evolution of meat (refrigerated at 2^{o}C) was monitored during of 18 days after slaughter and was used the Hanna Electronics pH meter, 212 model. There have been sampled different muscle groups (*Longissimus dorsi, Psoas major, Triceps brachi, Biceps femoris, Semimembranosus, Intercostalis, Cervicalis* muscles). The sample storage was made in hermetically sealed plastic bags for each muscle group, being numbered for each individual (females or males). Measurement was performed by calibrating the pH-meter with two standard solutions of known pH. After balancing the device, the electrode is inserted in previously prepared meat broth and the pH reading is achieved. Meat broth was prepared by adding 10 g of a finely chopped sample in 100 ml distilled water and then filtering the mixture. The results were statistically interpreted (by gender, for all seven muscle groups), by analysis of variance test (ANOVA multiple comparisons), using the GraphPad Prism 8.1 software.

3. Results and discussion

The mean values calculated for the evolution of pH of rabbit meat were similar for both sexes, ranging from those found in the specialized literature for the 24 and 48 hours after slaughter.

Dalle Zotte, et al., 2016, found the mean value of pH at 24h in rabbit, variable for two muscle groups: 5.83 in *Biceps femoris* muscles and 5.71 in *Longissimus lumborum* muscles. As stress before slaughter probably varies, it is not surprising to find that certain authors have noted some differences in pH. The pH 24 of *Longissimus dorsi* (5.66) was lower than the pH 24 of the *Biceps femoris* (5.77) due to the different metabolism of the muscles, *Biceps femoris* being more oxidative [1]. In our study, the pH value at 24h was close with that from the previous mentioned studies for *Longissimus dorsi* (5.72 for females and 5.73 for males) and higher for *Biceps femoris* (6.02 for females and 6.06 for males). The pH of meat is mainly influenced by the composition of muscle (glycolytic and oxidative fibres). Musculus *Biceps femoris* has higher oxidative metabolism and lower glycolytic potential and it has higher pH value than *Longissimus dorsi* muscles. In white muscles (*Psoas major* are pure white fast contracting type, αW), which are glycolytic in the adults, the oxidative activity decreases after birth [1]. The limits of admissibility for consumption, of rabbit meat pH (and for other species) are 5.65-6.45 (Banu, 2003)[11].

For *Psoas* muscle, in our study, the mean value of pH at 24 h was 5.83 for males and 5.89 for females (Figure 1).

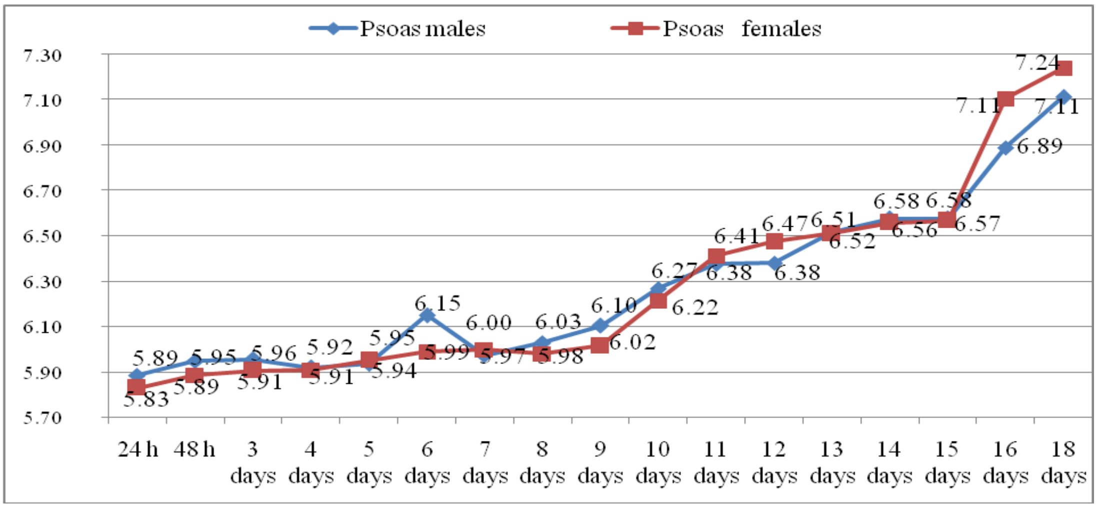

Figure 1. The pH evolution for *Psoas* muscles - females and males

The pH evolution of the *Psoas* muscles (Figure 1) was relatively similar for both sexes, except that for the samples harvested from females, the pH values were higher at the end of the followed period than those recorded for males.

For *Intercostalis* muscles, the mean pH values followed a growing trend, slightly fluctuating in the first seven days. After this period there were some oscillating increases, with higher values for males at the end of the analyzed period (Figure 2).

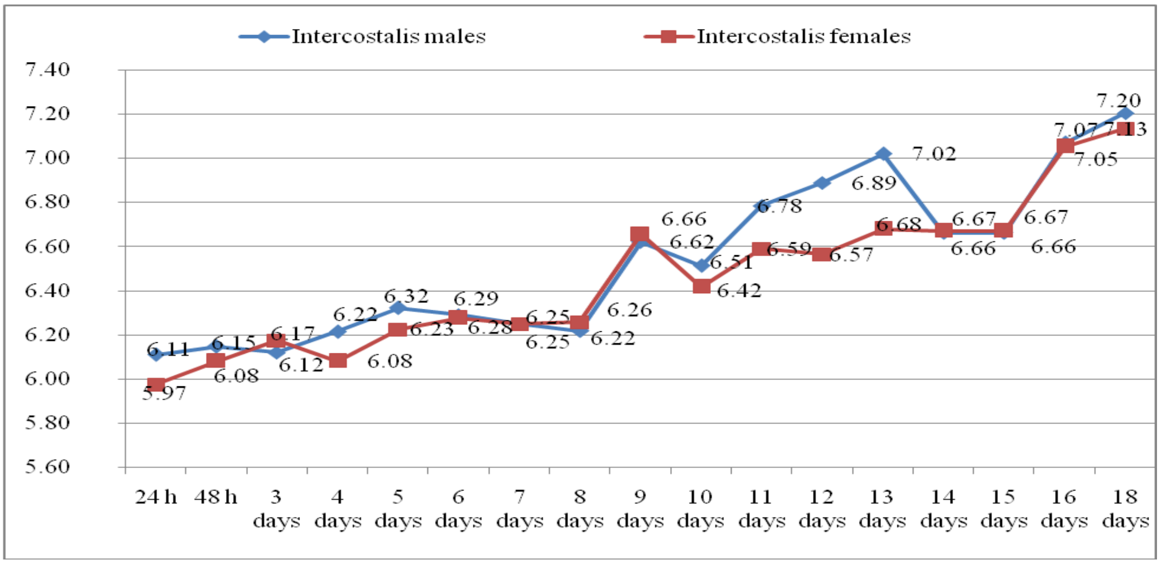

Figure 2. The pH evolution of Intercostalis muscles for females and males

For cervical muscles (Figure 3), the pH evolution had a constant growth rate up to the day eight for males; starting at day eight, there is a disorderly increase of the pH, more pronounced than for females, especially at day 12.

For females, there was a decrease in pH at day five and six, followed by stagnation for days seven and eight, then a slight increase until at the level of day 15, followed by an accelerated growth for the end of the analyzed period.

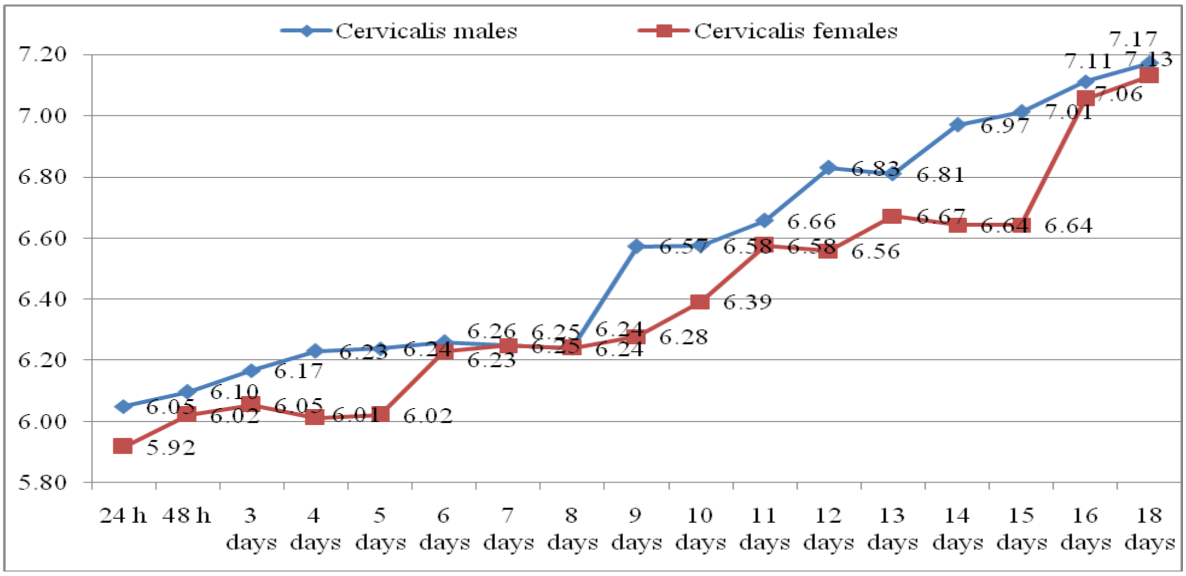

Figure 3. The pH evolution for Cervicalis muscles for females and males

For *Longissimus dorsi* muscles (Figure 4), the pH evolution had an upward trend to the level of day seven, where it decreases, followed by a high increase for females and a fluctuating one for males, with an acceleration after day 14

The reason for the pH decreasing is an accumulation of lactic acid in muscles, which comes from degradation of glycogen.

After Chodova and Tumova, 2013 [5], the ultimate pH of meat is mainly influenced by the glycogen stores in muscle at the moment of slaughtering. This is related to fibre composition of muscle and ante mortem factors that can lead to a depletion of glycogen stores in muscles [5].

Dalle Zotte et al., 2016, found that the breed, parity and gender are not able to modify tissue organisation (muscle fibre types, areas or shape, main energetic pathways) in *Longissimus* muscle. The absence of genetic effect on *Longissimus* muscle fibres characteristics supports the data reported in Champagne d'Argent and Chinchilla breeds. However, another research work comparing 3 sire strains found the lowest percentage of βR (slow contracting red type) fibres in the breed with the highest degree of maturity.

The crossbreds showed an identical degree of maturity, and this justified the absence of effect on muscle fibre traits. The lack of significance in the main muscle fibre characteristics can therefore explain similar values observed for meat quality traits (pH, colour, tenderness), which are under the influence of muscle structure and metabolism [4-6].

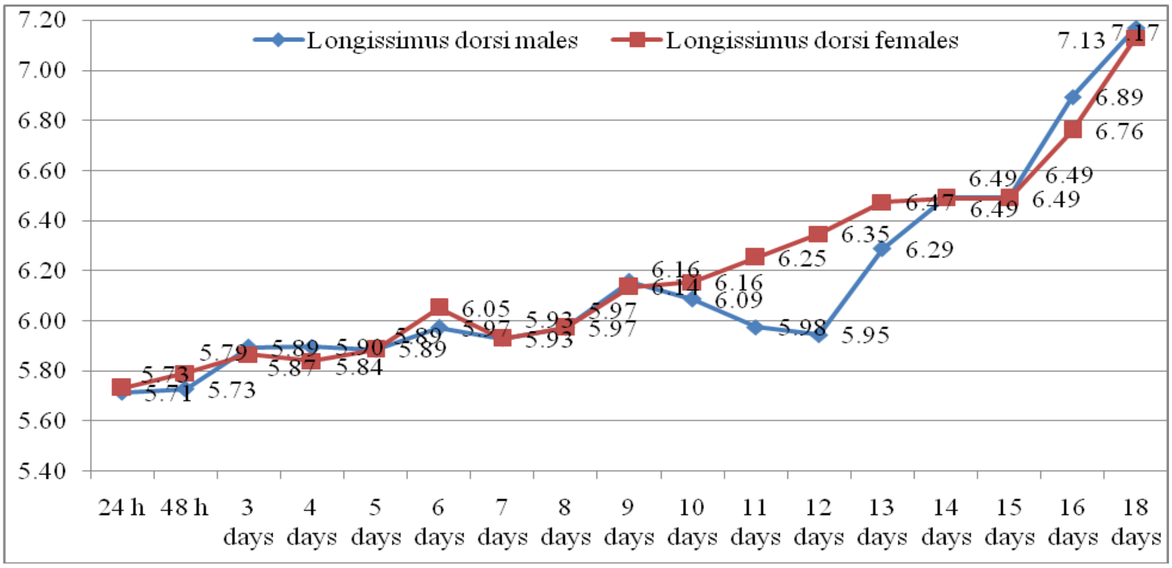

Figure 4. The pH evolution of *Longissimus dorsi* muscles - females and males

At the *Semimembranosus* muscles, pH evolution was relatively similar for both females and males. Thus, there is a very slight increase to the first six days, with a stagnation of days six and seven, with a fall in day 9, followed by an increase that accelerates from day 12, until alteration, day 15. The coefficient of variation did not exceed the 10% threshold, representing a very homogeneous population for both, females and males (Figure 5).

Gondret et al., 2000 [7] did not find any significant difference in fibre type composition of *Biceps femoris*, *Longissimus lumborum* and *Semimembranosus proprius* muscles between quantitatively restricted rabbits and the ad libitum fed group.

However, these authors stated that *Longissimus lumborum* had lower proportion of oxidative fibres in restricted group (11.8 vs. 16.9% in restricted rabbits and ad libitum fed), but proportion of oxidative fibres in *Biceps femoris* and *Semimembranosus proprius* were not affected by feed restriction. The proportion of oxidative fibres varied between muscles, irrespective of the feeding status. Musculus *Semimembranosus proprius* consisted only from oxidative muscle fibres, lower concentration of oxidative fibres was in *Biceps femoris* and the lowest in musculus *Longissimus lumborum*, after Chodova and Tumova, 2013 [5].

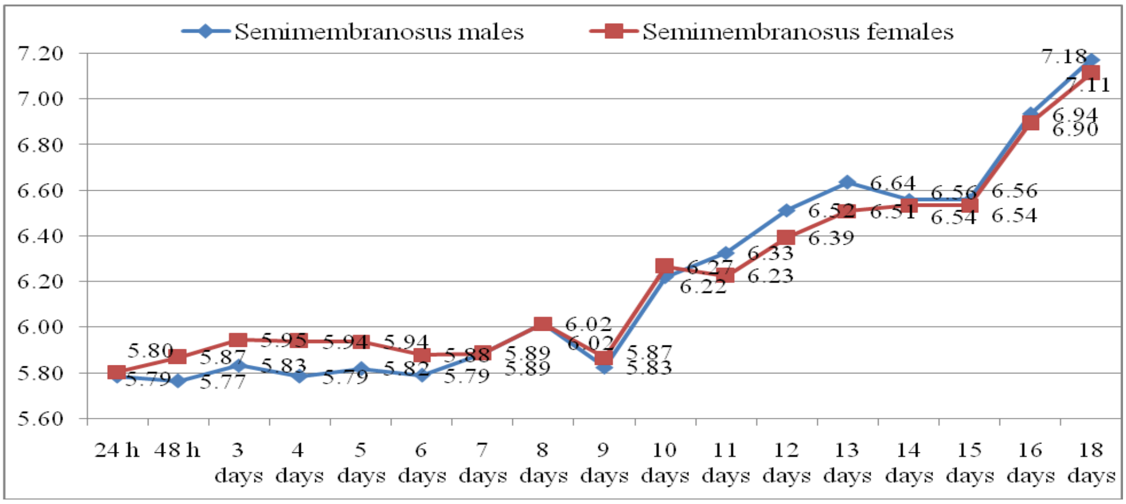

Figure 5. The pH evolution for *Semimembranosus* muscles - females and males

For *Triceps brachii* muscles, the pH evolution was relatively similar for females and males, with a fall in day six followed by a gradual and continuous increase with a stagnation at days 13 and 14, then by an suddenly increase until the end of the studied period (Figure 6).

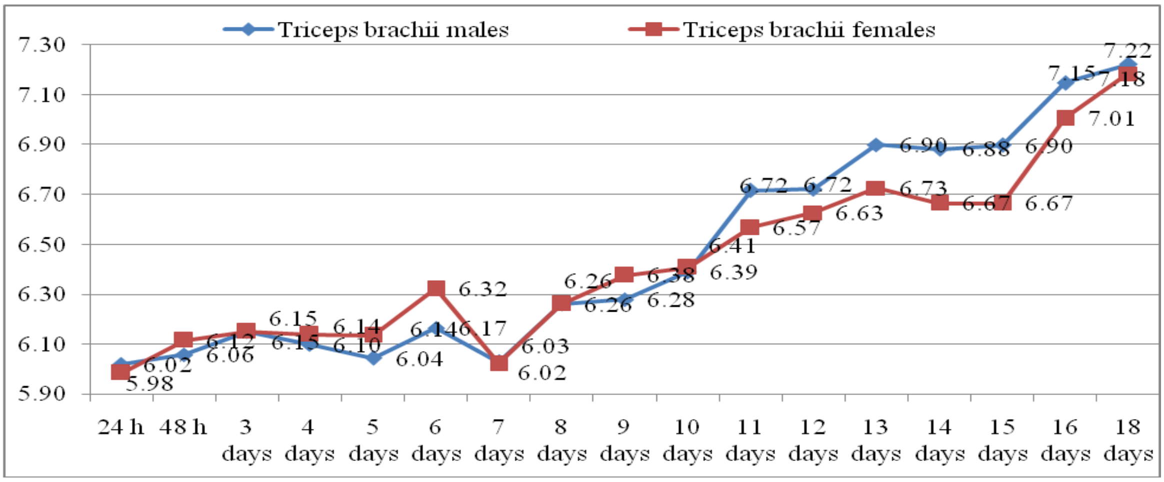

Figure 6. The pH evolution of *Triceps brachii* muscles - females and males

Regarding the pH evolution observed for the *Biceps femoris* muscles, it was recorded slight fluctuating growth throughout the study period, with stagnation at the day 14 and 15, followed by a accentuated increase until the end of the period (Figure 7).

After a statistically evaluation between all muscular groups analyzed (Table 1), we found preponderant insignificant differences on pH evolution of rabbit meat by gender ($p<0.05$), with exception of *Intercostalis*, *Cervicalis* (6.05), *Triceps brachi* and *Biceps femoris* muscles were we found significant differences on pH evolution for 24h, five and nine days. For 18 days we found insignificant differences for all muscle groups, the pH value being over 7.1.

The quality of meat develops during the post-mortem process via a variety of biochemical processes. The final meat quality is a resultant of the course of temperature and pH in the post-mortem period. Important quality traits that are influenced by temperature and pH are tenderness, water holding capacity and colour, after Hamoen et al., 2013 [8].

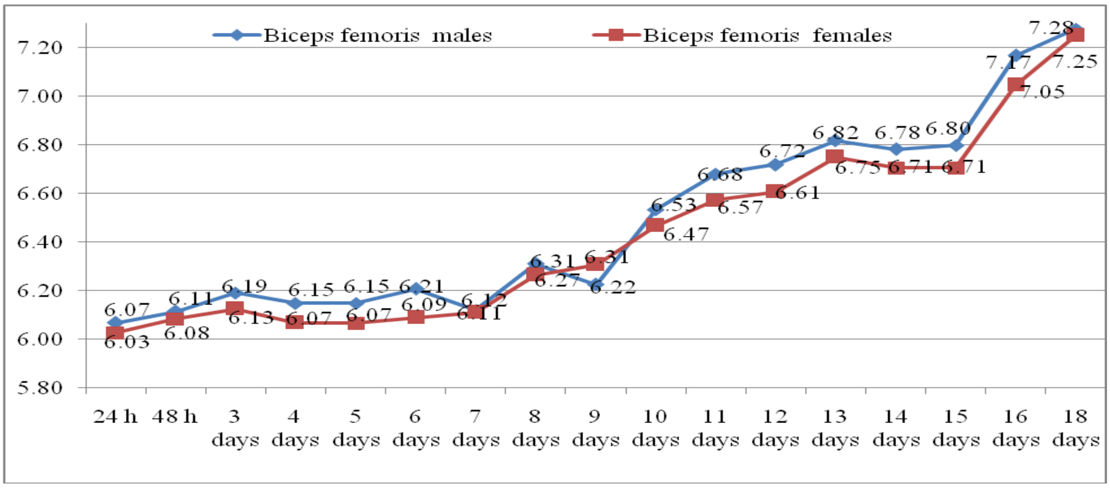

Figure 7. The pH evolution of *Biceps femoris* muscles – females and males

Feed restriction increases proportion of oxidative fibres in muscles and leads to higher pH value (Chodova and Tumova, 2013) [5].

As muscle is converted to meat, many changes occur, including: 1) a gradual depletion of available energy; 2) a shift from aerobic to anaerobic metabolism favouring the production of lactic acid resulting in the pH of the tissue declining from near neutrality to 5.4–5.8; 3) a rise in ionic strength, in part, because of the inability of ATP dependent calcium, sodium, and potassium pumps to function; 4) an increasing inability of the cell to maintain reducing conditions. All of these changes can have a profound effect on numerous proteins in the muscle cell, especially on one of the proteolytic enzyme systems that is thought to play a significant role in the tenderization that occurs during post-mortem aging. Among some of the microenvironmental factors that can have a major influence on post-mortem changes and specifically, the calpain system are the temperature, pH and ionic strength and oxidative and nitrosylation status of the proteins in the cell (Huff Lonergan, 2010) [9]. Meat quality differences due to gender depend on the slaughter age, as the differences between sexes become more evident as age gradually approaches puberty. In literature, most of the data relating to gender effect concerns hybrids selected for fast growth, and they are conflicting as at commercial slaughter age some authors observed significant gender differences on some carcass traits and on meat quality, whereas others did not observe any significant difference (Dalle Zotte, 2016) [4].

After Weglarz, 2010 [10], in the summer season a higher frequency of meat with improper values of pH>5.8 was observed. Almost 30% of meat from young bulls slaughtered in the summer season had high pH values of 6.2, which indicated DFD defect.

After Hamoen et al., 2013 [8], if temperature drops below 10 degrees the sarcoplasmic reticulum starts leaking due to a phase transition of the phospholipids in the cell membrane. Under these conditions the calcium level quickly rises, even at pH>6.5. This leads to extreme shortening. If pH remains above the threshold for calpain activation, pH>6.2, the meat remains tough. This toughening is called *cold shortening*.

Table 1. The statistical significance of the differences of rabbit meat by gender and muscle groups

Anova multiple comparisons test	24 h		5 days		9 days		14 days		18 days	
	S	P value	S	P value	S	P value	S	P value	S	P value
Psoas males vs. Psoas females	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	0.9765
Psoas males vs. Intercostalis males	*	0.0295	*	0.0166	ns	0.1777	ns	0.9926	ns	>0.9999
Psoas males vs. Intercostalis females	ns	0.9147	**	0.0069	ns	0.0888	ns	0.9706	ns	0.9949
Psoas males vs. Cervicalis males	ns	0.1394	ns	0.0958	ns	0.2295	ns	0.7639	ns	>0.9999
Psoas males vs. Cervicalis females	ns	0.9990	ns	>0.9999	ns	0.9856	ns	0.9974	ns	0.9932
Psoas males vs. Longissimus dorsi males	ns	0.9414	ns	>0.9999	ns	>0.9999	ns	0.9999	ns	>0.9999
Psoas males vs. Longissimus dorsi females	ns	0.9906	ns	>0.9999	ns	>0.9999	ns	0.9997	ns	0.9932
Psoas males vs. Semimembranosus males	ns	>0.9999	ns	0.9722	ns	0.9994	ns	>0.9999	ns	>0.9999
Psoas males vs. Semimembranosus females	ns	>0.9999	ns	0.9991	ns	>0.9999	ns	>0.9999	ns	0.9765
Psoas males vs. Triceps brachi males	ns	0.3116	ns	0.9982	ns	0.9813	**	0.0057	ns	>0.9999
Psoas males vs. Triceps brachi females	ns	0.7528	ns	0.9500	ns	0.8505	ns	0.9797	ns	>0.9999
Psoas males vs. Biceps femoris males	ns	0.0606	ns	0.5767	ns	0.9978	ns	0.2018	ns	>0.9999
Psoas males vs. Biceps femoris females	ns	0.2728	ns	0.8400	ns	0.9502	ns	0.7535	ns	>0.9999
Psoas females vs. Intercostalis males	ns	0.1975	*	0.0102	ns	0.2479	ns	0.9974	ns	0.9980
Psoas females vs. Intercostalis females	ns	0.9989	**	0.0037	ns	0.1187	ns	0.9842	ns	>0.9999
Psoas females vs. Cervicalis males	ns	0.5797	ns	0.0651	ns	0.3164	ns	0.7886	ns	>0.9999
Psoas females vs. Cervicalis females	ns	>0.9999	ns	>0.9999	ns	0.9992	ns	0.9994	ns	>0.9999
Psoas females vs. Longissimus dorsi males	ns	0.4987	ns	>0.9999	ns	>0.9999	ns	0.9943	ns	>0.9999
Psoas females vs. Longissimus dorsi females	ns	0.7528	ns	0.9998	ns	>0.9999	ns	0.9903	ns	>0.9999
Psoas females vs. Semimembranosus males	ns	0.9798	ns	0.9542	ns	0.9450	ns	>0.9999	ns	>0.9999
Psoas females vs. Semimembranosus females	ns	0.9984	ns	0.9982	ns	0.9849	ns	>0.9999	ns	>0.9999
Psoas females vs. Triceps brachi males	ns	0.8364	ns	0.9974	ns	0.9988	**	0.0027	ns	0.9807
Psoas females vs. Triceps brachi females	ns	0.9906	ns	0.9349	ns	0.9519	ns	0.9903	ns	0.9998
Psoas females vs. Biceps femoris males	ns	0.3686	ns	0.5017	ns	>0.9999	ns	0.1755	ns	0.6922
Psoas females vs. Biceps femoris females	ns	0.7873	ns	0.7953	ns	0.9931	ns	0.7699	ns	0.8631
Intercostalis males vs. Intercostalis females	ns	0.9483	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	0.9999
Intercostalis males vs. Cervicalis males	ns	0.9999	ns	0.9996	ns	>0.9999	ns	>0.9999	ns	>0.9999
Intercostalis males vs. Cervicalis females	ns	0.6018	ns	0.1287	ns	0.8441	ns	>0.9999	ns	0.9998
Intercostalis males vs. Longissimus dorsi males	***	<0.0001	***	0.0005	ns	0.4152	ns	0.6366	ns	>0.9999
Intercostalis males vs. Longissimus dorsi females	***	0.0004	***	0.0006	ns	0.3415	ns	0.5915	ns	0.9998
Intercostalis males vs. Semimembranosus males	**	0.0017	***	<0.0001	**	0.0038	ns	0.9865	ns	>0.9999
Intercostalis males vs. Semimembranosus females	*	0.0108	***	0.0003	**	0.0080	ns	0.9250	ns	0.9980
Intercostalis males vs. Triceps brachi males	ns	0.9880	ns	0.1035	ns	0.8119	ns	0.2306	ns	>0.9999
Intercostalis males vs. Triceps brachi females	ns	0.9338	ns	0.4569	ns	0.9873	ns	>0.9999	ns	>0.9999
Intercostalis males vs. Biceps femoris males	ns	>0.9999	ns	0.7720	ns	0.6178	ns	0.9540	ns	0.9998
Intercostalis males vs. Biceps femoris females	ns	0.9966	ns	0.4901	ns	0.8658	ns	>0.9999	ns	>0.9999
Intercostalis females vs. Cervicalis males	ns	0.9996	ns	0.9979	ns	>0.9999	ns	>0.9999	ns	>0.9999
Intercostalis females vs. Cervicalis females	ns	>0.9999	ns	0.0701	ns	0.6708	ns	>0.9999	ns	>0.9999
Intercostalis females vs. Longissimus dorsi males	ns	0.1025	***	0.0001	ns	0.2323	ns	0.3857	ns	>0.9999
Intercostalis females vs. Longissimus dorsi females	ns	0.2311	***	0.0002	ns	0.1793	ns	0.3412	ns	>0.9999
Intercostalis females vs. Semimembranosus males	ns	0.5504	***	<0.0001	***	0.0009	ns	0.9420	ns	>0.9999
Intercostalis females vs. Semimembranosus females	ns	0.7767	***	<0.0001	**	0.0021	ns	0.7886	ns	>0.9999
Intercostalis females vs. Triceps brachi males	ns	>0.9999	*	0.0477	ns	0.6160	ns	0.1413	ns	0.9971
Intercostalis females vs. Triceps brachi females	ns	>0.9999	ns	0.3124	ns	0.9450	ns	>0.9999	ns	>0.9999
Intercostalis females vs. Biceps femoris males	ns	0.9962	ns	0.6223	ns	0.3960	ns	0.9353	ns	0.8453
Intercostalis females vs. Biceps femoris females	ns	>0.9999	ns	0.3279	ns	0.6855	ns	>0.9999	ns	0.9540
Cervicalis males vs. Cervicalis females	ns	0.9336	ns	0.4793	ns	0.9170	ns	0.9992	ns	>0.9999
Cervicalis males vs. Longissimus dorsi males	***	0.0002	**	0.0036	ns	0.5121	ns	0.1126	ns	>0.9999
Cervicalis males vs. Longissimus dorsi females	**	0.0023	**	0.0041	ns	0.4281	ns	0.0943	ns	>0.9999
Cervicalis males vs. Semimembranosus males	*	0.0110	***	0.0002	**	0.0045	ns	0.6330	ns	>0.9999
Cervicalis males vs. Semimembranosus females	ns	0.0576	**	0.0020	**	0.0099	ns	0.3857	ns	>0.9999
Cervicalis males vs. Triceps brachi males	ns	>0.9999	ns	0.4500	ns	0.8944	ns	0.4487	ns	>0.9999
Cervicalis males vs. Triceps brachi females	ns	0.9997	ns	0.9147	ns	0.9973	ns	>0.9999	ns	>0.9999
Cervicalis males vs. Biceps femoris males	ns	>0.9999	ns	0.9969	ns	0.7251	ns	0.9990	ns	0.9843
Cervicalis males vs. Biceps femoris females	ns	>0.9999	ns	0.9432	ns	0.9339	ns	>0.9999	ns	0.9988
Cervicalis females vs. Longissimus dorsi males	ns	0.4333	ns	0.9597	ns	>0.9999	ns	0.6497	ns	>0.9999
Cervicalis females vs. Longissimus dorsi females	ns	0.6574	ns	0.9446	ns	>0.9999	ns	0.5994	ns	>0.9999
Cervicalis females vs. Semimembranosus males	ns	0.9388	ns	0.5935	ns	0.3731	ns	0.9943	ns	>0.9999
Cervicalis females vs. Semimembranosus females	ns	0.9885	ns	0.8767	ns	0.5320	ns	0.9481	ns	>0.9999
Cervicalis females vs. Triceps brachi males	ns	0.9921	ns	>0.9999	ns	>0.9999	ns	0.0537	ns	0.9958
Cervicalis females vs. Triceps brachi females	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	>0.9999
Cervicalis females vs. Biceps femoris males	ns	0.8309	ns	0.9719	ns	>0.9999	ns	0.7600	ns	0.8232
Cervicalis females vs. Biceps femoris females	ns	0.9847	ns	0.9987	ns	>0.9999	ns	0.9994	ns	0.9432

Anova multiple comparisons test	24 h		5 days		9 days		14 days		18 days	
	S	P value	S	P value	S	P value	S	P value	S	P value
Longissimus dorsi males vs. Longissimus dorsi females	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	>0.9999
Longissimus dorsi males vs. Semimembranosus males	ns	0.9983	ns	>0.9999	ns	0.8271	ns	0.9994	ns	>0.9999
Longissimus dorsi males vs. Semimembranosus females	ns	0.9923	ns	>0.9999	ns	0.9262	ns	>0.9999	ns	>0.9999
Longissimus dorsi males vs. Triceps brachi males	***	0.0009	ns	0.7663	ns	>0.9999	***	<0.0001	ns	>0.9999
Longissimus dorsi males vs. Triceps brachi females	*	0.0211	ns	0.4511	ns	0.9921	ns	0.4326	ns	>0.9999
Longissimus dorsi males vs. Biceps femoris males	***	<0.0001	ns	0.0740	ns	>0.9999	**	0.0061	ns	0.9821
Longissimus dorsi males vs. Biceps femoris females	***	0.0009	ns	0.2178	ns	0.9997	ns	0.0848	ns	0.9985
Longissimus dorsi females vs. Semimembranosus males	ns	>0.9999	ns	>0.9999	ns	0.8849	ns	0.9987	ns	>0.9999
Longissimus dorsi females vs. Semimembranosus females	ns	0.9995	ns	>0.9999	ns	0.9582	ns	>0.9999	ns	>0.9999
Longissimus dorsi females vs. Triceps brachi males	**	0.0075	ns	0.7375	ns	0.9999	***	<0.0001	ns	0.9958
Longissimus dorsi females vs. Triceps brachi females	ns	0.0777	ns	0.4297	ns	0.9820	ns	0.3857	ns	>0.9999
Longissimus dorsi females vs. Biceps femoris males	***	0.0006	ns	0.0758	ns	>0.9999	**	0.0048	ns	0.8232
Longissimus dorsi females vs. Biceps femoris females	**	0.0067	ns	0.2132	ns	0.9987	ns	0.0695	ns	0.9432
Semimembranosus males vs. Semimembranosus females	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	>0.9999
Semimembranosus males vs. Triceps brachi males	*	0.0356	ns	0.2356	ns	0.3141	**	0.0012	ns	>0.9999
Semimembranosus males vs. Triceps brachi females	ns	0.2643	ns	0.0936	ns	0.1187	ns	0.9590	ns	>0.9999
Semimembranosus males vs. Biceps femoris males	**	0.0030	**	0.0062	ns	0.5213	ns	0.1001	ns	0.9882
Semimembranosus males vs. Biceps femoris females	*	0.0312	*	0.0261	ns	0.1919	ns	0.5993	ns	0.9992
Semimembranosus females vs. Triceps brachi males	ns	0.1485	ns	0.5869	ns	0.4697	***	0.0003	ns	0.9807
Semimembranosus females vs. Triceps brachi females	ns	0.5305	ns	0.3018	ns	0.2025	ns	0.8283	ns	0.9998
Semimembranosus females vs. Biceps femoris males	*	0.0217	*	0.0414	ns	0.6920	*	0.0385	ns	0.6922
Semimembranosus females vs. Biceps femoris females	ns	0.1284	ns	0.1300	ns	0.3166	ns	0.3406	ns	0.8631
Triceps brachi males vs. Triceps brachi females	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	0.1193	ns	>0.9999
Triceps brachi males vs. Biceps femoris males	ns	>0.9999	ns	0.9825	ns	>0.9999	ns	0.9720	ns	>0.9999
Triceps brachi males vs. Biceps femoris females	ns	>0.9999	ns	0.9997	ns	>0.9999	ns	0.2825	ns	>0.9999
Triceps brachi females vs. Biceps femoris males	ns	0.9955	ns	>0.9999	ns	0.9997	ns	0.9124	ns	0.9946
Triceps brachi females vs. Biceps femoris females	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	0.9998
Biceps femoris males vs. Biceps femoris females	ns	>0.9999	ns	>0.9999	ns	>0.9999	ns	0.9951	ns	>0.9999

S=statistical significance; ns=insignificant; ns =p>0.05; *=0.05> p>0.01; **=0.01>p>0.001; ***=0.001>p.

After Nache et al., 2016 [12], the ultimate quality of the porcine meat can be estimated from the pH changes occurring during the first 24 h postmortem (p.m.) [13]. These pH changes result from the p.m. enzymatic breakdown of the glycogen into lactate in the process of the lactate glycogenolysis. Variation in the rate and the extent of this conversion is responsible for the different meat characteristics and implicitly for its freshness. Thus, monitoring the pH dynamics can be potentially used as an indicator for the meat quality evolution [14–18]. Following a normal p.m. pH dynamic, pork reaches a pH of 5.4–5.6 within 3–5 h p.m. [19]. However, due to antemortem stress, pork does not follow the normal p.m. pH dynamics. In this case, the pH value may decrease faster than normal when protein denaturation appears which results in meat with reduced water holding capacity [20]. In some extreme cases, the abnormally fast decreasing pH leads to pale, soft, and exudative (PSE) meat [21] which reaches a pH of 5.6 as early as 45 min p.m. (pH45). Besides, as a result of glycogen depletion prior to slaughtering, the meat can turn dark, firm, and dry (DFD)[22]. Its characteristic dark appearance, firm texture, and low drip loss result from the inhibited glycolytic acidification indicated by a higher-than normal pH value after 24 h (pH24) leading to a reduced shelf life. The most commonly applied DFD criterion is pH24>6.0. Both PSE and DFD pH-correlated deviations lead to considerable losses for the food industry [23].

In our study we found pH24 value higher than 6.0 for males in particular, for the muscles *Intercostalis* (6.11), *Cervicalis* (6.05), *Triceps brachi* (6.02) and *Biceps femoris* (6.07 for males and 6.03 for females) depending primarily on the different metabolic type of muscle.

4. Conclusions

The pH value of the meat varies, depending primarily on the type of muscle, the lowest pH level, at 24 h after slaughter, it has been found in *Longissimus dorsi* muscles (5.7) and the highest values in *Intercostalis* muscles (6.1). The pH evolution had an ascending trend, quite similar for females and males, presenting preponderant insignificant differences by gender. Starting with the day 9 or 11 the muscle groups analysed were relatively fresh and with the 14th day of storage the meat was altered, the pH being close to 7 for males and females (on the average 6.49 for *Longissimus* *dorsi* muscles, 6.57 for *Psoas* muscles, 6.56 for *Semimembranosus* muscles, 6.66 for *Intercostalis* muscles, 6.73 for *Triceps brachi* muscles, 6.75 for *Biceps femoris* muscles, and the highest value 6.81 for *Cervicalis muscles*).

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