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The use of *longissimus dorsi* muscle measurements in assessing meat content of pig carcasses

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The research was conducted on 287 pig carcasses, divided into two groups on the basis of their hot weight. Group 1 consisted of carcasses weighing 60-80 kg (n = 159), while group 2 of those heavier than 80,1 kg (n=128). The carcasses were divided into main joints and dissected according to Walstra and Merkus method used in EU for certification of the equipment used for estimating the lean meat content of pig carcasses. The loin was cut behind the last thoracic vertebra and between 3rd and 4th thoracic vertebra, counting from the last. The cross-sections obtained allowed to make measurements of width, depth and area of the *Longissimus dorsi* muscle (LD). The depth of LD measured behind the last thoracic vertebra was about 5 mm greater, whereas the width was very close to that measured between 3rd and 4th thoracic vertebrae. Simultaneously, about 15 kg increase in carcass weight caused 5 mm increase of depth and width of LD. The thickness of LD measured behind the last thoracic vertebra correlated slightly higher with meat content of four dissected joints (r = 0.48) than the thickness measured between 3rd and 4th thoracic vertebrae (r = 0.38). Slightly higher correlations were found for measurements of muscle depth made 6 cm from middle line in comparison to the measurements made 7 cm from middle line. That is why, as for ultrasonic and optical-probe equipment, one should use measurement behind last thoracic vertebra, 6 cm from middle line for estimating lean meat content of carcass. Measurements of LD muscle width correlated lower with meat content of the sum of four dissected joints than the measurements of LD muscle height. However, as for loin eye area behind the last thoracic vertebra, it correlated higher.

KEY WORDS: carcass / loin eye area / meat content / pigs

Polish accession to EU is connected with a number of changes of regulations currently valid in our country, concerning agriculture, veterinary rules and meat industry, the purpose of which is adjusting the legislation to EU standards. One of the key EU regulations is obligation to classify in EUROP class pig carcasses in abattoirs slaughtering more than 200 pigs weekly as the yearly mean. Pig carcass classification in this system must be objective. That is why specialized, certificated equipment is used, the deviation precision of which (known as RSD) cannot exceed 2,5% [EU Commission Reg., 1994]. These apparatuses – depending on type and applied measurement method – estimate lean meat content of pig carcass usually on the basis of fat and meat thickness of loin (muscle depth) cut surface measurement [Borzuta 2002, Lisiak 2002]. That is why a question occurs, which measurements and at which point of carcass would be the most beneficiary for decreasing the RSD at lean meat content estimation and would such measurements be helpful for predicting lean meat content of most valuable joint.

The purpose of this study was defining the correlations between measurements performed at loin cross-section surface*, i.e.* width, depth and area (termed the loin eye area), of *Longissimus dorsi* muscle, and content (%) of meat in ham, loin, shoulder and belly.

Material and methods

This study accompanied the research performed within the confines of project entitled "EUROP classification of animal carcasses in Poland" approved by twin agreement TWINNING PL/IB/2002/AG/06, MF no PL01.04.06 [Borzuta *et al*. 2002ab, Wajda and Borzuta 2003]. The material consisted of purposely selected 287 pig carcasses, originating from raw material base of Meat Plants in Łuków, Morliny and Przechlewo (93, 62 and 132 carcasses, respectively). Carcasses were chosen in such a way to precisely reflect pig population in Poland, so it was preceded by broad research on carcass fatness level, which was performed on over 14 thousand pigs slaughtered in different meat plants all over Poland [Grześkowiak *et al*. 2002, Borzuta *et al*. 2003]. Moreover, the proper cutting of carcasses into halves was taken into account.

After slaughter and preliminary preparation the carcasses were chillled to 2-4°C.Carcass-sides originating from Łuków and Przechlewo were transported in refrigeration trucks to Meat Plant at Morliny. Left carcass-sides were divided according to Walstra and Mercus [1996] method used in EU for attestation of equipment used for estimating lean meat content of pig carcasses. During the division of carcasses into halves, loins were cut behind the last thoratic vertebrae and between 3rd and 4th thoratic vertebrae, counting from the last. On those cuts *longissimus dorsi* muscle (LD) depth was measured 6 and 7 cm from carcass division line. LD width was measured at the widest point of muscle. Both results were used to calculate the LD cut area (loin eye area) according to the formula: muscle height × muscle width × 0.8 [Kielanowski 1957, Osińska 1962]. Then, four main joints, *i.e*. ham, loin, shoulder and belly were

dissected into meat, intermuscular fat, skin with subcutaneous fat and bones and components obtained were weighed exact to 1 g. Carcass division and dissection were both made in Meat Plant Morliny by a team of trained and experienced plant workers. The statistical evaluations were performed for two groups of pigs, depending on carcass weight. Group 1 consisted of carcasses weighing 60-80 kg (n=159) and group 2 of carcasses weighing 80.1-120 kg (n =128). Correlation coefficients between LD thickness (depth), width and area and meat content of four joints were estimated. STATISTICA version 5 was used to perform the calculations. Significance of differences between group means was evaluated with Tukey's test.

Results and discussion

Mean weight of a carcass (groups pooled) was 79.33 kg (Tab. 1). In group 1 the mean carcass weight was 73.01 kg while in group 2 – 87.18 kg. Standard devations were similar in both groups. Mean meat content of carcass (goups pooled) as calculated according to Walstra and Merkus [1996] was 52.85%, being by about 2% higher from the value quoted by Lisiak and Borzuta [2003ab] on the basis of monitoring of pigs slaugtered in January and February 2003 eleven meat processing plants and classified according to EUROP grading system. Meat content of group 1 carcasses was 54.07% and 51.87% in group 2. Lowering meat content of carcass accompanied by the increase in live weight of pigs corroborate earlier results reported by Buck *et al*. [1962] and Wajda [1973]. Lean meat content of joints examined was lower in belly and loin than in ham and shoulder.

In EUROP classification system, lean meat content of pig carcasses is estimated mainly on the basis of fat thickness measured. Still, in the equipment used in meat processing plants to estimate lean meat content of carcass, *i.e*. optical probe or ultrasonic apparatus, apart from fat thickness measurements, the LD depth measurements are also used. In order to define the optimum measuring point which will correlate the highest with meat content, two measurements were tested on two loin cuts – behind the last and between 3rd and 4th thoratic vertebra (counting from the rear) and 6 or 7 cm aside from carcass splitting line. In the present study the mean LD depth depended on the cut point. Depth by 5 mm greater was found for the cut made behid the last than between 3rd and 4th thoratic vetebrae, counting from the last.

LD thickness in the cut made 7 cm from carcass division line was about 3 mm bigger, than in the cut made 6 cm from carcass division line. It was also observed that the depth of LD muscle at each point increased together with the carcass weight. An increase in carcass weight by 15 kg was accompanied by about 5 mm increase of LD depth in the cut behind the last thoracic vertebrae and between 3rd and 4th vertebrae. Standard deviations for muscle depth measurement were similar for all the measurements, *i.e*. about 8 mm.

Measurements of LD width in the cuts proceeded in a different way. The muscle had similar size in the cut behind the last thoracic vertebra and between 3rd and 4th

Table 1. Means and their standard deviations (SD) for traits analysed

Trait		Group I 60-80 kg (n=159)	Group II 80.1-120 kg (n=128)	Groups pooled (n=287)
Weight of hot carcass (kg)	mean	73.01	87.18**	79.33
	SD	5.10	5.43	8.79
Weight of half carcass (kg)	mean	36.00	42.99**	39.11
	SD	2.48	2.80	4.36
Meat content in carcass (%)	mean	54.07**	51.87	52.85
	SD	4.83	5.20	5.15
Per cent of meat in				
belly	mean	51.57**	48.81	50.34
	SD	8.03	6.57	7.53
loin	mean	55.95**	52.69	54.50
	SD	6.98	7.25	7.27
leg	mean	69.00**	66.70	67.97
	SD	4.71	4.86	4.90
shoulder	mean	64.53**	62.38	63.57
	SD	4.24	4.54	4.50
sum of for dissected joints	mean	61.95**	59.15	60.70
	SD	5.57	5.61	5.75
LD muscle depth at last thoracic vertebra[1]	mean	54.74	60.59**	57.35
(mm)	SD	8.47	8.27	8.86
LD muscle depth at last thoracic vertebra[2]	mean	57.00	62.27**	59.35
(mm)	SD	9.18	7.27	8.77
LD muscle depth between 3rd and 4th thoracic	mean	49.52	54.84**	51.90
vertebrae, counting from the last[1] (mm)	SD	7.78	7.23	7.98
LD muscle depth between 3rd and 4th thoracic	mean	52.58	57.61**	54.82
vertebra, counting from the last[2] (mm)	SD	8.96	7.46	8.68
LD muscle width at last thoracic vertebra	mean	92.70	97.35**	94.77
(mm)	SD	6.04	7.71	7.21
LD muscle width between3rd and 4th thoracic	mean	93.00	96.25**	94.45
vertebra, counting from the last (mm)	SD	25.23	6.47	19.31
Loin eye area at last thoracic vertebra[1]	mean	40.85	47.45**	43.79
(cm^2)	SD	8.25	9.01	9.19
Loin eye area last thoracic vertebra[2]	mean	42.50	48.68**	45.26
(cm^2)	SD	8.50	8.02	8.83
Loin eye area between 3rd and 4th thoracic	mean	37.19	42.44**	39.53
vertebra[1], counting from the last[1] (cm^2)	SD	13.61	7.53	11.59
Loin eye area between 3rd and 4th thoracic	mean	39.41	44.51**	41.69
vertebra[1], counting from the last[2] (cm^2)	SD	14.04	7.47	11.84

[1]6 cm from carcass division line.
[2]7 cm from carcass division line.
**Inter-group differences significant at $P \leq 0.01$.

vertebrae. However, every 15 kg increase in carcass weight caused 4 mm increase of *Longissimus dorsi* muscle's width.

LD width and depth measurements became the basis of calculating loin eye's area. This area was bigger in the cut behind the last thoracic vertebra than between 3rd and

Table 2. Coefficients of simple correlation between traits analysed

Trait	Group of carcass	Meat content of				
		leg	loin	shoulder	belly	four dissected joints
LD muscle depth at last thoracic vertebra[1] (mm)	1	0.608**	0.623**	0.543**	0.532**	0.619**
	2	0.588**	0.611**	0.580**	0.567**	0.621**
	pooled	0.473**	0.495**	0.435**	0.445**	0.488**
LD muscle depth at last thoracic vertebra[2] (mm)	1	0.627**	0.607**	0.505**	0.513**	0.610**
	2	0.540**	0.579**	0.502**	0.519**	0.569**
	pooled	0.476**	0.483**	0.391**	0.429**	0.474**
LD muscle depth between 3rd and 4th thoracic vertebra, counting from the last[1] (mm)	1	0.588**	0.575**	0.700**	0.495**	0.581**
	2	0.610**	0.613**	0.555**	0.578**	0.624**
	pooled	0.470**	0.469**	0.406**	0.426**	0.468**
LD muscle depth between 3rd and 4th thoracic vertebra, counting from the last[2] (mm)	1	0.516**	0.469**	0.411**	0.413**	0.488**
	2	0.467**	0.652**	0.433**	0.447**	0.487**
	pooled	0.392**	0.379**	0.320**	0.347**	0.381**
LD muscle width at last thoracic vertebra (mm)	1	0.563**	0.631**	0.576**	0.497**	0.606**
	2	0.521**	0.593**	0.479**	0.498**	0.559**
	pooled	0.421**	0.490**	0.405**	0.393**	0.453**
LD muscle width between 3rd and 4th thoracic vertebra, counting from the last (mm)	1	0.164*	0.178*	0.119	- 0.325	0.564*
	2	0.591**	0.621**	0.487**	0.520**	0.599**
	pooled	0.181**	0.197**	0.134*	-0.198**	0.106
Loin eye area at last thoracic vertebra[1] (cm^2)	1	0.647**	0.682**	0.608**	0.571**	0.671**
	2	0.635**	0.680**	0.611**	0.612**	0.674**
	pooled	0.499**	0.540**	0.468**	0.469**	0.522**
Loin eye area at at last thoracic vertebra[2] (cm^2)	1	0.683**	0.691**	0.596**	0.574**	0.686**
	2	0.626**	0.687**	0.579**	0.602**	0.664**
	pooled	0.518**	0.551**	0.452**	0.473**	0.530**
Loin eye area between 3rd and 4th thoracic vertebra, counting from the last[1] (cm^2)	1	0.371**	0.378**	0.306**	-0.697	0.280**
	2	0.668**	0.680**	0.590**	0.619	0.681**
	pooled	0.369**	0.380**	0.305**	0.066	0.313**
Loin eye area between 3rd and 4th thoracic vertebra, counting from the last[2] (cm^2)	1	0.367**	0.357**	0.286**	- 0.778	0.267**
	2	0.591**	0.621**	0.525**	0.548	0.609**
	pooled	0.345**	0.350**	0.274**	0.405	0.284**

[1]6 cm from carcass division line.
[2]7 cm from carcass division line.
1 – carcass weight 60-80 kg (group 1).
2 – carcass weight 80.1-120 kg (group 2).
Groups pooled – carcass weight 60-120 kg.
*P≤0.05.
** P≤0.01.

4th vertebrae. Judge's research [Judge 1964 quoted after Osińska 1971] shows that loin eye's area visibly increases from fifth to last thoracic vertebrae, and then decreases over the last lumbar vertebrae. The loin eye area in group 2 carcasses appeared by 5 cm^2 greater than in carcasses from group 1, confirming earlier reports by Wajda [1973] and Wajda *et al*. [1997].

Main objective of this research was to define optimal point of *Longissimus dorsi* muscle depth measurement, which would help to estimate, as precisely as possible, meat per cent of carcass. Correlation coefficients were calculated between measurements of LD depth determined in two cross-sections and meat content in four dissected joints obtained from carcass division (Tab. 2).

Devices manufactured for estimating the meat per cent of carcass use the LD muscle depth. In the present study the LD muscle depth measured behind last thoracic vertebra correlated slightly higher with meat content of four dissected joints ($r = 0.48$) than that measured between 3rd and 4th thoracic vertebrae ($r = 0.38$). Slightly higher correlations were found for LD depth measured on 6th than on 7th cm from carcass middle line. Wajda *et al*. [2004] showed that all fat thickness measurements made at the same points as muscle depth had similar correlation coefficient with the meat content of dissected joints. It can, therefore, be anticipated that in order to estimate lean meat content of carcass one should base upon measurement behind last thoracic vertebra, 6 cm from splitting line.

Further analysis shows that higher correlations were achieved for estimations conducted separately for group 1 (60-80 kg carcass weight) and group 2 (80,1-120 kg carcass weight) than for all carcasses pooled. Moreover, muscle depth measurements correlated higher with meat content of loin and ham than of belly and shoulder.

Slightly lower correlation coefficients were found between LD width and lean meat content of dissected elements. As in case of muscle depth, higher correlations were found between width of LD and meat content of ham and loin than of shoulder and belly. Higher correlations were also found while estimating factors separately for each carcass weight group rather than for all analysed material pooled. Characteristically, very low correlations were found for muscle width measurements between 3rd and 4th thoracic vertebrae, counting from the rear.

Loin eye area is widely used at slaughter value indicator of pigs [Kielanowski 1957, Osińska 1958, Kowalski and Panasik 1966, Bochno, 1971]. In the present study, on the basis of measurements performed, four areas of loin eye were obtained, for which correlation coefficients with four dissected joints were estimated (Tab. 2). Higher correlations with meat per cent of dissected joints were found for loin eye area behind last thoracic vertebra rather than between 3rd and 4th thoracic vertebrae. Regardless of the fact that muscle depth measurements were taken 6 or 7 cm from splitting line, correlation coefficients with meat per cent of the joints appeared similar. Table 2 shows also that correlation coefficients were similar for loin eye measurements made behind the last thoracic vertebra in both groups of carcasses. Still, for loin eye measurements made between 3rd and 4th thoracic vertebrae correlations were significantly higher

for heavier carcasses (group 2). It appears interesting as well, that in group 1 correlations between the loin eye measurements and meat per cent of belly were negative. On the basis of many reports, Osińska [1971] stated that correlations between loin eye area and lean meat content of carcasses range from 0.46 to 0.95.

Concluding, the depth of LD muscle measured on the cross-section behind the last thoracic vertebra was found about 3 mm greater than, whereas the LD width very close to the LD depth measured between 3rd and 4th thoracic vertebrae, counting from the rear. At the same time, about 15 kg increase in carcass weight caused 5 mm increase in depth and width of LD. The thickness of LD measured behind the last thoracic vertebra correlated slightly higher with meat per cent of four dissected joints (r = 0.48) than the same measurement made between 3rd and 4th thoracic vertebrae, counting from the last (r = 0.38). Slightly higher correlations were also found for measurements of muscle depth made 6 than 7 cm from carcass middle line. Therefore, as for both ultrasonic and optical-probe equipment, to estimate the lean meat content of carcass one should use measurements made behind last thoracic vertebra, 6 cm from carcass middle line. LD muscle width correlates lower with meat per cent in the sum of four dissected joints than LD height. However, as for loin eye area behind the last thoracic vertebra, it correlates higher.

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Przydatność pomiarów mięśnia *longissimus dorsi* do szacowania zawartości mięsa w tuszach wieprzowych

S t r e s z c z e n i e

Badania przeprowadzono na 287 tuszach wieprzowych, które podzielono zależnie od masy na dwie grupy, tj. tusze o masie 60-80 kg (159 tusz) oraz powyżej 80,1 kg (128 tusz). Badane tusze poddawano podziałowi oraz dysekcji według metodyki Walstra i Merkusa stosowanej w Unii Europejskiej do atestacji urządzeń służących do szacowania zawartości mięsa w tuszach. Polędwicę przecinano za ostatnim kręgiem piersiowym oraz między 3 a 4 kręgiem piersiowym licząc od końca tuszy. Na uzyskanych w ten sposób przekrojach wykonano pomiary szerokości i wysokości mięśnia najdłuższego grzbietu (LD) oraz obliczono pole jego przekroju. Wysokość mięśnia LD mierzona na przekroju za ostatnim kręgiem piersiowym była większa o około 5 mm, a jego szerokość okazała się zbliżona do wymiarów uzyskanych między 3 i 4 kręgiem piersiowym licząc od końca. Natomiast wzrost masy tusz o około 15 kg powodował wzrost wysokości i szerokości mięśnia LD o około 5 mm. Grubość LD mierzona na przekroju za ostatnim kręgiem piersiowym nieznacznie wyżej korelowała z procentem mięsa w czterech elementach tuszy ($r = 0,48$) niż mierzona między 3 a 4 kręgiem piersiowym licząc od końca (około $r = 0,38$). Uzyskano również nieznacznie wyższe współzależności dla wysokości mięśnia mierzonej 6 cm od linii środkowej tuszy w porównaniu z pomiarem w odległości 7 cm. W urządzeniach ultradźwiękowych i optyczno-igłowych należy zatem wykorzystywać do szacowania mięsności tusz pomiar za ostatnim kręgiem piersiowym, 6 cm od linii podziału tuszy na półtusze. Pomiary szerokości LD wykazały niższą, a powierzchnia oka polędwicy za ostatnim kręgiem piersiowym wyższą korelację z zawartością mięsa w dysekowanych elementach, niż pomiar wysokości tego mięśnia.