Improvement of accuracy in the estimation of lean meat content in pig carcasses

M. Vítek, J. Pulkrábek, L. Vališ, L. David, J. Wolf

Institute of Animal Science, Prague-Uhříněves, Czech Republic

ABSTRACT: Fat thickness including skin and muscle depth measured on the left carcass side between the second and third from the last rib 70 mm off the dorsal midline were measured in a total of 168 pig hybrid carcasses. The lean meat content was then determined on the basis of simplified dissections of the carcasses. Multiple regressions of the measurements of the fat and muscle thickness on the lean meat content obtained by dissections were used to construct the following basic regression formulae for the ultrasound and probe apparatuses: $y_{IS\text{-}D\text{-}05} = 60.69798 - 0.89211S_{IS\text{-}D\text{-}05} + 0.10560M_{IS\text{-}D\text{-}05}$ and $y_{IS\text{-}D\text{-}15} = 60.92452 - 0.77248S_{IS\text{-}D\text{-}15} + 0.11329M_{IS\text{-}D\text{-}15}$, respectively. To increase the accuracy of the prediction formulae, additional measures were included in the calculation which reduced s_e by 0.48 to 0.54 percent points. The relationships between the lean meat content and other indicators of carcass value were also assessed. The highest correlation coefficient was determined in the ratio of the fat cover area above the *musculus longissimus lumborum et thoracis* (MLLT) to the MLLT area ($r = -0.87$). On the contrary, the lean meat content demonstrated the lowest correlation with the cold carcass weight ($r = -0.25$). Major carcass cuts (ham, loin, shoulder, belly with bones) from the carcasses classified in different SEUROP classes were evaluated. Significant differences between the classes were found in the proportions of cuts without fat cover, fat thickness measured at point "P_2", and fat thickness measured on the midline plane separating the left and right sides of the carcass.

Keywords: pig; dissection; lean meat content; prediction formula; SEUROP; classification

Objective methods of pig carcass classification have been applied in the EU since 1984. The methods of classification used in different member states are laid down by the relevant EU legislation. The classification of pig carcasses is based on the lean meat content predicted on the basis of fat and muscle measurements taken at specific carcass sites. A high correlation to the carcass lean meat content is a fundamental condition for these measurements. The correlation coefficients reported by Branscheid et al. (1987) for fat and muscle thickness measured between the third and fourth from the last rib were $r = -0.846$ and $r = 0.739$, respectively. Somewhat lower coefficients $r = -0.736$ and $r = 0.538$ for fat and muscle thickness, respectively, were found by Lagin et al. (1995). Hulsegge et al. (1994) assessed the accuracy of the lean meat content in carcasses and in major cuts when using multiple site measurements compared with a single site measurement. They analysed 17 measurement sites and evaluated the accuracy of prediction formulae according to s_e. The addition of another measurement to the prediction formulae improved this value by 0.03 to 0.13 percent points. Šprysl et al. (2007) took measurements at six chosen carcass sites using the FOM apparatus. They reported correlations between the lean meat content and muscle and fat measurements taken at different sites.

Regression formulae for the prediction of lean meat content are constructed on the basis of the

Supported by the Ministry of Agriculture of the Czech Republic (Project MZe No. 0002701403).

results from detailed carcass dissections performed in different EU member states. Engel et al. (2003) referred to the adverse effects of incorrect sampling of carcasses used for dissections. The sample of carcasses should be highly representative from the point of view of its size and pig genotype distribution. The regression formulae were also constructed separately for different pig genders (Engel and Walstra, 1993). Similarly, Daumas et al. (1998) established different regression formulae for each gender in France for the apparatuses CGM and Ultra-Meater. Pulkrábek et al. (2004) proposed the regression formulae predicting the lean meat content using the apparatuses FOM, HGP, UFOM-300, and the two-point method for the pig population in the Czech Republic. However, the formula for UFOM-300 reported in this study did not meet the criterion of s_e, which has to be below 2.5.

Other methods of predicting the lean meat content in pig carcasses have also been investigated. The use of the VIA (Video Image Analysis) was described by Sönnichsen et al. (2002). Computer tomography (CT) methods can also be applied for the indirect determination of the carcass lean meat content (Romvári et al., 2006). Another potential indirect method is based on magnetic resonance imaging (MRI) Collewet et al. (2005). Additionally, this method was used for the prediction of lean meat and fat in the ham of pig hybrids (Margeta et al., 2007).

The main objective of the study was to construct basic and improved regression formulae predicting the lean meat content in pig carcasses on the basis of carcass measurements followed by detailed carcass dissections. The measurements required for the construction of basic formulae were taken on the slaughter line by probe and ultrasound classification apparatuses. The formulae with increased prediction accuracy included the following additional carcass characteristics: leg without fat cover proportion of the carcass weight, fat thickness (S_{1-3}), cold carcass weight, and the ratio of the fat cover area above MLLT to the MLLT area. We also aimed to quantify the differences in the overall composition of carcasses with different lean meat content.

MATERIAL AND METHODS

A total of 168 pig carcasses were selected for detailed dissections. The carcasses were sampled at two abattoirs in the Czech Republic.

The sample was stratified on the basis of fat thickness including skin measured with the apparatus HGP on the left carcass side at the site "P_2" between the second and third from the last rib 70 mm off the dorsal midline. The main parameters of the selected set of carcasses are given in Tables 1 and 2.

Due to the fact that the three selected hybrid combinations were not always available, the data set was completed with results obtained from the carcasses of other final hybrids marked as OG.

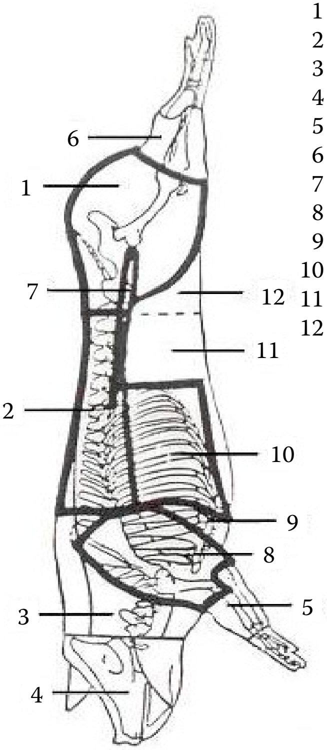
Table 1. Number of carcasses in the groups with different fat thickness (*n* = 168)

Fat thickness (mm)	Gilts	Barrows	Total
<14	30	25	55
14–20	32	27	59
>20	23	31	54
Total	85	83	168

Table 2. Number of carcasses from the animals of different hybrid combinations (*n* = 168)

Hybrid combination	Gilts	Barrows	Total
(CLW × CL) × LW	24	22	46
(CLW × CL) × (LW × PN)	10	11	21
(CLW × CL) × (D × PN)	31	31	62
OG	20	19	39
Total	85	83	168

CLW = Czech Large White; CL = Czech Landrace; LW = Large White; D = Duroc; PN = Pietrain; OG = other genotypes



1 Leg
2 Loin
3 Neck
4 Head + cheek
5 Fornt foot + front shank
6 Hind foot + hind shank
7 Tenderlion
8 Shoulder
9 Jawl
10 Belly
11 Ventral part of belly
12 To ventral part of belly

Figure 1. Scheme of carcass dissection

The ratio of gilts to barrows was 1:1, and the carcass weight recorded up to 45 min *post mortem* ranged from 60 to 120 kg.

All the carcasses were classified using the apparatuses IS-D-05 and IS-D-15. The site of measurement with both apparatuses was at the point "P_2".

The classification apparatus IS-D-05 is a device for measuring lean meat and fat thickness on the basis of the response analysis of the range of ultrasonic impulses which are transmitted in sequence into the carcass at the specified place.

The classification apparatus IS-D-15 is a probe device based on different reflective characteristics of carcass tissues (muscle and fat).

Selected characteristics were recorded for each carcass. Carcass weight was determined by weighing both sides while the other measurements were taken on the left side. The following measurements were taken up to 45 min *post mortem* (on hot carcasses):

– carcass weight (kg)
– fat thickness including skin ($S_{IS\text{-}D\text{-}05}$), measured with the ultrasound apparatus IS-D-05 at P_2 (mm)
– muscle thickness measured with the ultrasound apparatus IS-D-05 at the same site and time (mm)
– fat thickness including skin ($S_{IS\text{-}D\text{-}15}$), measured with the probe apparatus IS-D-15 at P_2 (mm)
– muscle thickness measured with the probe apparatus IS-D-15 at the same site and time (mm)

The following measurements were taken 24 h *post mortem* (on cold carcasses):

– carcass weight (kg)
– left carcass side before dissection
– fat thickness S_1 – thickness of fat including skin, measured with the side calliper in the dorsal midline above the second thoracic vertebrae (mm)
– fat thickness S_2 – thickness of fat including skin, measured with the side calliper in the dorsal midline above the last thoracic vertebrae (mm)
– fat thickness S_3 – thickness of fat including skin, measured with the side calliper in the dorsal midline above the first sacral vertebrae (mm)
– *m. longissimus lumborum et thoracis* (MLLT) area and fat area above MLLT measured planimetrically on the basis of the image analysis at the section between the twelfth and thirteenth rib

The left carcass sides were divided into cuts (Figure 1) according to Scheper and Scholze (1985), and the weight of each cut was recorded. The major cuts (leg, loin, shoulder, belly with bones, fillet) were analysed in detail according to the method described by Walstra and Merkus (1996), and the weights of muscle, intermuscular fat, subcutaneous fat with skin (SF) and bones were determined. The cuts analysed during this simplified dissection are highlighted in bold in Figure 1.

Lean meat content was calculated according to the following formula:

$$Y = C \times 100 \times \frac{\sum_{i=1}^{4} (J_i - SSF_i - IF_i - B_i) + T}{\sum_{i=1}^{12} J_i}$$

where:

Y = lean meat content
C = 1.3 (constant)
J_i = weight of the i-th cut prior to dissection
SSF_i = weight of subcutaneous fat, including skin, of the i-th cut
IF_i = weight of intermuscular fat of the i-th cut
B_i = weight of bones of the i-th cut
T = weight of fillet

Data were analysed using the REG, CORR and MEANS procedures of SAS (SAS, 2001). To construct regression equations, multiple regressions of

Table 3. Basic statistical parameters of the measurements used for the prediction of the lean meat content (n = 168)

Apparatus	Fat and skin thickness (mm)					Muscle depth (mm)				
	$\bar{x}$	x_{min}	x_{max}	median	s	$\bar{x}$	x_{min}	x_{max}	median	s
IS-D-05	14.88	8.40	25.30	13.90	4.006	63.84	46.00	90.70	64.10	7.921
IS-D-15	17.68	9.90	29.40	16.50	4.678	60.86	44.70	84.00	60.30	7.466

the measurements S and M on the lean meat content obtained by dissections were used. Regression coefficients were determined by the least-square means method.

RESULTS AND DISCUSSION

The basic statistical parameters of the measurements taken with the apparatuses IS-D-05 and IS-D-15 are given in Table 3. There is a difference of 2.8 mm between both devices in the average thickness of fat and skin. Similarly, the average value obtained with the IS-D-05 was lower compared to the value from the ultrasound apparatus Ultra-FOM (Pulkrábek et al., 2004). In that study, no differences were found in the results obtained with a probe device and with the IS-D-15.

The following regression formulae were constructed to predict the lean meat content in pig carcasses using the IS-D-05 and IS-D-15:

$$y_{IS\text{-}D\text{-}05} = 60.69798 - 0.89211S_{IS\text{-}D\text{-}05} + 0.10560M_{IS\text{-}D\text{-}05}$$

$R^2 = 0.71$; $r = 0.84$; $s_e = 2.48$

$$y_{IS\text{-}D\text{-}15} = 60.92452 - 0.77248S_{IS\text{-}D\text{-}15} + 0.11329M_{IS\text{-}D\text{-}15}$$

$R^2 = 0.73$; $r = 0.85$; $s_e = 2.41$

where:

$y_{IS\text{-}D\text{-}05}$, $y_{IS\text{-}D\text{-}15}$ = estimate of lean meat (%)
$S_{IS\text{-}D\text{-}05}$, $S_{IS\text{-}D\text{-}15}$ = fat thickness including skin measured at "P_2" (mm)
$M_{IS\text{-}D\text{-}05}$, $M_{IS\text{-}D\text{-}15}$ = muscle depth measured at "P_2" (mm)
R^2 = coefficient of determination
r = correlation coefficient between estimate and dissection
s_e = square root of residual variance

The basic statistical parameters of the lean meat content determined by IS-D-05 and IS-D-15 are shown in Table 4. The average lean meat content of the analysed set determined on the basis of detailed dissections was 54.16% and corresponded to the current average lean meat content of the Czech pig population. This value is, however, somewhat lower than that reported by Václavovský et al. (2002). The reduced lean content was possibly due to the NV animals with unknown hybrid combination included in the analysed set. The carcasses of these animals exhibited a lean meat content averaging about 52%.

It is difficult to achieve the normal distribution of the lean meat content data when the pig carcasses are selected for the experiment. The difference between the mean and median of the lean meat content obtained by dissections was –0.05%. These differences were increased to –1.0% and –1.09 when the lean meat content was estimated by the formulae for IS-D-05 and IS-D-15, respectively. A skew asymmetric distribution of the resulting estimated lean meat content was caused by the used method of estimation. For this reason, the mean is different from the median. In spite of these deviations, the prediction formulae met the required parameters of statistical accuracy.

Table 5 shows the prediction biases (bias = the value predicted by formula minus the value from dissection) for sex and lean meat percentage subsamples. It is apparent that the lean meat content is differently predicted in gilts and barrows as well as in carcasses classified in different SEUROP classes. Such prediction bias gives to barrows an advantage over gilts within the SEUROP classification system. As reported by Stupka et al. (2004), gilts

Table 4. Carcass traits obtained on the basis of dissections and the derived regression formulae (n = 168)

Trait	$\bar{x}$	x_{min}	x_{max}	Median	s
Weight of left side prior to dissection (kg)	45.25	30.73	57.08	45.05	5.672
Lean meat content – dissections (%)	54.16	44.63	62.76	54.21	4.581
Lean meat content – formulae for IS-D-05 (%)	54.16	44.36	60.16	55.16	3.859
Lean meat content – formulae for IS-D-15 (%)	54.16	44.46	60.26	55.25	3.902

Table 5. Prediction bias (in percent points) associated with sex and lean meat content

Formula for apparatus	Sex		Carcass lean meat (%)			
	gilts	barrows	45–50 *R*	50–55 U	55–60 E	60 > S
IS-D-05	–0.284	0.287	1.033	1.123	–0.737	–2.768
IS-D-15	–0.278	0.282	0.946	1.087	–0.668	–2.706

Table 6. Prediction bias (in percent points) associated with fat thickness in P_2 (mm)

Formula for apparatus	Fat thickness (mm)		
	< 14	14–20	20>
IS-D-05	–0.618	0.454	0.254
IS-D-15	–0.550	0.489	0.116

exhibited lower growth traits but markedly better carcass traits than barrows in the test of growth performance and carcass value of final hybrids. In addition, significant sex differences in other carcass traits and in the composition of the belly were also described (Stupka et al., 2004; Vališ et al., 2005).

The proposed formulae slightly overpredict the lean meat content in the carcasses graded in lower quality classes, while the opposite tendency can be seen in higher quality classes. Generally, such differences are eliminated in large pig groups.

The effect of sex on the lean meat content predicted according to European standards is also relatively eliminated mainly due to the selection of pigs for dissections. Under conditions in practice, the ratio of fattened gilts and barrows is 1:1, and the prediction error is therefore corrected. Such an approach is applied in most EU countries. Another method is the construction of two separate formulae for gilts and barrows (Engel and Walstra, 1993; Daumas et al., 1998). A similar approach was applied to predict the lean meat content in pig carcasses in the Netherlands when different formulae were established for gilts, barrows, and boars (Engel et al., 2005).

The prediction bias for fat thickness subgroups is indicated in Table 6. The bias is more evident for the carcasses with fat thickness less than 14 mm. Due to a high correlation between this measurement and the carcass lean meat content, the bias has a similar tendency to that associated with different lean meat percentage classes ranging from S (60%>) to *R* (45–50%), described in Table 5.

The prediction bias associated with the cold carcass weight is given in Table 7. The lowest bias was observed for a carcass weight of about 95 kg. This is demonstrated by the values for IS-D-15 which are –0.26 and +0.26 percent points for the carcass weight intervals of 85 to 95 kg and 95 to 105 kg, respectively. On the contrary, the bias is more pronounced for a carcass weight higher than 105 kg. Animals falling into this group have a higher proportion of subcutaneous fat, which increases particularly in the final fattening stage (Demo et al., 1995).

In an effort to increase the prediction accuracy of regression formulae, we have been searching for some additional carcass measurements. On the basis of the correlations between the lean meat content obtained by dissections and carcass measurements (Table 8), the following measurements were included in formulae: proportion of the leg without fat cover, fat thickness S_{1-3}, cold carcass weight, and the ratio of the fat cover area above MLLT to the MLLT area at the section between the twelfth and thirteenth rib.

The following improved regression formulae were established using the regression analysis:

Table 7. Prediction bias (in percent points) associated with carcass weight (kg)

Formula for apparatus	Carcass weight (kg)			
	< 85	85–95	95–105	105>
IS-D-05	–0.298	–0.271	0.389	0.643
IS-D-15	–0.215	–0.256	0.263	0.648

Table 8. Correlations between the carcass lean meat content determined by dissections and selected carcass value traits (n = 168)

Trait	r
Fat thickness including skin(IS-D-05)	–0.82
Muscle depth (IS-D-05)	0.37
Lean meat content (IS-D-05)	0.84
Fat thickness including skin (IS-D-15)	–0.83
Muscle depth (IS-D-15)	0.37
Lean meat content (IS-D-15)	0.85
Cold carcass weight	–0.25
Ratio of the fat cover area above MLLT to the MLLT area	–0.87
Leg proportion of the carcass weight	0.60
Fat thickness (S_1–S_3)	–0.76

$$y_{IS\text{-}D\text{-}05} = 45.25284 - 0.20347S_{IS\text{-}D\text{-}05} + 0.08205M_{IS\text{-}D\text{-}05} - 0.00185CW - 15.36405MLLT + 0.66310HAM - 0.12775S_{1-3}$$

R^2 = 0.83; r = 0.91; s_e = 1.94

$$y_{IS\text{-}D\text{-}15} = 45.25440 - 0.18669S_{IS\text{-}D\text{-}15} + 0.09266M_{IS\text{-}D\text{-}15} - 0.00378CW - 15.30253MLLT + 0.65025HAM - 0.11445S_{1-3}$$

R^2 = 0.83; r = 0.91; s_e = 1.93

where:

$y_{IS\text{-}D\text{-}05}$, $y_{IS\text{-}D\text{-}15}$ = estimate of lean meat (%)
$S_{IS\text{-}D\text{-}05}$, $S_{IS\text{-}D\text{-}15}$ = fat thickness including skin measured at P_2 (mm)
$M_{IS\text{-}D\text{-}05}$, $M_{IS\text{-}D\text{-}15}$ = muscle depth measured at P_2 (mm)
CW = cold carcass weight (kg)
MLLT = ratio of the fat cover area above MLLT to the MLLT area
HAM = proportion of the leg without fat cover of the carcass weight (%)
S_{1-3} = average of fat thickness measurements S_1, S_2, S_3 (mm)
R^2 = coefficient of determination
r = correlation coefficient between prediction and dissection
s_e = square root of residual variance

Based on the values of R^2, r, and s_e, it is evident that the inclusion of additional parameters improved the predictive ability of both regression formulae. Compared to the original formulae, s_e was especially reduced by 0.54 and 0.48 percent points for IS-D-05 and IS-D-15, respectively. Similarly to our study, different measurement sites were investigated by Hulsegge et al. (1994). They also established a formula with a higher predictive ability when using additional measurements highly correlated with the carcass lean meat content.

It would be difficult to apply the proposed improved formulae under practical conditions in an abattoir due to the fact that some of the measurements used are not easy to obtain. Only carcass weight and fat thickness S_{1-3} are directly measurable in the slaughterline. Therefore, the practical application of the proposed formulae is feasible only for experimental purposes and special tests of carcass value, e.g. in pig final hybrids.

The formulae for different classification apparatuses can be approved only when a certain accuracy of the prediction is achieved. The residual standard deviation (s_e), calculated as the square root of the residual variance, must be below 2.5. In addition, the coefficient of determination must be above 0.64, which means that the correlation coefficient (r) of the relationship between the lean meat content predicted by formulae and by dissection must be at least 0.8. All the above mentioned formulae (both standard and improved ones) meet these statistical criteria.

The observed s_e for the formula IS-D-15 is lower compared to the formula FOM (s_e = 2.49) as reported by Pulkrábek et al. (2004). In the same study, the lowest s_e was found for the apparatus HGP (s_e = 2.27), while the ultrasound apparatus UFOM did not fulfil the statistical criteria (s_e = 3.26).

The prediction formula for the apparatus FOM (s_e = 2.13) was established by Desmoulin et al. (1986). The required statistical criteria were met by the prediction formulae mostly based on the measurements taken at the P_2 site (Walstra, 1991;

Demo et al., 1995; Lagin et al., 1995). Pomar et al. (2001) compared the prediction accuracy in four different classification apparatuses, with s_e = 2.14 in the most accurate one.

Table 8 describes the relationships between the carcass lean meat content determined by dissections and the other carcass value traits. A high correlation (*r* = –0.87) was observed for the ratio of the fat cover area above MLLT to the MLLT area as well as for the S measurements obtained with IS-D-05 and IS-D-15 (*r* = –0.82 and *r* = –0.83, respectively). A somewhat lower correlation was found for the average fat thickness S_{1-3} (*r* = –0.76). Generally, fat thickness considerably increases the predictive ability of regression formulae. These measurements are more correlated to the carcass lean meat content than to the muscle depth (Küchenmeister, 1985; Branscheid et al., 1987).

The correlation coefficient between the muscle depth (M) and the carcass lean meat content was *r* = 0.37 for both apparatuses. Cold carcass weight (*r* = 0.25) was the parameter entering the improved regression formulae with the lowest correlation coefficient. This trait is however easily obtainable. The proportion of leg of the carcass weight (*r* = 0.60) can also be used to increase the predictive ability of the formulae, but the value of this trait is available only after dividing the carcass into primal cuts.

CONCLUSIONS

As the calculated values of s_e were 2.48 and 2.41 percentage points for IS-D-05 and IS-D-15, respectively, and the required accuracy criteria were thus met, the basic formulae for the lean meat content prediction based on the fat and muscle thickness measurements at point "P_2" are applicable for pig carcass classification in abattoirs in the Czech Republic. Additional measurements are necessary for the use of regression formulae with an improved predictive ability (s_e 1.94 and 1.93 for IS-D-05 and IS-D-15, respectively). Therefore, they can be applied only for special tests of the pig carcass value and not in ordinary abattoirs.

REFERENCES

Branscheid W., Komender P., Oster A., Sack E., Fewson D. (1987): Untersuchungen über die Eignung einzelner Schlachtkörpermasse und Messstellenkombinationen für die Klassifizierung von Schweinehälften nach dem Muskelfleischanteil. Züchtungskunde, 59, 258–267.

Collevet G., Bogner P., Allen P., Busk H., Dobrowolski A., Olsen E., Davenel A. (2005): Determination of the lean meat percentage of pig carcasses using magnetic resonance imaging. Meat Sci., 70, 563–572.

Demo P., Poltársky J. (1994): Predikcia podielu mäsových častí ošípaných s využitím niektorých mier jatočného tela. Živoč. Výr., 39, 275–284.

Demo P., Poltársky J., Fülöp L., Lukáčová A. (1995): Instrumental prediction of some carcass parameters of pigs at a progeny testing station. Živoč. Výr., 40, 181–185. (in Czech)

Daumas G., Causer D., Dhorne T., Schollhammer E. (1998): Les méthodes de classement des carcasses de porc autorisées en France en 1997. Journées Recherche Porcine en France, 30, 1–6.

Desmoulin B., Ecolan P., Peinian P., Mulani C. (1986): Pig carcass classification according to lean percentage. Possibilities and limitations of the Danish Fat – O – Meater. Pig News, 7, 58 pp.

Engel B., Walstra P. (1993): Accounting for subpopulations in prediction of the proportion of lean meat of pig carcasses. Anim. Prod., 57, 147–152.

Engel B., Buist W.G., Walstra P., Olsen E., Daumas G. (2003): Accuracy of prediction of percentage lean meat and authorization of carcass measurement instruments: adverse effects of incorrect sampling of carcasses in pig classification. Anim. Sci., 76, 199–209.

Engel B., Buist W., Lambooij B. (2005): Results Dutch dissection experiment for HGP and Vision. Animal Sciences Group, Wageningen Unpublished document UR, Lelystad, Netherlands, 1–13 pp.

Hulsegge B., Sterrenburg P., Merkus G.S.M. (1994): Prediction of lean meat proportion in pig carcasses and in the major cuts from multiple measurements made with the Hennessy Grading Probe. Anim. Prod., 59, 119–123.

Küchenmeister U., Ender K. (1985): The measurement sites and apparatuses for the classification of pig carcasses. Živoč. Výr., 30, 733–741. (in Czech)

Lagin L., Benczová E., Chudý J., Pavlič M. (1995): Objective approach to slaughter pig classification in the Slovak Republic. Živoč. Výr., 40, 369–373. (in Czech)

Margeta V., Kralik G., Kušec G., Baulain U. (2007): Lean and fat development in the whole body and hams of hybrid pigs studied by magnetic resonance tomography. Czech J. Anim. Sci., 52, 130–137.

Pomar C., Fortin A., Marcoux M. (2001): Estimation du rendement boucher et de la teneur en viande maigre (TVM) des carcasses de porc à l' aide de différentes méthodologies de mesure de l' épaisser de gras et du muscle dorsal. Journées Recherche Porcine en France, 33, 71–77.

Pulkrábek J., Fiedler J., Smital J., Houška L., Adamec T. (1994): Tissue percentages in the side of pork of pig breeds raised in the Czech Republic. Živoč. Výr., 39, 743–751. (in Czech)

Pulkrábek J., Wolf J., Vališ L., Vítek M., Höreth R. (2004): Vergleich verschiedener Methoden zur Bestimmung des Muskelfleischanteils im Schlachtkörper des Schweins. Züchtungskunde, 76, 6–17.

Romvári R., Dobrowolski A., Repa I., Allen P., Olsen E., Szabo A., Horn P. (2006): Development of a computed tomographic calibration method for the determination of lean meat content in pig carcasses. Acta Vet. Hung., 54, 1–10.

SAS (2001): Release 8.2 (TS2MO) of the SAS® System for Microsoft® Windows®. SAS Institute Inc., Cary, NC, USA.

Scheper J., Scholz W. (1985): DLG-Schnittführung für die Zerlegung der Schlachtkörper von Rind, Kalb und Schwein. DLG-Verlag, Frankfurt/M, Germany.

Sönnichsen M., Dobrowolski A., Höreth R., Branscheid W. (2002): Videobildauswertung an Schweinehälften. Fleischwirtschaft, 82, 98–101.

Stupka R., Šprysl M., Pour M. (2004): Analysis of the formation of the belly in relation to sex. Czech J. Anim. Sci., 49, 64–70.

Šprysl M., Čítek J., Stupka R., Vališ L., Vítek M. (2007): The accuracy of FOM instrument used in on-line pig carcass classification in the Czech Republic. Czech J. Anim. Sci., 52, 149–158.

Václavovský J., Matoušek V., Kernerová N., Kouglová P., Nýdl V., Novotný F. (2002): Prediction of lean content in breeding pigs by *in vivo* and *post mortem* methods. Czech J. Anim. Sci., 47, 476–483.

Vališ L., Pulkrábek J., Pavlík J., Vítek M., Wolf J. (2005): Conformation and meatiness of pork belly. Czech J. Anim. Sci., 50, 116–121.

Walstra P. (1991): Definitions and conversion factors for carcasses, cuts and lean tissue. Research Institute for Animal Production Schoonoord, Netherlands.

Walstra P., Merkus G.S.M. (1996): Procedure for assessment of the lean meat percentage as a consequence of the new EU reference dissection method in pig carcass classification. Zeist, 1–22.

Received: 2007–08–14
Accepted after corrections: 2008–01–07

Corresponding Author

Ing. Martin Vítek, Institute of Animal Science, Přátelství 815, 104 00 Prague-Uhříněves, Czech Republic
Tel. +420 267 009 575, fax +420 267 710 779, e-mail: vitek.martin@vuzv.cz