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Acidity and electrical conductivity of selected muscles in lamb carcass

Kwasowość i przewodność elektryczna wybranych mięśni tuszy jagnięcej

Summary. In the study the level of changes in acidity and electrical conductivity measured 45 minutes and 24 h after slaughter was analyzed in three muscles (*m. supraspinatus, m. longissimus* i w *m. semimembranosus*) of lambs carcasses coming from commercial crossing of prolific Wielkopolska dams with Berrichon du Cher rams. Moreover, correlation coefficients between the analyzed traits were estimated.

Changes in acidity and electrical conductivity in each of the three analyzed muscles indicate an appropriate course of meat ageing. Sex, age at slaughter and carcass weight of the analyzed lambs did not have an effect on the level and changes in acidity and electrical conductivity in those muscles. High and similar correlations were found between measurements taken in the three analyzed muscles only in case of pH_1.

Key words: lambs, carcass, acidity, electrical conductivity

INTRODUCTION

Quality attributes of meat have a decisive effect on its processability and eating value. Good indicators of meat quality after slaughter are measurements of acidity and electrical conductivity [Apple *et al*. 1995, Vergara *et al*. 1999, Litwińczuk *et al.* 2000, McGeehin *et al.* 2001, Pietrzak *et al*. 2001, Diaz *et al*. 2003]. Two mentioned indicators are easy to measure immediately in a slaughter house and in storage place, without necessity of possessing a laboratory.

The aim of the conducted studies was to determine the level of changes in acidity and electrical conductivity in three muscles of the lamb carcass, i.e. *m. supraspinatus, m. longissimus* and *m. semimembranosus.*

MATERIAL AND METHODS

In the years 2002–2003 a total of 93 carcasses were analyzed of intensively fattened lambs of both sexes, which came from commercial crossing of Wielkopolska prolific ewes with Berrichon du Cher rams. The lambs were weaned at the age of approx. 60 days and after a 10-day transition period they were introduced to fattening. In the period preceding fattening the lambs received the CJ compound feed, rolled oats and meadow hay. In the transition period the above mentioned feeds were gradually replaced with balanced pelleted feed. Experimental fattening was conducted in individual pens until day 100 ± 5 (34 animals), 120 ± 5 (34 animals) and 140 ± 5 (25 animals) of life, using balanced pelleted feed, 1 kg of which contained 6.9 MJ net energy and 155 g crude protein. The lambs for fattening in the three analyzed periods were selected on the basis of analogs (sex and type of birth). The lambs were slaughtered according to the methodology of the Institute of Animal Science. Diverse carcass weights were grouped in 4 weight classes, 12.0–14.0 (15 animals), 14.1–16.0 (26 animals), 16.1–18.0 (29 animals) and 18.1–20.0 (23 animals). Carcasses were cooled at the temperature of 2–4°C for 24 h. Acidity (pH) and electrical conductivity (EC – mS/cm) were measured in three muscles, *m. supraspinatus, m. longissimus* and *m. semimembranosus* 45 minutes (pH_1, EC_1) and 24 h (pH_{24}, EC_{24}) after slaughter. Acidity was measured using a combination glass calomel electrode, whereas electrical conductivity with an LF-STAR apparatus by Matthäus.

The effect of sex, age, carcass weight and place of measurement, and the interaction on the level of the analyzed traits were estimated using a least squares multivariate analysis of variance with the application of the SAS ver. 8.02 software package [SAS 1998]. Moreover, Pearson's linear correlation coefficients were estimated for meat quality attributes.

RESULTS AND DISCUSSION

Changes in acidity after slaughter in the three analyzed muscles (Tab. 1) indicate an appropriate course of meat ageing [Pieniak-Lendzion 1994, Tański *et al*. 1994, Apple *et al*. 1995, Vergara *et al*. 1999, Litwińczuk *et al*. 2000, Diaz *et al*. 2003]. The pH_1 index measured 45 minutes after slaughter depending on the analyzed muscle ranged from 6.38 to 6.54, while after 24 h carcass cooling (pH_{24}) it was from 5.54 to 5.77, respectively. The highest acidity (pH_1 and pH_{24}) was found in *m. supraspinatus* ($P \leq 0.01$). A similar level of acidity (pH_{24}) in the same muscles in lambs of mutton breeds (Ile de France, Suffolk, Texel) was reported by Grześkowiak *et al.* [2003].

Investigations conducted by the authors of this study and the results obtained by Diaz *et al.* [2003], McGeehin *et al.* [2001], Pietrzak *et al.* [2001] and Stanisz and Pietrzak [2004] did not show any effect of sex on the level of acidity.

In this study the age at slaughter and carcass weight did not have an effect on the level of acidity in muscles 45 minutes and 24 h after slaughter. In turn, Tański *et al.*

[1994], while analyzing acidity of *m. quadriceps femoris* in pure-bred Polish Merino lambs and crosses sired by rams of mutton breeds slaughtered at the age of 50, 100 and 180 days, found significantly higher pH_{24} values in carcasses of 50-day-old lambs than in carcasses of 100- and 180-day-old lambs. Carcasses of older lambs had similar pH_{24} levels as those found in this study, which could indicate higher quality and shelf life of meat coming from older lambs.

Table 1. Acidity (pH) and electrical conductivity (EC – mS/cm) of analyzed muscles
Tabela 1. Kwasowość (pH) i przewodność elektryczna (EC – mS/cm) badanych mięśni

Factor Czynnik	n	Acidity Kwasowość		Electrical conductivity EC – mS/cm Przewodność elektryczna	
		pH_1 LSM ± se	pH_{24} LSM ± se	EC_1 LSM ± se	EC_{24} LSM ± se
Place of measurement Miejsce pomiaru		**	**	**	**
M. supraspinatus	*93*	6.54 ± 0.02 AB	5.77 ± 0.02 AB	4.04 ± 0.07 A	2.43 ± 0.11 AB
M. longissimus	93	6.38 ± 0.02 A	5.54 ± 0.02 A	2.39 ± 0.06 AB	1.91 ± 0.11 AC
M. semimembranosus	93	6.42 ± 0.02 B	5.56 ± 0.02 B	3.87 ± 0.07 B	3.21 ± 0.11 BC
Sex – Płeć		ns	ns	ns	ns
Ewe lambs – Maciorki	45	6.44 ± 0.02	5.63 ± 0.01	3.39 ± 0.07	2.47 ± 0.11
Ram lambs – Tryki	48	6.43 ± 0.02	5.63 ± 0.01	3.42 ± 0.05	2.55 ± 0.08
Age at slaughter, days Wiek przy uboju, dni		ns	ns	ns	ns
100	32	6.46 ± 0.03	5.63 ± 0.03	3.52 ± 0.08	2.58 ± 0.11
120	31	6.38 ± 0.03	5.62 ± 0.04	3.45 ± 0.11	2.42 ± 0.17
140	30	6.46 ± 0.04	5.65 ± 0.03	3.33 ± 0.12	2.53 ± 0.12
Weight of carcass, kg, Waga tuszy		ns	ns	ns	ns
12.0–14.0	15	6.45 ± 0.03	5.64 ± 0.02	3.39 ± 0.08	2.47 ± 0.12
14.1–16.0	26	6.43 ± 0.03	5.62 ± 0.02	3.55 ± 0.07	2.59 ± 0.11
16.1–18.0	29	6.42 ± 0.02	5.63 ± 0.01	3.41 ± 0.11	2.63 ± 0.17
18.1–20.0	23	6.46 ± 0.02	5.63 ± 0.02	3.45 ± 0.09	2.39 ± 0.12

Interactions sex x place of measurement, weight of carcass x place of measurement, age at slaughter x place of measurement, age at slaughter x weight of carcass – non-significant
Zależności płeć x miejsce pomiaru, masa tuszy x miejsce pomiaru, wiek przy uboju x waga tuszy – nieistotne
* – $P \leq 0.05$; ** – $P \leq 0.01$; ns – differences are non-significant – różnice nieistotne
Means denoted by identical letters in columns differ statistically at aa – $P \leq 0.05$; AA – $P \leq 0.01$
Średnie oznaczone tymi samymi literami w kolumnach różnią się istotnie przy aa – $P \leq 0,05$; AA – $P \leq 0,01$

Electrical conductivity measured 45 min after slaughter (EC_1) in the three muscles ranged from 2.39 to 4.04 mS/cm, whereas after 24 h (EC_{24}) it was from 1.91 to 3.21 mS/cm. Directly after slaughter electrical conductivity (EC_1) in *m. supraspinatus* and *m. semimembranosus* was similar, at the same time being higher than that found in *m. longissimus* ($P \leq 0.01$). In contrast, after 24 h of cooling carcass (EC_{24}) high electrical conductivity was recorded in *m. semimembranosus* (3.21 mS/cm). A decrease in electrical conductivity of muscles 24 h after slaughter reported in this study was confirmed by the results obtained by Litwińczuk *et al.* [2000] in *m. longissimus* in lambs of the Polish Lowland sheep

Table 2. Correlations between analyzed traits (n = 93)
Tabela 2. Korelacje między badanymi cechami (n = 93)

Trait – Cecha		1	2	3	4	5	6	7	8	9	10	11
1.	pH_1 *M. supraspinatus*											
2.	pH_1 *M. longissimus*	0.650**										
3.	pH_1 *M. semimembranosus*	0.654**	0.777**									
4.	pH_{24} *M. supraspinatus*	-0.082	-0.214	-0.105								
5.	pH_{24} *M. longissimus*	0.045	-0.077	-0.032	0.416**							
6.	pH_{24} *M. semimembranosus*	0.011	-0.152	-0.091	0.452**	0.446**						
7.	EC_1 *M. supraspinatus*	-0.158	-0.207	-0.205	0.108	0.006	0.045					
8.	EC_1 *M. longissimus*	-0.549**	-0.554**	-0.626**	0.215	0.172	0.125	0.551**				
9.	EC_1 *M. semimembranosus*	-0.314*	-0.396**	-0.298*	0.122	0.170	0.146	0.426**	0.485**			
10.	EC_{24} *M. supraspinatus*	-0.364**	-0.188	-0.216	0.021	0.009	0.017	0.261	0.375**	0.436**		
11.	EC_{24} *M. longissimus*	-0.259	-0.329*	-0.356**	-0.009	0.178	0.206	0.169	0.499**	0.469**	0.465**	
12.	EC_{24} *M. semimembranosus*	-0.232	-0.177	-0.267	-0.028	0.192	0.084	0.039	0.504**	0.297*	0.426**	0.587**

* – $P \leq 0.05$; ** – $P \leq 0.01$

and in two mutton breeds (Suffolk and Berrichon du Cher). In turn, similar relationships of electrical conductivity (EC_{24}) as in this study were found in the same muscles by Grześkowiak *et al.* [2003].

No effect of sex, age at slaughter and carcass weight on electrical conductivity 45 minutes and 24 h after slaughter was found in this study. While testing carcasses of lambs after dams of the prolific Wielkopolska ewes sired by rams of the Whiteheaded mutton and Dorset breed, Stanisz and Pietrzak [2004] did not find any effect of sex on the level of electrical conductivity 24 h after slaughter.

Relatively high correlations were found between measurements of acidity (pH_1) taken 45 minutes after slaughter in each of the three analyzed muscles (from 0.650^{**} to 0.777^{**}), (Tab. 2). Lower correlations were found for pH_{24} (from 0.416^{**} to 0.452^{**}) and for electrical conductivity EC_1 (from 0.426^{**} to 0.551^{**}) and EC_{24} (from 0.426^{**} to 0.587^{**}). Gruszecki *et al.* [2003] reported correlations lower than in this study between measurements of *m. longissimus* and *m. semimembranosus*, e.g. for pH_1 (0.44) and electrical conductivity EC_1 (0.31) and EC_{24} (0.32), and a higher correlation only for pH_{24} (0.83).

In contrast, relatively high correlations need to be stressed between electrical conductivity EC_1 in *m. longissimus* and pH_1 in each of the three analyzed muscles (from 0.549^{**} to 0.626^{**}). Taking into consideration the previously shown high correlation between the pH_1 values in each of the three muscles, the obtained results suggest the possibility to reduce the scope of measurements only to the assessment of pH_1 in *m. longissimus*.

Low correlations are also given between measurements of pH taken in *m. longissimus* 45 minutes and 24 h after slaughter and electrical conductivity EC_{24} as it was reported in their study by Stanisz and Pietrzak [2004], both in ewe and ram lambs – crosses after dams of the prolific Wielkopolska sheep and rams of the Whiteheaded mutton and Dorset breeds.

CONCLUSIONS

1. Changes in acidity and electrical conductivity in carcasses of lambs – crosses after dams of prolific Wielkopolska breed sired by Berrichon du Cher rams indicate an appropriate course of the meat ageing process.

2. Sex, age at slaughter and carcass weight of the analyzed lambs did not have any effect on the level and changes in acidity and electrical conductivity in the analyzed muscles.

3. Relatively high and similar correlations between measurements taken in the three analyzed muscles (*m. supraspinatus, m. longissimus* and *m. semimembranosus*) indicate a possibility to limit measurements of acidity (pH_1) to one muscle.

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Streszczenie. W pracy badano poziom zmian kwasowości i przewodności elektrycznej określonej 45 minut i 24 godziny po uboju w trzech mięśniach (*m. supraspinatus, m. longissimus* i *m. semimembranosus*) tusz jagnięcych pochodzących z towarowego krzyżowania maciorek plennej owcy wielkopolskiej z trykami berrichon du cher. Oszacowano też współczynniki korelacji pomiędzy badanymi cechami.

Zmiany kwasowości i przewodności elektrycznej w każdym z trzech badanych mięśni wskazują na prawidłowy przebieg procesu dojrzewania mięsa. Płeć, wiek uboju i masa tuszy badanych jagniąt nie miały wpływu na poziom i zmiany poziomu kwasowości i przewodności elektrycznej w badanych mięśniach. Stwierdzono wysokie i zbliżone korelacje pomiędzy pomiarami wykonanymi w trzech badanych mięśniach tylko dla pH_1.

Słowa kluczowe: jagnięta, tusza, kwasowość, przewodność elektryczna