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MEAT QUALITY OF RABBIT. I. DIFFERENCES BETWEEN MUSCLES IN POST MORTEM pH

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INTRODUCTION

In rabbit slaughter-houses, the elapsed time between carcass preparation and chilling (15 to 120 mn), the temperature of chilling rooms (< 3 to + 9°C), the duration of chilling (from 1 h 45 to 24 hours, most durations inferior or equal to 3 hours) are extremely varied (OUHAYOUN, 1985 ; CHAMPAGNE et al., 1986).

If some thermal treatments cannot guarantee a good bacteriological quality, it is likely that very fast chilling engineering, sometimes implemented to avoid the multiplication of pathogenic microorganisms, to delay the growth of psychrotrophic bacteria, but also to limit the carcass shrinkage, alter meat tenderness, particularly by encouraging cold shortening.

The present study was undertaken to verify if the general conditions of cold shortening development (pH, temperature) are combined when carcass chilling is "conventional", i.e. in a room weakly ventilated and at positive temperature (3°C).

MATERIAL AND METHODS

Two experiments are carried out. The first one is a study of carcass temperature and pH evolution of two muscles with different metabolic profiles, during chilling. The second one is aimed at assessing the variability between muscles of the ultimate muscular pH ; this one depends upon the metabolic and contractile fibre type balance in muscles, their energy reserves and buffer power ; this study deals with 16 muscles (18 muscular sites) exclusively made of βR (Semimembranosus proprius), αW (Psoas major) or βR, αR and αW fibres (ASHMORE et al., 1971) in different proportions.

Muscular pH measurement

Temperature and muscular pH are evaluated using a portable Knick-Portamess apparatus fitted with a temperature probe (accuracy 0,1°C) and a composite Ingold 406 M3 electrode (accuracy 1/100 pH).

pH is measured, either in situ, after incision of muscular site indexed in a reproducible way (3 successive measurements), or after crushing of 2 grams of muscle into 10 ml of sodium iodoacetate in cold watery solution 5 mM (3 samples). The iodoacetate- ion blocks phospho-3 glyceraldehyde transhydrogenase at active -SH site and interrups glycolysis.

Animal material : rabbit number and treatment

The study deals with 172 male rabbits of NewZealand breed (INRA 9077 strain), 11 weeks old, weighing 2,4 ± 0,25 kg. Rabbits are killed immediately after being removed from breeding without having undergone any previous fast. They are stunned by electroanesthesia (90 V, 50 Hz, 2 s), bleeded by cutting of jugular vein and carotid. Carcasses are introduced 30 mn after killing in a cold room. Musculature temperature taken close to the Semimembranosus proprius muscle is then of 30°C on an average (standard deviation = 2,5°C). The ventilated cold room temperature is of 3°C.

1. Muscular post mortem pH evolution

This study deals with 144 carcasses kept in the cold room for 1, 3, 5, 7, 9, 17, 19, 21 or 23 hours. Out of the 16 carcasses assigned to each one of these treatments, the pH of Biceps femoris and Longissimus dorsi muscles (second lumbar vertebra) is measured by the two methods on the left side and on the right one.

2. Muscular pH mapping

This study deals with 28 rabbits. After a chilling of 24 hours, carcasses are transferred to an air-conditioned room (10°C) where the following muscles are taken :

- Trunk muscles : Psoas major, Longissimus dorsi in three sites, considering its heterogeneity (VIGNERON et al., 1976), at the level of the 1st (intermediate part) and the 6th lumbar vertebra (back part), and the 9th thoracic vertebra (fore part) ;

- Anterior limb muscles : Teres major, Supraspinatus, Triceps brachii, Biceps brachii ;

- Posterior muscles : Biceps femoris, Parameralis, Gastrocnemius, Soleus, Tensor fasciae latae, Gracilis, Semimembranosus accessorius, Semimembranosus proprius, Adductor brevis and magnus, Semitendinosus.

RESULTS

1. Temperature and muscular post mortem pH evolution

Muscular temperature, in these chilling conditions, goes from 30°C at initial moment (entrance in cold room) to 7°1C within one hour. Afterwards, temperature slowly decreases from 4°3C (2 hours) to 3°6C (17 hours), then keeps stable. In situ pH is on an average higher than pH measured after sample crushing in iodoacetate, in the case of L. dorsi muscle. The opposite is true, most frequently for the B. femoris muscle (table 1). But the deviations between homologous means are not significant. Hence, within measurement time, the correlation between pH measured by the two methods is higher in the case of L. dorsi muscle (r = 0,92**) than in the case of B. femoris muscle (r = 0,85**). Nevertheless, in both cases, it is very high, which corroborates the works by KORKEALA et al. (1986).

TABLE 1
Muscular post mortem pH evolution of L. dorsi and B. femoris (means and standard deviations)

Muscles	Method of pH measure	Chilling duration (hours)								
		1	3	5	7	9	17	19	21	23
L. dorsi	A	6.60a 0.32	6.50ab 0.25	6.25ab 0.26	6.20b 0.25	6.15b 0.23	5.67c 0.10	5.75c 0.18	5.68c 0.09	5.63c 0.11
	B	6.49a 0.26	6.42a 0.23	6.25a 0.28	6.20a 0.25	6.14a 0.17	5.62b 0.11	5.70b 0.13	5.67b 0.11	5.61b 0.10
B. femoris	A	6.47a 0.23	6.28ab 0.21	6.17ab 0.18	6.14b 0.17	6.02b 0.17	5.74c 0.10	5.78c 0.12	5.72c 0.09	5.70c 0.11
	B	6.40a 0.18	6.29ab 0.16	6.21ab 0.18	6.18ab 0.16	6.11b 0.15	5.80c 0.09	5.83c 0.12	5.79c 0.13	5.77c 0.12

A : pH measured "in situ"
B : pH measured after crushing muscle in iodoacetate 5 mM.
Values with differents superscripts in the same row are significantly different ($P < 0.05$).

Linear correlation coefficients between pH logarithm and chilling duration (minutes) are high in the case of L. dorsi muscle ($r = -0,86^{**}$) as well as in that of B. femoris ($r = -0,85^{**}$). Muscular pH thus may be regarded as exponentially decreasing within the elapsed time (30 mn to 23 hours post mortem). pH decreasing is of the form :

$$pH = pHi.e^{-bt}$$

where pHi is the value of muscular pH 30 mn after killing. The b values concerning B. femoris and L. dorsi muscles compared according to DAGNELIE (1970) method are significantly different. According to this model, L. dorsi muscle acidification is faster than that of B. femoris muscle :

$$\text{L. dorsi} \quad pH = 6,52.e^{-1,15.10^{-4}t}$$

$$\text{B. femoris} \quad pH = 6,39.e^{-0,79.10^{-4}t}$$

Nevertheless, 30 minutes after killing and during the first chilling hours, B. femoris muscle pH is more acid than that of L. dorsi muscle, whereas its energy metabolism is relatively more oxidative.

2. Ultimate pH mapping

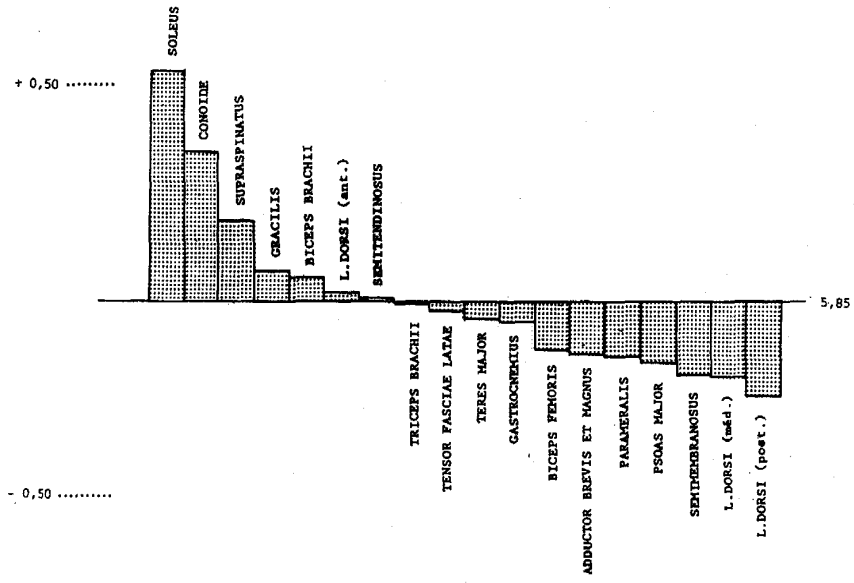
24 hours after killing, carcass temperature is, on an average, of 3°2C (standard deviation 0°4C). Intra-muscle, pH interindividual variability is weak (CV < 2 %). Mean pH of 18 muscular sites vary between 6,42 (Soleus muscle) and 5,61 (L. dorsi back part) (table 2, figure 1).

TABLE 2
Ultimate pH of 18 muscular locations

Muscles	pH Mean (1)	Standard deviation
Soleus	6.42 a	0.09
Semimembranosus proprius	6.22 b	0.06
Supraspinatus	6.05 c	0.15
Gracilis	5.93 d	0.10
Biceps brachii	5.92 de	0.11
Longissimus dorsi (fore part)	5.88 ef	0.12
Semitendinosus	5.86 ef	0.11
Triceps brachii	5.85 f	0.12
Tensor fasciae latae	5.83 f	0.09
Teres major	5.81 f	0.09
Gastrocnemius caput laterale	5.80 f	0.12
Biceps femoris	5.73 g	0.09
Adductor brevis et magnus	5.72 g	0.10
Parameralis	5.71 g	0.10
Psoas major	5.70 g	0.10
Semimembranosus accessorius	5.67 gh	0.08
Longissimus dorsi (inter. part)	5.66 gh	0.09
Longissimus dorsi (back part)	5.61 h	0.06

(1) Values with different superscripts are significantly different ($P < 0.05$)

FIGURE 1
Ultimate pH of 18 muscular locations
Overall mean and deviations.



DISCUSSION

Theoretically, muscle cold shortening may start as soon as temperature goes below 10°C, while these ones are in pre-rigor state and that their pH is still superior to 6. Muscle sensitivity both depend of their refrigerating front accessibility and of their metabolic and contractible characteristics. The muscles with a high content of fast contraction and oxidative energy metabolism fibres are the more sensitive. Muscle pH lowers slowly enough after killing ; they have ATPases capable of exhausting the energy reserves (ATP) they hold at low temperature. This ATPase activity is encouraged by Ca++ ions, products of mitochondria membranes abounding in oxidative metabolism fibres which cannot be reabsorbed by sarcoplasmic reticulum at low temperature (BUEGE, 1976). Cold shortening was observed in rabbit by BENDALL (1971); some results of fast chillings on water holding capacity, carcass weight losses at heating, shortening of rabbit L. dorsi muscle sarcomeres, were reported by JOLLEY et al. (1984).

The present study indicates that even when chilling conditions are said to be "conventional" (positive temperature, air low speed), heat transfers outside of the carcass of young rabbits weighing more or less 1,3 kg are important ; approximately 95 Joules/mn/kg during the first hour. Effectively, carcass temperature, measured close to the Semimembranosus proprius muscle, which is deep-seated and located at 15 mm of carcass surface, is lowered by 23°C within 60 mn.

While muscular temperature is close to 7°C, the pH of Psoas major and Semimembranosus accessorius muscles, exclusively made of αW fibres (RENOU et al., 1986) is superior to 6. The Longissimus dorsi and Biceps femoris muscles, for instance, whose energy metabolism is oxido-glycolytic (VIGNERON et al., 1976 ; OUHAYOUN and DELMAS, 1983) register a pH superior to 6.5. The relatively fast acidification of B. femoris muscle during the first chilling hours, compared to that of L. dorsi muscle, whose metabolism is more glycolytic, may be due to cold shortening, the activation of myofibril ATPases causing an increased production of ADP and thus a glycolysis acceleration.

Temperature and pH conditions, favourable to cold shortening seem to be combined, at least in the muscles whose attachments to skeleton allow them to be shortened. The studies in progress intend to verify its frequency, its intensity and possible technological outcomes.

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I. DIFFERENCES BETWEEN MUSCLES IN POST MORTEM pH

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The evolution of the post mortem pH of various muscles is measured with INRA 9077 male rabbits, 11 weeks old. Between muscles, pH variability (23 h post mortem) is high ; from 6.42 (Soleus) to 5,61 (back part of Longissimus dorsi). These differences are accounted for by the variability of muscle metabolic and contractible profile, energy reserves and buffer power. In these chilling conditions (+ 3°C, air low speed), heat transfer is of 95 Joules/mn/kg. After 1 hour chilling, the deep-seated muscles reach a temperature of 7°C. If we consider the pH reached at this stage by the muscles with oxidoglycolytic metabolism (Biceps femoris = 6.40, Longissimus dorsi = 6.49), the development conditions of cold shortening are theoretically put together. Studies are in progress to evaluate occurrence, intensity and possible technological consequences.

QUALITE DE LA VIANDE DE LAPIN
I. DIFFERENCE ENTRE LES pH POST-MORTEM DE PLUSIEURS MUSCLES

Ouhayoun J., Delmas Danielle

L'évolution du pH post mortem de différents muscles est mesurée chez des lapins mâles INRA 9077 âgés de 11 semaines. Entre muscles, la variabilité du pH ultime (23 h post mortem) est élevée : de 6,42 (Soleus) à 5,61 (partie postérieure du Longissimus dorsi). Ces différences résultent de la variabilité du profil métabolique et contractile des muscles, de leurs réserves énergétiques et de leur pouvoir tampon. Dans les conditions de réfrigération utilisées (+ 3°C, faible vitesse de l'air), le transfert de chaleur est de 95 Joules/mn/kg. Après une heure de réfrigération, les muscles profonds ont une température de 7°C. Compte tenu du pH atteint à ce moment par les muscles à métabolisme oxydoglycolytique (Biceps femoris = 6,40 ; Longissimus dorsi = 6,49), les conditions de développement de la contracture au froid sont théoriquement réunies. Des études sont en cours pour vérifier l'existence de ce phénomène chez le Lapin et en estimer l'intensité et les éventuelles conséquences technologiques.