DEVELOPMENT OF ZP METHOD FOR SEUROP PIG CARCASS GRADING IN POLAND*

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Abstract

In the present study, ZP method for lean meat content (LMC) evaluation in pig carcasses was tested. The experiment was carried out on 141 pigs selected from animals delivered for slaughter to the SKIBA S.A. meat plant located in Chojnice. The selected pigs originated from three country regions, and differed in respect of subcutaneous fat thickness (7–32 mm), carcass weight (60–120 kg) and sex (50% gilts and 50% castrated males). The main result of the study was a rectilinear regression equation for lean meat content assessment. Two linear measurements were used in the equation, i.e. backfat thickness measured on sacral vertebra and thickness of the muscle layer located between the beginning of the cross section of *gluteus medius* and back edge of the spinal cord. The evaluation error RMSEP was 2.33% and did not exceed the limit defined in EU regulations. Based on the Commission Decision 2011/506/EU the ZP method was approved to be used for pig carcass grading in Poland. A special measuring template was developed for the industrial use of the ZP method.

Key words: pig carcasses, lean meat content evaluation, the ZP method

Since the first electronic equipment for carcass classification was developed, a constant search for more precise and more efficient classification devices has taken place. The Danish optical-needle MFA-Recorder introduced in 1973 followed by the German SKG robot in 1980 were very soon replaced by greater quality devices (Borzuta, 1998; Dobrowolski et al., 1993). Almost at the same time, in 1982, the New Zealand Hennessy HGP and Danish Fat-o-Meater, two of the most popular optical-needle devices in the world, were constructed (Kempster et al., 1985). Further work on improving devices led to different optical-needle tools like the German PG-200 probe (Branscheid et al., 1990), the Canadian Destron probe (Fortin, 1989),

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the French Sydel probe (Daumas et al., 1998) and the Polish IM-03 probe (Lisiak et al., 2006). Ultrasound devices were constructed slightly later. In 1990 two German ultrasound probes were developed: the US-Porkitron and Ultra-Meater (Branscheid et al., 1991). In 1991 the Danish company SFK-Technology (now Carometec A/S) constructed the Ultra-Fom 100 which was improved in 1998 and used in the meat industry under the name Ultra-Fom 300 (Blicharski et al., 2002). The fully automatic Auto-Fom constructed in 1996 by the same Danish company was considered as a significant achievement (Brøndum and Jensen, 1996). Almost all of the carcass grading devices described above have one thing in common, i.e. their functioning is based on the measurements of backfat and *longissimus dorsi* thickness taken on the carcasses on layers of fat and muscle which are not visible to the naked eye. These linear measurements are taken indirectly using either the difference in fat and muscle colour (optical-needle devices) or differential tissue response to ultrasound waves (ultrasound devices). Both indirect measuring techniques are burdened with errors that may occur because of different reasons, e.g. little difference in fat and muscle colour observed in meat with the PSE defect or when ultrasound waves rebound from connective tissue membrane in fat when a probe has not been fitted tightly to the measurement point. The search for direct carcass grading methods, visible with the naked eye, led to the development of the linear method called ZP (Zwei Punkten Methode) in Germany. In this method the regression equation includes measurements of backfat thickness taken over sacral vertebra and thickness of the lumbar and gluteal muscle layer at the level of *m. gluteus medius* (Borzuta, 1998). Studies showed that the reproducibility and repeatability of the method is comparable to ultrasound optical probe devices (Olsen et al., 2007). The ZP method was officially recognized in Austria in 1994 as the only method used for pig carcass grading according to the EUROP system because its estimation error was within the limit ($RMSEP < 2.5\%$) required by the EU Commission Regulation no 1249/2008. The ZP method had been used slightly earlier in German slaughterhouses with low slaughter capacity (Dobrowolski et al., 1993). A modified version of the ZP was used in Poland before EU accession (Borzuta, 1998) but at that time it did not fulfil EU requirements ($RSD = 2.93\%$) because of the too great value of variability of carcass lean meat content ($47.79 \pm 5.25\%$). After almost a 10-year break, ZP method is reconsidered for use in Poland since the average lean meat content in a population of commercial pig increased from 50.3% to 55% and also decreased the variability (Lisiak et al., 2012). Due to change in pig population it was possible to check if the ZP method might be used for pig carcass grading in Poland again. The aim of the research was to develop a regression equation for lean meat content evaluation using the linear measurements of backfat and muscle thickness visible on the carcass split-line at the ham level.

Material and methods

The experiment was carried out in 2010 on 141 pigs selected from animals delivered to the SKIBA S.A. meat plant located in Chojnice. The selected pigs originated

from three regions of Poland (Table 1) and belonged to five different groups in terms of fat thickness (7–32 mm). Warm carcass weight ranged between 60 and 120 kg and the distribution by sex was about 50% gilts and 50% surgically castrated males.

Table 1. Number of pigs from particular regions of Poland with different backfat thickness groups, selected for the test

Region	<15 mm	15–20 mm	21–25 mm	26–30 mm	>30 mm	Total
Western	5	17	13	10	3	48
Central	5	14	17	8	5	49
Eastern	4	11	20	6	3	44
Total	14	42	50	24	11	141

The pigs were transported to the slaughterhouse by livestock lorries and were slaughtered after a few hours of lairage. Only evenly cut carcasses without visible veterinary confiscations were chosen for the experiment. After tagging, the still warm, left carcasses were the subject of linear measurements taken with a ruler (with a precision of 1 mm). Backfat thickness (F) was measured over sacral vertebra (the thinnest backfat layer over the *m. gluteus medius*) and thickness of the lumbar and the gluteal muscle layer (M) located between the spinal cord and beginning of the *m. gluteus medius*. After cooling, the left carcasses were dissected according to the EU reference method (Commission Regulation no 1249/2008). Four primal cuts, i.e. shoulder, loin, belly and ham are analysed in this method. The lean meat content LMC (%) of whole carcass was calculated according to the following equation:

$$LMC = 0.89 * 100 * \frac{\text{weight of tenderloin} + \text{weight of lean meat in 4 cuts}}{\text{weight of tenderloin} + \text{weight of dissected cuts}}$$

The cuts and dissected elements weight were measured on a legalized electronic scale measuring up to 15 kg with a 1 g precision. The regression equation for the tested device was developed using the PLS (Partial Least Squares) procedure (as in the case of the other devices tested in Poland – Lisiak et al., 2012), which is permitted for use by EU regulations (Causeur et al., 2003). The PLS was used because we wanted to ensure that all the equations were obtained by the same method as other equipment used in Poland. The assumption of this method is that the prediction error is minimized by using functions and predictors, which explain the variability in the sample and linear model of regression in the most comprehensive way. The estimation accuracy was rated using the RMSEP (root mean square error of prediction) indicator calculated with the PRESS statistic, which complies with cross-validation (SAS V. 9.2). Regression equations were estimated without considering outliers. Removed observations were read errors of measuring devices or incorrectly entered values into the dataset. RMSEP were estimated including outliers because they explained the real data error.

Results

Regression analysis was used to develop an equation for the prediction of lean meat content (LMC) in pig carcasses using the ZP method. However, during the calculation it was necessary to separate all outlying values. Outliers were identified in the data set and then eliminated and based on the analysis of the following plots: histogram of residuals plot, scatter plot of studentized residuals by predicted values, scatter plot of observed vs. predicted values, needle plot of Cook's D statistic by observation number, standard Q-Q plot of residuals. The equation obtained was as follows:

$$LMC_{ZP} = 52.61 - 0.6148 F + 0.1842 M \quad (n=138)$$

$$RMSEP = 2.48 \text{ (with outliers, } n=141)$$

$$RMSEP = 2.33 \text{ (without outliers, } n = 138)$$

where:

M – muscle thickness in a defined point of measurement (mm),

F – backfat thickness in a defined point of measurement (mm).

A total of 138 carcasses were analysed whereas 3 carcasses were removed as outliers. Average of lean meat content from dissection compared to lean meat content evaluated with the ZP method did not show any differences (Table 2).

Table 2. Descriptive statistics of linear measurements and meat content evaluated by dissection and estimated using the ZP method

Traits	N	Mean	Minimum	Maximum	Standard deviation
Carcass weight (kg)	138	88.59	67.20	119.20	10.330
LMC dissection (%)	138	55.02	44.29	65.07	4.123
LMC ZP (%)	138	55.02	44.55	61.39	3.433
Backfat thickness (mm)	138	16.21	7.00	32.00	4.928
Muscle thickness (mm)	138	67.16	53.00	85.00	6.725

Correlation coefficients between lean meat content evaluated using the dissection method and linear measurements of backfat thickness measured over sacral vertebra as well as the thickness of the lumbar and gluteal muscle layer were statistically significant ($P < 0.01$) and reached $r = -0.78$ and $r = 0.41$, respectively. Statistically highly significant ($P < 0.001$) was the correlation coefficient ($r = 0.84$) between LMC evaluated with the dissection method and LMC evaluated using the ZP regression equation. The evaluation error, RMSEP, was 2.33% (2.48% with included outliers) and did not exceed the limit defined in EU regulations, i.e. 2.50%. Quite a high correlation between dissected LMC and LMC evaluated with the ZP method is shown in Figure 1A. However, a cloud of points without a clear increasing or decreasing tendency of residual variance, shown in Figure 1B, proved that the random element variance has been stable (homoscedasticity) as assumed (Stanisz, 2000). For practical use a special template was developed in order to grade pig carcasses in the SEUROP

system without calculations (Figure 2). After taking measurements of backfat and muscle thickness, the carcass grade can be found on the intersection of both values in the template. The ZP method is an inexpensive way for pig carcass grading to be used by small slaughterhouses. According to EU regulations the ZP method might be used in Poland in slaughterhouses with a maximum capacity of 40 pigs slaughtered per hour (Commission Decision 2011/506/EU).

Figure 1. Correlation (A) and scatter plot of the residuals (B) representing differences between lean meat content (LMC) of carcass evaluated by dissection (dis.) and estimated with ZP method

Figure 2. Template to grade pig carcasses for ZP method in SEUROP system (fat thickness – horizontal line, muscle thickness – vertical line)

Discussion

The research proved that the linear method of lean meat content evaluation turned out to be an interesting alternative to the methods based on ultrasound measurements or optical-needle devices. Lean meat coefficients (measurements) used in the regression equations of both systems differ significantly. In optical-needle and ultrasound devices these coefficients are backfat and *longissimus dorsi* thickness whereas in the ZP method the LMC evaluation is based on similar measurements taken on lumbar and sacral carcass parts. Instead of the LD muscle, in the ZP method the muscle layer would be equivalent to an end part of *m. longissimus lumborum* but measured in the front part of *m. gluteus medius*. The value of the simple correlation indexes between lean meat and measurements is similar in both methods. Research done by many scientists has proved that measurements of backfat thickness in point C, measured on the prolongation line of the loin eye highness, behind the last rib at 7 cm from the carcass midline, as well as backfat thickness measured on sacral vertebra have the greatest relationship with carcass lean meat content (Borzuta, 1998). Correlation coefficients for both indicators, e.g. point C and point ZP are usually at the level of approximately -0.8 . Blicharski et al. (2003) as well as Borzuta et al. (2004) obtained

$r = -0.83$. Blicharski et al. (2002) reported $r = -0.84$. Backfat thickness measured on sacral vertebra was also highly correlated with LMC, just like the measurement taken in point C, which was confirmed by Borzuta (1998), $r = -0.8$ and also by Wajda and Daszkiewicz (1997), $r = -0.75$. A similar correlation between lean meat content and muscle thickness was observed in both methods. Behind last rib, LD muscle thickness is correlated with lean meat at $r = 0.48$ according to Winarski et al. (2004). According to Borzuta (1998) this correlation also reached $r = 0.48$ and according to Blicharski et al. (2003) $r = 0.53$. In the ZP method the correlation of lumbar and gluteal muscles thickness with lean meat content was similar as described above, e.g. according to Borzuta (1998) $r = 0.46$.

Correlations found in this research allow the development of a regression equation which includes measurements visible with the naked eye without need for special equipment. However, this method is slightly less accurate than methods using different devices. This fact has been confirmed by slightly greater RMSEP values for the ZP method. When testing different devices on the same group of carcasses in Poland in 2011 the following evaluation errors RMSEP were reported (Lisiak et al., 2012): Ultra-Fom 300 – 2.07%, IM-03 – 1.89%, CGM – 2.16%, Fat-o-Meater II – 2.18%. As can be seen evaluation errors were lower than the ZP method error (2.33%) obtained in this research. Research carried out by other scientists has also confirmed this fact. Engel et al. (2012) found the following RMSEP errors of different devices: HGP7 – 2.10%, CGM – 2.20%. Font-i-Furnols and Gispert (2009) proved a 1.8% RMSEP error for the Fat-o-Meater, 2.3% for Ultra Fom 300, 1.9% for Auto Fom and 2.3% for VCS 2000. Canadian research proved even lower RMSEP values, i.e. 1.56% for HGP2, 1.7% for Ultra Fom 300, 1.68% for Auto-Fom and 1.57% for an American ultrasound device called CVT-2. RMSEP error values determined for the ZP method were slightly greater reaching 2.52% in Germany, 2.38% in Sweden, 2.45% for gilts and 2.49% for castrated males in France (Daumas and Dhorne, 1998). Regardless of the differences found in RMSEP values the ZP method still represents a legal and acceptable RMSEP value below 2.5% that is within the EU allowed limit. The correlation coefficients between lean meat estimated with ZP and other methods, determined at testing research performed in Poland, were as follows (own testing research, 2011): Fat-o-Meater II $r = 0.74$, Ultra Fom 300 $r = 0.78$, IM-03 $r = 0.76$ and CGM $r = 0.66$. The ZP method indicators were used in constructing automatic devices like the CSB-Image Meater with 2.02% RMSEP reported by Engel et al. (2012) as well as VCS 2000 with 2.3% RMSEP reported by Font-i-Furnols and Gispert (2009). The ZP method can be used as a classification method in 9 member states since it has approved equations.

Some interesting data emerged when the differences in the amount of meat obtained from carcasses of different sex, using dissection or ZP method, were compared (Table 3). BIAS for gilt and castrate carcasses reached -0.38 and 0.37 , respectively. The total difference between the lean meat content evaluated on carcasses of two sexes was 0.75 pp (percentage point). The commonly observed sex bias can partially be explained by an error in measurement of the fat and muscle thickness, which had been shown in the research of Schinckel et al. (2007). The obtained results proved that use of the two different regression equations for the evaluation of lean

meat content in gilt and castrate carcasses, applied in some countries, e.g. France, was justified (Daumas et al., 1998). But the difficulties in determining the gender of the carcasses and also low sex effect (Engel et al., 2012) were the main reason to quit using this method. The influence of the gender on lean meat evaluation results was too low when compared to RMSEP evaluation error of different devices.

Table 3. Average linear measurements and meat content evaluated by dissection and estimated using the ZP method for gilt and hog carcasses

Traits	Gilt carcasses		Hog carcasses	
	mean	standard deviation	mean	standard deviation
n	69		72	
LMC dissection (%)	55.85	4.00	54.23	4.11
LMC ZP (%)	55.47	3.32	54.60	3.51
LMC, sex bias (%)	-0.38		0.37	
Backfat thickness (mm)	15.88	4.75	16.52	5.11
Muscle thickness (mm)	68.48	6.43	65.92	6.81

As a summary, the obtained results proved that the linear measurement method called ZP fulfils the requirements of EU regulations also in Polish conditions. The rectilinear regression equation has been developed. Two linear measurements were used in the equation, i.e. backfat thickness measured on sacral vertebra and thickness of the muscle layer located between the beginning of the cross section of the *gluteus medius* and back edge of the spinal cord. The evaluation error RMSEP was 2.33% and did not exceed the limit defined in EU regulations (Commission Regulation no 1249/2008). Based on Commission Decision no 2011/506/EU the ZP method was approved to be used for pig carcass grading in Poland. A special measuring template was developed for the industrial use of the ZP method.

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