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The Faculty of Management, Rzeszow University of Technology
Al. Powstańców Warszawy 8, 35-959 Rzeszów
e-mail: kteresz@prz.edu.pl; choroszy@prz.edu.pl

KRZYSZTOF TERESZKIEWICZ, KAROLINA CHOROSZY

Assessment of post-slaughter exsanguination degree of selected muscles of fatteners' carcasses

Ocena stopnia wykrwawienia poubojowego wybranych mięśni tuszy wieprzowej

Summary. The main aim of this study was to assess the post-slaughter exsanguination degree of selected muscles of pork carcass. The research material covered samples of five muscles. The post-slaughter exsanguination degree of muscles was determined with the haemoglobin agar diffusion test and the compressor test. The studies showed statistically highly essential differences in the post-slaughter exsanguination degree of the tested muscles. The *longissimus thoracis musculus* is characterized by the most advantageous exsanguination degree, and the *diaphragm musculus* and *colli musculi* by the least advantageous exsanguination degree.

Key words: fatteners, slaughter, muscles, exsanguination, exsanguination rate

INTRODUCTION

Modern systems of obtaining and processing raw materials attach a lot of weight to the quality, microbiological and hygienic safety and durability of the products [Migdał *et al*. 2004]. A comprehensive presentation of the problem of meat products' quality should cover all features of the product which are essential for the consumer and which decide about its quality, in particular the microbiological and sensory aspects [Rosenvold and Andersen 2003]. Post-slaughter exsanguination of the main raw materials and by-products, the most significant of which is meat, constitutes the basic factor determining the quality of meat. Exsanguination degree is determined by genetic and physiological factors as well as processes associated with the stinging technique, exsanguination time and the position of the carcass. The process of the transformation of muscles into meat takes place immediately after exsanguination. Lack of circulation and oxygen flow to tissues causes that further production of ATP takes place through glycogenolisis [Stoier

et al. 2001]. The pace of the processes following slaughter and the final pH of the meat determines its structure and organoleptic features such as colour, smell, water absorbency, consistency, texture, as well as susceptibility to putrefaction [Kortz 2001].

Research conducted so far [Beutling and Hahlweg 1981, Bojovic *et al*. 1992, Szkucik 1996, Szkucik *et al*. 2001, Warriss 1984] pointed to a clear connection between the exsanguination degree and the development of pathogenic microflora determining the quality features of the raw material. This interplay is important for the safety of the raw material, as it leads to microbial inoculation of the meat. The development of the microflora influences the nutritional value of the meat, changes its chemical structure and forms new organoleptic features. The chemical composition of the raw material and meat constitutes a favourable environment for the development of microorganisms [Pełczyńska *et al*. 1992]. The susceptibility to the development of the microflora and occurrence of changes of the organoleptic features grows together with an increase in the amount of blood in raw materials. With 50% exsanguination rate, the meat is not fit for consumption after 3 days due to intensive processes of microbiological decomposition taking place in the meat [Pełczyńska *et al*. 1992, Szkucik 2001].

Signs of microbiological decomposition of meat can be seen when the number of microorganisms is at the level of 708 log per 1 cm^2 surface or 1 g of meat [Jeremiah 2001]. Reaching this level of infection mainly depends on the initial contamination, which also depends on the post-slaughter exsanguination degree. Studies show that muscles of pork carcass are characterized by varying degrees of residual blood, the content of which is determined by the muscle structure, its functions and blood flow.

The aim of the following study is to assess the post-slaughter exsanguination rate of selected muscles of pork fatteners.

MATERIALS AND METHODS

The research was conducted in the Pig Slaughter Performance Testing Station in Chorzelów. The material comprised samples of five muscles (*musculus longissimus thoracis, musculus semimembranosus, musculi colli, musculus internal oblique, musculus diaphragm*), obtained from 100 carcasses of Polish Landrace fatteners.

The fatteners were slaughtered in a slaughter house located in the Pig Slaughter Performance Testing station in Chorzelów. From the piggery to an ante-mortem facility the fatteners were transported individually with a hand-cart. The transport distance was 70 m. From the ante-mortem facility the animals were transferred to the slaughter sector, where slaughter activities were carried out. In the first stage, fatteners were stunned with STZ-2 stunning device, powered by 230 V electricity and 50 Hz frequency and amperage of 1,2–2,5 A. The electric current was applied using Lotterschmid-Winberer clasps, 250 mm wide, and 950 mm long, with electrode gap range from 40 to 500 mm. After stunning was completed, fatteners were hanged by the left hind leg. In this position binaural stinging was performed, which involved cutting the neck vascular trunks: the brachiocephalic trunk, carotid arteries and jugular veins. Fatteners were left in a hanging position until the outflow of blood from the slaughter wounds was completed. After 24 h cooling, muscle samples were obtained from the carcass to mark the exsanguination degree [Tereszkiewicz 2009].

Post-slaughter exsanguination rate of the analysed muscles was estimated with the haemoglobin in agar diffusion test [Beutling 1984] and the compressor test [Szkucik 2004]. Results of the test were expressed along a 3 point scale [Szkucik 1996]:

– 1 point – lack of a haemoglobin ring,

– 2 points – presence of haemoglobin ring, thickness of 2 mm,

– 3 points – presence of haemoglobin ring, thickness of more than 3 mm.

Results of the compressor test were also expressed along a 3 point scale, applying the following assessment criteria:

– 1 point – 4 cm^2 stain of yellow colour,

– 2 points – up to 5 cm^2 stain of light red colour,

– 3 points – above 6 cm^2 stain of red colour.

On the basis of the test results, post-slaughter exsanguination degree of the carcasses was estimated and the following criteria were applied:

– 1 point – 100% exsanguination (complete),

– 2 points – 75% exsanguination (incomplete),

– 3 points – 50% exsanguination (partial).

The collected numerical material was statistically analyzed. The significance of the differences between the exsanguination rate of the muscles was evaluated with the chi-square test (χ^2). Results were processed with the STATISTICA 9.0 computer program.

RESULTS

Results of the assessment of fatteners' muscle exsanguination using the haemoglobin diffusion test are presented in Table 1. In the group of carcasses with 100% exsanguination, statistically significant differences were observed between *the longissimus thoracis musculus* – 1,01 pts, and *colli musculi* – 1,10 pts and the *diaphragm musculus* – 1,11 pts. In carcasses with 75% exsanguination, the highest residual blood content was observed in the *diaphragm musculus*, while the *longissimus thoracis musculus* was characterized by the statistically significantly lowest amount of residual blood estimated at 1,32 points. Average difference between the exsanguination rates of these muscles was 0,46 pts.

Table 1. Assessment of post-slaughter exsanguination degree of selected muscles of pork carcasses with haemoglobin diffusion test

Tabela 1. Ocena wykrwawienia poubojowego wybranych mięśni tuszy wieprzowej testem dyfuzji hemoglobiny

Muscle Mięsień	Exsanguination 100% Wykrwawienie 100%		Exsanguination 75% Wykrwawienie 75%		Exsanguination 50% Wykrwawienie 50%	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Musculus longissimus thoracis	1,01[ab]	0,11	1,32[a]	0,16	-	-
Musculus semimembranosus	1,05	0,09	1,46	0,24	-	-
Musculi colli	1,10[a]	0,17	1,59	0,23	2,30	0,22
Musculus Interial oblique	1,05	0,16	1,58	0,32	-	
Musculus diaphragm	1,11[b]	0,05	1,78[a]	0,43	2,39	0,41

aa – statistically significant differences with identical letters in the columns.

aa – różnice statystycznie istotne w kolumnach oznaczono jednakowymi literami.

Table 2. Assessment of post-slaughter exsanguination degree of selected muscles of pork carcasses with compressor test
Tabela 2. Ocena wykrwawienia poubojowego wybranych mięśni tuszy wieprzowej testem kompresorowym

Muscle Mięsień	Exsanguination 100% Wykrwawienie 100%		Exsanguination 75% Wykrwawienie 75%		Exsanguination 50% Wykrwawienie 50%	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Musculus longissimus thoracis	1,09	0,10	1,29^{ab}	0,23	-	-
Musculus semimembranosus	1,12	0,14	1,40	0,34	-	-
Musculi colli	1,09	0,08	1,64^{a}	0,28	2,28	0,37
Musculus Interial oblique	1,03	0,07	1,35	0,42	-	-
Musculus diaphragm	1,13	0,11	1,68^{b}	0,43	2,35	0,29

aa – statistically significant differences with identical letters in the columns.
aa – różnice statystycznie istotne w kolumnach oznaczono jednakowymi literami.

In the group of carcasses with 50% post-slaughter exsanguination (partial exsanguination), the highest level of residual blood was observed in the *diaphragm musculus* and in the *colli musculi*. Signs of partial exsanguination were not observed in the *longissimus thoracis musculus*, in the *semimembranosus musculus*, nor were they seen in the *internal oblique muscle.* The assessment of post-slaughter exsanguination carried out using the compressor test (Table 2) shows that all muscles were characterized by complete exsanguination. There were no statistically significant differences observed in the exsanguination of the analyzed muscles in the group of carcasses with 100% bleeding.

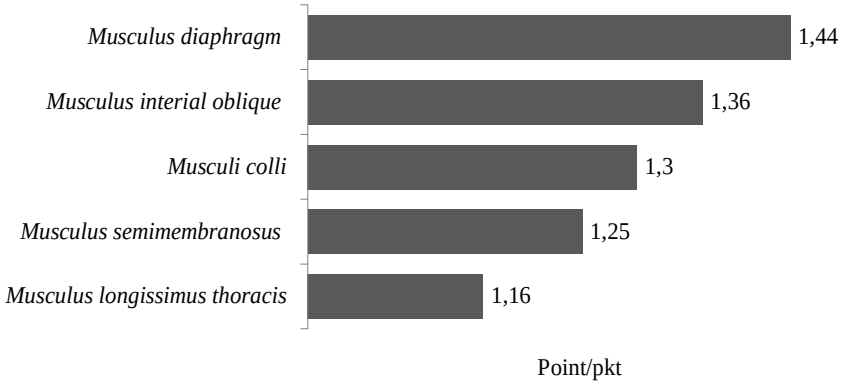

Fig. 1. The sequence of muscle having regard descending order blood content (point)
Ryc. 1. Sekwencja mięśni na podstawie oceny stopnia wykrwawienia (pkt)

It is worth noting that in this group of carcass the results of exsanguination assessment by point ranged between 1,09 and 1,13 points. In the group of carcasses with 75% bleeding, statistically significant differences were observed between the *longissimus thoracis musculus* – 1,29 pts, the *diaphragm musculus* – 1,68 and *colli musculi* – 1,64 pts. Analogical relations were observed while assessing the exsanguination rate

using the haemoglobin diffusion test (Table 1). It is worth noting that both tests produced similar results for carcasses with partial bleeding (Table 1, Table 2).

The assessment of post-slaughter exsanguination carried out with two independent physicochemical tests allows us to assume that there are significant differences in the residual blood content in the analyzed muscles. The study shows that the diaphragm and the colli muscles are characterized by a high blood content. Signs of incomplete and partial exsanguination can be observed in these muscles. To the muscles characterized by increased residual blood content belong the *semimembranosus musculus* and the *oblique internal musculus*, while the most advantageous exsanguination and at the same time the highest post-slaughter exsanguination rate in the group of analyzed muscles was observed in the *longissimus thoracis musculus*. The sequence of the analyzed muscles taking into account increasing blood content is presented in Fig. 1.

DISCUSSION

According to Moje [1993], complete blood weight constitutes around 1/22 of a fattener's body weight. Other authors claim that only a part of the total blood content of an organism is obtained during post-slaughter bleeding [Grandin 2003, Szkucik 1998]. Normally, around 40–60% of the total blood content is obtained during post-slaughter bleeding [Warriss 1984]. After slaughter the residual blood remains mainly in internal organs, which constitute an organism's stock of blood. Most of the blood is located in the liver, lungs and in the spleen. Significant amounts of blood remain also in muscles. According to Warriss [1984], the amount of blood in muscles ranges from 2,0 to 9,0 ml per one kg. According to Szkucik [1998], blood constitutes on average 1,63% of the muscle weight and its percentage increases to 1,89% in the case of incomplete exsanguination. Authors [Melier *et al.* 2006. Szkucik 1996, Tereszkiewicz 2009] also point to significant variation in the residual blood content remaining in muscles after slaughter.

Studies [Pisula 1974, Szkucik 2004, Tereszkiewicz 2009] show that the *internal oblique musculus*, the *supraspinatus musculus* and the *colli musculi* serve best for correct assessment of exsanguination. According to Szkucik [1996], analyzing residual blood content in these muscles is representative for the whole carcass. Assessment of blood in these muscles makes it possible to appropriately determine all degrees of post-slaughter exsanguination. Other authors [Burson *et al.* 1983, Meiler 2006] point to the usefulness of the diaphragm and the triceps *brachii musculus* for the assessment of slaughter exsanguination of pork carcass. Muscles recommended by the above-mentioned authors were used in this study.

Statistically significant differences in the exsanguination rate of the examined pork carcass muscles were observed on the basis of the heamoglobin diffusion test. Partial exsanguination at the level of 50% was observed in the *colli* and *diaphragm musculus* (Table 1).

It is worth noting that partial exsanguination was not observed in the *longissimus thoracis musculus*, *semimembranosus musculus*, nor was it identified in the *internal oblique musculus*. Statistical analysis showed that blood content in the *longissimus thoracis musculus*, *semimembranosus musculus*, and the *internal oblique musculus* was significantly lower compared to the *colli* and *diaphragm musculi*. Incomplete exsanguination (75%) was observed in all the examined muscles. The highest residual blood content in the carcasses characterized by incomplete bleeding was observed in the *dia-*

phragm musculus, with a smaller content in the *colli musculi*, *internal oblique musculus*, and in the *semimembransous musculus*. The lowest blood content in this group was observed in the *longissimus thoracis musculus*. In the group of carcasses characterized by complete exsanguination – 100%, the exsanguination rate was confirmed in the case of all the examined muscles. It should be noted that in this group, the *longissimus thoracis musculus* was characterized by the lowest amount of residual blood content. A high blood content was observed in diaphragm and *colli musculi* (Table 1). The results of the compressor test (Table 2) showed that the *longissimus thoracis musculus* was characterized by the lowest amount of residual blood. Low blood content was also observed in the *semimembransous* and the *internal oblique muscles*. Comparing post-slaughter exsanguination of the five muscles, it should be noted that only the *colli musculi* and the *diaphragm musculus* showed 50% partial exsanguination. Results of the present analysis showing differences in post-slaughter exsanguination in the particular muscles comprising the pork carcass are in line with the previous research [Meiler 2006, Pisula 2005, Szkucik 1996]. According to the studies, pork muscles with a high amount of blood comprise the *diaphragm musculus*, the masseter muscle and the *colli musculi*, while to the muscles with a low blood content belong the *longissimus thoracis musculus*, as well as the gluteus *medius musculus*, not included in the present study. It is worth noting that the *longissimus dorsi musculus*, obtained from the thoracic segment, is used the most often in analyzing quality features of pork carcasses. However, as was shown in the present study, the muscle does not constitute an appropriate diagnostic material for the assessment of exsanguination because it contains small amounts of residual blood and does not allow an appropriate determination of the exsanguination of other muscles comprising the pork carcass. A similar opinion was earlier stated by Szkucik [1996].

CONCLUSIONS

1. The research showed statistically significant differences in post-slaughter exsanguination of the examined muscles. The most favourable post-slaughter bleeding was observed in the *longissimus thoracis musculus*, while the least favourable in the *diaphragm* and *colli musculi*.

2. Considering the increase in blood content, the examined muscles can be arranged in the following order: the *longissimus thoracis musculus*, the *oblique internal musculus*, the *semimembransous musculus*, the *colli musculi* and the *diaphragm musculus*.

3. The assessment of residual blood content performed only on the *longissimus thoracis musculus* does not allow a correct determination of the pork carcasses' exsanguination.

4. Both the compressor test and the haemoglobin diffusion test can be recommended for assessing post-slaughter exsanguination since both tests provide similar results. The compressor test should be recommended for use in slaughter houses owing to the ease and time of marking.

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Streszczenie. Celem pracy była ocena stopnia wykrwawienia poubojowego wybranych mięśni tuszy wieprzowej. Materiał badawczy stanowiły próby pięciu mięśni pobranych z 100 tusz wieprzowych. Stopień wykrwawienia poubojowego badanych mięśni określono testem dyfuzji hemoglobiny w agarze oraz testem kompresorowym. W badaniach wykazano statystycznie istotne różnice w stopniu wykrwawienia poubojowego ocenianych mięśni. Najkorzystniejszym wykrwawieniem poubojowym charakteryzował się mięsień najdłuższy klatki piersiowej, a najmniej korzystnym mięsień przepony i mięśnie szyi.

Słowa kluczowe: tuczniki, ubój, mięśnie, wykrwawienie, stopień wykrwawienia