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STUDY OF INTERRELATION BETWEEN CHOSEN SLAUGHTER VALUE TRAITS OF PIGS AND MARBLING OF MUSCLES

Summary. The experimental material comprised 129 fatteners derived from the raw material base of three slaughterhouses from the area of Poznań. Bydgoszcz and Lublin. Left half-carcasses were cut into prime cuts and then dissection of the following four cuts was carried out: ham, shoulder, loin and belly from which lean meat, intermuscular and subcutaneous fats were separated. Using a five point scale (from 1 to 5), marbling was assessed in six selected muscles. Correlation coefficients were calculated between marbling and slaughter value traits as well as the tissue components obtained from the dissection. On the basis of the performed investigations, significant differences were demonstrated between the extent of the intramuscular fattening of the six assessed muscles (for example: *biceps femoris* muscle – 2.76 points, *quadrices femoris* muscle – 1.86 points). Significant interrelationships were found between marbling and some traits of the slaughter value (for meatiness r from 0.426^{**} to 0.629^{**} depending on the muscle type). Values of correlation coefficients were found higher for the subcutaneous fat than for intermuscular fat.

Key words: pork meat, marbling, correlation

Introduction

Long-term attempts of breeders and raw-material services of slaughterhouses, employment of scientific-research advances in the field of genetics and nutrition as well as meat technology all led to a significant increment of the meat content in carcasses and reduction of fattening (BORZUTA et AL. 2003, BLICHARSKI et AL. 2004, MIGDAŁ et AL. 2004). Lower carcass fattening is associated not only with thinner backfat but also with a lower content of both inter- and intramuscular fat referred to international nomenclature as IMF. IMF is the slowest-deposited fat in animal organisms. It is assumed that its optimal level in the loin should range from 2 to 2.5% (EIKELENBOOM et AL. 1996).

This fat forms an important meat quality trait and is very desirable both by the meat processing industry and consumers. Intramuscular fat exerts a favourable impact on meat tenderness, palatability and juiciness and reduces losses in the course of thermal treatment (KIRCHHEIM et AL. 1997, BLICHARSKI et AL. 2004, FORTIN et AL. 2005). KIRCHHEIM et AL. (1997) found significant correlations between meat tenderness and fat content in meat ($r = 0.45^{**}$). IMF is easily recognised after cutting a given muscle, in particular loin, because it forms – what is usually referred to – as meat marbling. Some investigations revealed a high correlation ($r = 0.51^{**}$ $r = 0.61^{**}$) between IMF and the marbling of the *longissimus dorsi* (LD) muscle (RYBARCZYK et AL. 2005, FAUCITANO et AL. 2005). In turn, reports on dependencies between marbling of different muscles and shlaughter value traits of carcass.

The aim of these investigations was to assess the marbling of six selected muscles and to determine its correlation with selected traits of the slaughter value of fatteners derived from a mass population.

Material and methods

Studies were conducted on 129 pig carcasses from the market population of the Bydgoskie, Poznańskie and Lubelskie regions, composed of equal proportions of gilts and hogs.

Backfat thickness was measured on warm, hanging carcasses on the back, over the shoulder and on the ham at points KI, KII and KIII. Carcasses selected in slaughterhouses were transported in hanging position by refrigerated trucks to the PPH ROMEKS slaughter house in Wielkopolska province where left half-carcasses were cut and dissected. The dissection was carried out by a team of 10 trained meat cutters supervised by three specialists from the Meat and Fat Research Institute.

The dissection was carried out in accordance with the Walstra and Merkus methodology currently in effect in the European Union which takes into consideration tissue division of four principal cuts, namely: ham without shank, shoulder without shank, loin, belly and tenderloin (WALSTRA and MERKUS 1996, BORZUTA et AL. 2004). Next, lean meat (together with membranes of the connective tissue), intermuscular and subcutaneous fat with skin and bones were separated from the above-mentioned cuts. The mass of the obtained tissue components was weighed on an authorised electronic balance with 1 g accuracy. The content of the dissection meat in the carcass was calculated in accordance with the formula developed in 2008 (ROZPORZĄDZENIE KOMISJI... 2008).

In the course of the dissection process, marbling of the following six selected muscles was assessed: *biceps femoris* (BF), *semimembranosus* (SEM), *quadriceps femoris* (QF), *triceps brachii* (TB) *longissimus dorsi* (LD) and *gluteus medius* (GM). The degree of muscle fattening was estimated according to Canadian and American models using the scale of 1 to 5 points (1 point – slight fattening, 5 points – strong fattening) (WISE 1981, KAUFFMAN et AL. 1992).

The results were elaborated statistically calculating means (x) and standard deviations (SD) of the examined traits. The significance of differences between muscle was calculated using the Tukey's test. In addition, the authors calculated correlation coefficients between the marbling of the six assessed muscles and traits of slaughter value, as well as the tissue components obtained from the dissection (STANISZ 1998).

Results

The obtained research results are presented in Tables 1 to 6. Carcasses selected for the performed investigations were characterised by the mean mass of 83.14 kg, meatiness of 51.12% and mean backfat thickness from five measurements of 26.27 mm (Table 1).

Table 1. Results of slaughter value of examined fatteners
Tabela 1. Wyniki wartości rzeźnej badanych tuczników

Trait	$\bar{x}$	SD	Min.	Max.
Hot carcass weight (kg)	83.14	9.66	64.60	118.54
Meat content in carcass (%)	51.12	6.81	36.27	62.89
Back fat thickness (mm)				
– over shoulder	39.99	8.53	24.00	70.00
– on back	21.11	7.58	8.00	53.00
– on cross I	26.25	9.16	11.00	52.00
– on cross II	18.44	8.70	6.00	43.00
– on cross III	25.55	11.31	8.00	56.00
Mean value of five backfat thickness measure (mm)	26.27	9.10	11.40	54.80
Loin eye area (cm^2)	36.89	1.47	28.13	65.52

The performed detailed dissection of prime cuts showed the following lean meat content (Table 2): 65.5% in the ham, 63.82% in the shoulder, 50.97% in the loin and 54.0% in the belly. The content of intramuscular fat in the above-mentioned cuts amounted to: 4.2%, 6.23%, 6.91%, and 21.28%, respectively. The total output of the dissection components obtained from the above prime cuts in relation to theirs weight amounted to: 59.31% of meat, 8.13% of intramuscular fat and 23.46% of fat with skin (Table 2).

Table 2. Results of four cuts dissection of investigated carcasses
Tabela 2. Wyniki dysekcji czterech podstawowych wyrębów badanych tusz

Cut	Mass of cut (kg)	Part of meat		Part of intramuscular fat		Part of bone		Part fat with skin	
		kg	%	kg	%	kg	%	kg	%
1	2	3	4	5	6	7	8	9	10
Ham									
$\bar{x}$	10.00	6.55	65.50	0.42	4.20	0.79	7.90	2.19	21.90
SD	1.12	0.99		0.17		0.09		0.78	
min.	7.58	4.56		0.16		0.62		1.01	
max.	14.58	11.16		1.16		1.17		4.01	

Table 2 – cont. / Tabela 2 – cd.

1	2	3	4	5	6	7	8	9	10
Shoulder									
$\bar{x}$	4.81	3.07	63.82	0.30	6.23	0.51	10.60	0.92	19.13
SD	0.57	0.51		0.11		0.08		0.26	
min.	3.72	2.15		0.07		0.40		0.35	
max.	7.69	5.63		0.59		0.88		1.49	
Loin									
$\bar{x}$	7.24	3.69	50.97	0.50	6.91	0.85	11.74	2.18	30.11
SD	1.26	0.63		0.27		0.14		1.05	
min.	4.98	2.36		0.11		0.50		0.75	
max.	12.05	6.31		1.62		1.43		5.35	
Belly									
$\bar{x}$	4.37	2.36	54.00	0.93	21.28	0.27	6.18	0.91	20.82
SD	0.67	1.62		0.40		0.05		0.32	
min.	2.93	1.19		0.16		0.17		0.37	
max.	6.67	2.81		1.96		0.44		1.82	
Total	26.42	15.67	59.31	2.15	8.13	2.42	9.15	6.20	23.46

Table 3. Results of average marbling evaluation of different muscles (points)
Tabela 3. Średnie wyniki marmurkowatości wybranych mięśni (pkt)

Muscle	$\bar{x}$	SD
Musculus longissimus dorsi	2.34 A	0.94
Musculus biceps femoris	2.76 B	0.74
Musculus semimembranosus	2.42 A	0.75
Musculus quadriceps femoris	1.86 C	0.59
Musculus triceps brachii	2.38 A	0.87
Musculus gluteus medius	2.48 A	1.18

A, B, C – $P \leq 0.01$.

The results of marbling assessment of the six muscles are presented in Table 3, whereas correlations between them and slaughter value traits are collated in Tables 4 and 5. Significant differences were found between the examined muscles with regard to the intramuscular fattening. Table 6 shows correlation coefficients calculated between the marbling of six muscles and the meat and fat obtained during dissection of the four prime cuts.

Table 4. Correlation coefficients between marbling of different muscles
Tabela 4. Współczynniki korelacji pomiędzy marmurkowatością wybranych mięśni

Muscle	LD	BF	SEM	QF	TB	GM
LD	–	0.617**	0.677**	0.544**	0.599**	0.586**
BF	0.617**	–	0.751**	0.580**	0.644**	0.529**
SEM	0.677**	0.751**	–	0.681**	0.639**	0.566**
QF	0.544**	0.579**	0.681**	–	0.658**	0.455**
TB	0.599**	0.644**	0.639**	0.658**	–	0.513**
GM	0.586**	0.566**	0.566**	0.455**	0.513**	–

** $P \leq 0.01$.

Table 5. Correlation coefficients between marbling of muscles and slaughter value traits
Tabela 5. Współczynniki korelacji pomiędzy marmurkowatością mięśni a cechami wartości rzeźnej

Trait	LD	BF	SEM	QF	TB	GM
Hot carcass weight	0.163	0.05	0.016	0.062	0.149	0.256
Meatiness	–0.629**	–0.521**	–0.443**	–0.426**	–0.427**	–0.523**
Thickness of fat						
– over shoulder	0.442**	0.354**	0.304**	0.345**	0.284**	0.472**
– on back	0.337**	0.269**	0.203*	0.194*	0.159	0.369**
– on cross I	0.463**	0.371**	0.310**	0.277**	0.240**	0.465**
– on cross II	0.495**	0.443**	0.376**	0.322**	0.320**	0.502**
– on cross III	0.478**	0.446**	0.362**	0.363**	0.329**	0.501**

* $P \leq 0.05$.
** $P \leq 0.01$.

Table 6. Correlation coefficients between marbling of muscles and mass of dissected elements
Tabela 6. Współczynniki korelacji pomiędzy marmurkowatością mięśni a masą elementów dysekcji

Specification	LD	BF	SEM	QF	TB	GM
1	2	3	4	5	6	7
Meat in ham	–0.444**	–0.409**	–0.361**	–0.299**	–0.279*	–0.277**
Meat in loin	–0.441**	–0.417**	–0.373**	–0.309**	–0.301**	–0.272**
Meat in shoulder	–0.372**	–0.389**	–0.359**	–0.342**	–0.274**	–0.259*
Meat in belly	–0.182**	–0.194*	–0.197*	–0.134	–0.151	–0.096
Tender loin	–0.473**	–0.462**	–0.442**	–0.387**	–0.374**	–0.334**
Intramuscular fat in ham	0.287**	0.304**	0.146	0.256**	0.256**	0.151

Table 6 – cont. / Tabela 6 – cd.

1	2	3	4	5	6	7
Fat with skin in ham	0.601**	0.472**	0.419**	0.340**	0.398**	0.588**
Intramuscular fat in loin	0.308**	0.188*	0.173	0.215**	0.144	0.357**
Fat with skin in loin	0.544	0.440**	0.372**	0.304**	0.377**	0.525**
Intramuscular fat in shoulder	0.381**	0.401**	0.277**	0.339**	0.379**	0.352**
Fat with skin in shoulder	0.506**	0.350**	0.286**	0.222*	0.318**	0.388**
Intramuscular fat in belly	0.625**	0.467**	0.427**	0.358**	0.409**	0.605**
Fat with skin in belly	0.413**	0.336**	0.263*	0.322**	0.299**	0.352**

* $P \leq 0.05$.
** $P \leq 0.01$.

Discussion

It was demonstrated that the examined carcasses were characterised by the mean meat content of 51.12% (Table 1). In comparison with the mean carcass meatiness recorded in domestic slaughterhouses in 2008 which, according to the data given by LISIAK and BORZUTA (2008) reached 54%, the examined population was characterised by about 3% lower meatiness, although in comparison with the purchase from 2002 it was by 1.25% higher (BORZUTA et AL. 2003). However, it should be stressed that the meatiness of the examined carcasses was characterised by considerable variability ranging from 36.27% to 62.89% which is very important for investigations associated with interrelationships between muscle marbling and slaughter traits. The mean after-slaughter weight of warm carcasses was 83.14 kg (Table 1) and was characterised by a considerable variability ranging from 64.60 kg to 118.54 kg.

The mean backfat thickness from five measurements was 26.27 mm and ranged from 39.99 mm over the shoulder to over 18.44 mm on the back II (Table 1). According to BORZUTA et AL. (2003) this value in 2002 for the population of over 14,000 amounted to: 34.51 mm and 19.47 mm, respectively. The area of the loin "eye" of the examined carcasses ranged from 28.13 to 65.52 cm^2 (on average – 36.89 cm^2).

Another result of the performed investigations was the determination of the tissue components of the four prime carcass cuts (Table 2). The total percentage proportion of the four dissected prime cuts amounted to 59.31%, while that of the subcutaneous fat with skin – 23.46%, whereas WINARSKI et AL. (2004) for similar material reported values of 60.38% and 22.32% of meat and fat, respectively. On the other hand, the proportion of intermuscular fat separated from these elements reached 9.65% and was by 1.23% higher in comparison with the results reported in the paper mentioned above.

From among the analysed cuts, the highest meat proportion was determined in the ham – 65.50% and shoulder – 63.82%, less – in belly – 54.00% and the smallest share – in the loin – 50.97%. It is interesting to compare these data with similar experiments conducted by BORZUTA et AL. (2004) in which they obtained by 2.20% more meat from

the ham and by 3.19% more meat from the loin and by 4.14% less meat from the belly in which, at the same time, there was by 4.07% more fat with skin. Nevertheless, the proportion of meat in the loin, at the employed system of carcass cutting, turned out to be similar to the meat content in the entire carcass. In addition, the research results from 2004 showed more intermuscular fat in the shoulder and less in the belly (by 2.80%, respectively). In comparison with the results reported by BORZUTA et AL. (2004), the results of these studies revealed in the examined carcasses more subcutaneous fat (with the exception of the shoulder) and smaller intermuscular fattening.

Another interesting observation from these investigations is associated with a considerable marbling variability found in the six selected muscles (Table 3). From among the examined muscles, the smallest intramuscular fattening was observed in the *quadriceps femoris* muscle (1.86 points), while the greatest – in the *biceps femoris* muscle (2.76 points). The remaining muscles were awarded intermediate scores ranging from 2.34 to 2.48 points. The performed correlation analysis between these muscles revealed significant correlations ranging from 0.455 to 0.751 (Table 4).

The intramuscular fat is, basically, made up of fat situated inside muscle fibres and fats found in the connective tissue membranes between fibres (BLICHARSKI et AL. 2006). In earlier domestic investigations carried out on a population of 1380 porcine carcasses derived from 10 crossbreds of different breeds, on average 2.79% fat was determined in the *longissimus dorsi* muscle ranging from 2.12 to 3.45% (GRZEŚKOWIAK et AL. 2006).

A fairly high correlation was determined between the marbling of the six selected muscles and the carcass slaughter value and the mass of tissue components obtained from the dissection of the four prime cuts (Tables 5, 6). First of all, significant ($P \leq 0.01$) correlations were obtained between the marbling of individual muscles backfat thickness on ham: $r = 0.463^{**}$ (LD and BF muscles) to $r = 0.502^{**}$ (GM muscle). Moreover, significant correlations were also obtained between marbling and carcass meatiness ($r = –0{,}443^{**}$ to $r = –0{,}629^{**}$) (Table 5). On the other hand, the performed analyses and measurements failed to show any influence of the carcass weight on the intramuscular fattening of the examined muscles. Also other researchers failed to report significant correlations between the content of intramuscular fat in the LD muscle and carcass mass (RYBARCZYK et AL. 2005), although they confirmed a significant correlation ($r = 0.51^{**}$) between marbling and the level of intramuscular fat in the LD muscle determined analytically.

Table 6 collates correlation coefficients between marbling and meat and fat mass of the four dissected cuts. Higher values of correlation coefficients were determined between the marbling of muscles, especially of the LD muscle (r from 0.506^{**} to 0.601^{**}) and the subcutaneous fat obtained from the dissection in comparison with the intermuscular fat, although in the case of bacon, a reverse correlation was observed. In the case of the LD and BF muscles, higher negative correlation values were recorded between marbling and ham and loin meat mass (relatively: r from $–0.409^{**}$ to $– 0.444^{**}$). WINARSKI et AL. (2004) calculated correlation coefficients for similar experimental material between the percentage proportion of meat and intermuscular and subcutaneous fat in four elements and their yields from a particular cut. The determined correlation coefficients for ham, for example, amounted to r which was $–0.374^{*}$, 0.570^{*} and 0.247^{*}, respectively.

Conclusions

On the basis of the performed investigations significant differences were demonstrated between the marbling of the analysed ham, shoulder and loin muscles. In addition, significant interrelations were found between the marbling of the examined six muscles and carcass musculature and fattening, as well as individual four prime cuts. Moreover, the authors corroborated the lack of influence of the carcass weight on the muscle intramuscular fattening. Obtained results may be helpful in the selection of raw material for the production of high quality products as well as modifications of purchasing policy concerning slaughter animals consistent with the needs of meat processing plants.

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BADANIA WSPÓŁZALEŻNOŚCI POMIĘDZY WYBRANYMI CECHAMI WARTOŚCI RZEŹNEJ A MARMURKOWATOŚCIĄ MIĘŚNI TUSZ WIEPRZOWYCH

Streszczenie. Materiał doświadczalny stanowiło 129 tusz tuczników, pochodzących z zaplecza surowcowego trzech zakładów mięsnych z rejonu Poznańskiego, Bydgoskiego i Lubelskiego. Lewe półtusze poddano rozbiorowi na części zasadnicze, a następnie wykonano dysekcję czterech wyrębów: szynki, łopatki, schabu i boczku. Z elementów tych wyodrębniono chude mięso, tłuszcz międzymięśniowy i tłuszcz podskórny. W sześciu wybranych mięśniach oceniono marmurkowatość w skali od 1 do 5 punktów. Obliczono współczynniki korelacji pomiędzy marmurkowatością a cechami wartości rzeźnej oraz składnikami tkankowymi uzyskanymi z dysekcji. Na podstawie przeprowadzonych badań wykazano istotne różnice pomiędzy stopniem przetłuszczenia śródmięśniowego sześciu ocenianych mięśni (np. *m. biceps femoris* – 2,76 pkt., *m. quadrices femoris* 1,86 pkt.) Stwierdzono istotne współzależności pomiędzy marmurkowatością a niektórymi cechami wartości rzeźnej (dla mięsności r od 0,426** do 0,629** w zależności od rodzaju mięśnia). Większe wartości współczynników korelacji notowano w przypadku tłuszczu podskórnego niż tłuszczu międzymięśniowego.

Słowa kluczowe: mięso wieprzowe, marmurkowatość, korelacja

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