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SUMMARY

The experiment was performed on 144 pig carcasses selected on the basis of backfat measures obtained by "ZP"-method. There was no stratification according to the carcass weight. One day after slaughter the carcasses were dissected by to EU reference method. The lean share was calculated by equation prescribed by European regulation (Commission Regulation No 3127/94) and estimated by six equations. The first one (MP1) is prescribed by current Croatian regulation (N.N. 119/1999) and the other five were developed on the basis of original data obtained by the experiment. The meat percentage estimated by equation MP1 differed statistically (p<0.01) from mean meat percentage obtained by EU referent method; the current formula significantly overestimates the meatiness of pig carcasses from Croatian population. Original measures of fat and muscle measured for "ZP"- method were used as independent variables in equation MP6. In order to improve the accuracy of estimation, transformed variables were used in equations MP2-MP5. Additional measure of warm carcass weight (T) was included as an independent variable to equations MP4 and MP5 but this did not improve their accuracy. Equation MP2 to MP5 satisfy the statistical criterion requested by EU regulations. The equation MP2 and MP5 can be recommended for lean share estimation in pig carcasses of Croatian pig population.

Key-words: swine, carcass, lean share, estimation, equations

INTRODUCTION

Current Croatian regulation enacts, besides the instrumental, a manual method for estimation of lean share in pig carcasses called the "ZP" (two points) method. Equation which should be used in this method is also prescribed by Croatian regulation. However, the coefficients used in equation are dependent on mean lean share, and after a two years time period or after a significant alteration in pig population, they should be checked (Commission Regulation No 2967/85). In order to establish the most accurate mathematical expression for lean share estimation, it is necessary to conduct a comprehensive dissection experiment. The criteria for sample size and accuracy of assessment are also prescribed by EU regulations (Commission Regulation No 2967/85). For the purpose of adjusting an old or establishing a new equation for meat share assessment, new European regulations (Commission Regulation No 3127/94, Walstra and Merkus, 1995) introduced a simplified dissection method by which the lean share of pig carcasses can be objectively determined. Usage of classical statistical methods requires a total dissection of at least 120 pig carcasses by EU referent method. The other approach of obtaining the equations for lean share estimation is double regression based on complete dissection of at least 50 carcasses and twice as much partial dissections (Conniffe and Moran, 1972). In both of these approaches root mean square error has to be less than 2.5. Malovrh *et al.* (2001) used double regression approach for developing of new equations for instrumental on-line lean share estimation and verifying the coefficients for "ZP"-method.

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Since this is the first time in Croatia that the equation for “ZP”-method is verified by EU referent dissection, the classic statistical admission was used in the investigation.
The aim of this paper is to introduce the equations for “ZP”-method that can be applied at Croatian slaughterhouses.

MATERIAL AND METHODS

The research was performed on 144 swine carcasses selected in accordance with backfat measures obtained by “ZP”- method, approved in Croatia (NN. 119/1999). There was no stratification according to the carcass weight.
Pigs were slaughtered in several Croatian slaughterhouses. One day after slaughter right sides of the carcasses were dissected using an EU referent method. Four main parts (ham, shoulder, loin and ribs) were dissected into muscles, bones, intramuscular and subcutaneous fat with skin. The tender loin was taken into calculation as a separate part.
Share of meat was calculated by equation from Commission Regulation (EC) No 3127/94:

$$\text{EU\_ref (\%)*} = 1.3 \times 100 \times \frac{\text{weight of tender loin + weight of lean (fascia included) in shoulder, loin, ham and belly}}{\text{weight of tender loin + weight of dissected cuts + weight of remaining cuts}}$$

* Referent lean meat percentage

Meat yield calculated by EU_ref equation was accepted as an objective indicator in further analyses and comparisons.
The lean meat percentage in pig carcasses was estimated by six equations. The first equation is prescribed by the Croatian regulation (No 119/1999) and the other five were developed on the basis of original data.
Measures necessary for obtaining the variables by “ZP”-method were: lumbar muscle thickness – Mdt (mm); measured as the shortest connection between the cranial end of the lumbar muscle and dorsal edge of the vertebral canal, and fat thickness – Sdt (mm), measured as the minimum thickness of subcutaneous fat (with skin) at the split of the carcass, above *m. gluteus medius.*
Results of lean meat yield determination by EU-referent method (EU-ref) and by equations (MP1, MP2, MP3, MP4, MP5 and MP6) were processed and compared. Differences and determination coefficients between meat percentages were calculated.
The obtained data were statistically processed by GLM procedures of SAS program package, version 9.0 (SAS Ins. Inc., 2002).

RESULTS AND DISCUSSION

Distributions of fat thickness (Sdt) and muscle thickness (Mdt) measured manually are presented in Fig. 1. It can be observed that the fat thickness of 53% of pig carcasses from Croatian pig population was between 12 and 20 mm and the muscle thickness was between 70 and 74 mm respectively. The distribution curve for Sdt measure shows a slight deflection from the normal curve to the left, whereas the curve for Mdt measure shows a slight deflection to the right.

a) b)

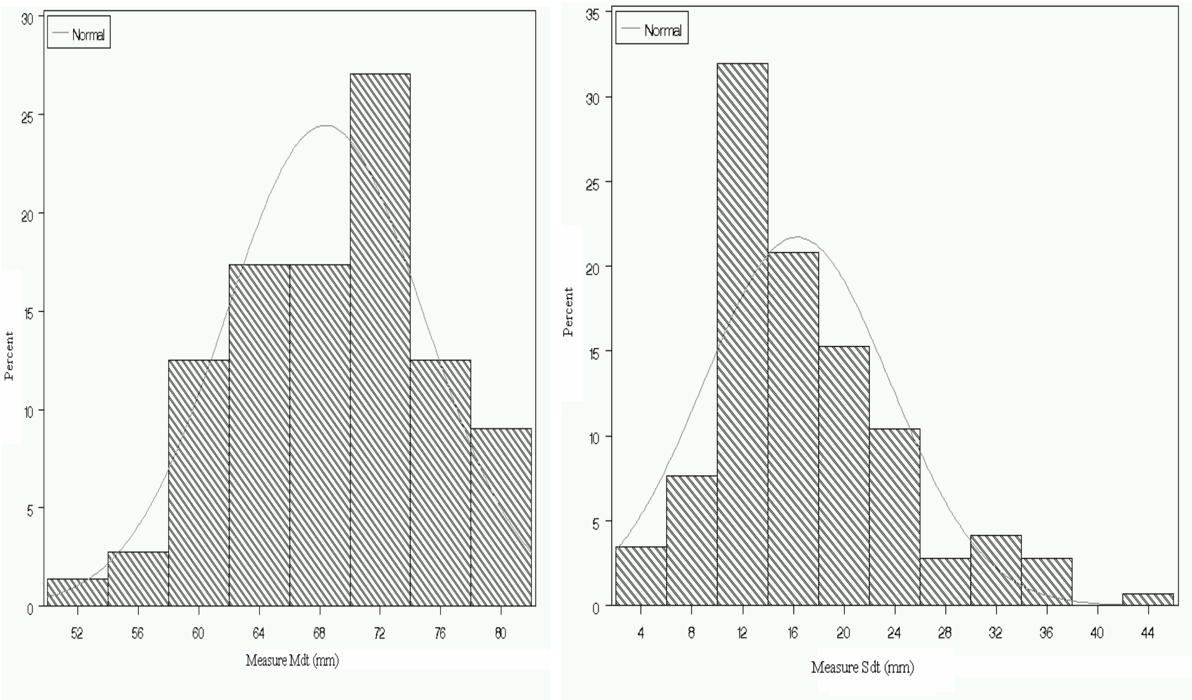

Figure 1. Distribution of muscle thickness (a) and fat thickness (b) measured by "ZP"-method (N=144)

On figure 2 it can be observed that the majority of swine carcasses had lean meat share between 49 and 53%. The distribution of meat percentage maches the normal curve.

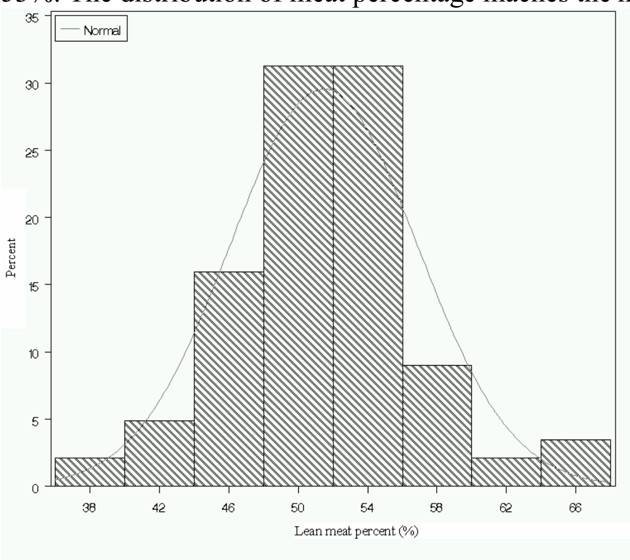

Figure 2. Distribution of meat share objectively determined by EU-referent method (N=144)

Table 1 shows evaluated equations for meat yield estimation. The first equation (MP1) presents the current equation for "ZP"-method prescribed by the Croatian regulation, whereas the other five were developed according to original data from dissection experiment. The dissection trial was conducted on 144 primarily processed swine carcasses, which were also evaluated by the equation prescribed by the Croatian Regulation. During the construction of original equations (MP2-MP6), outliers were detected by robust estimation method (Thorne, 1999) and removed from further analysis; final number of carcasses remained for evaluation was 134. Measures of muscle (Mdt) and fat (Sdt) thickness on original and transformed scales were taken as independent variables in meat percentage estimation formulae; the dependent variable was meat percentage objectively determined by EU-referent method. In equations MP4 and MP5 the warm carcass weight (T) was included as am independent variable, but this influence was not indicated as significant in statistical analysis. Also, measuring the weight of the carcasses at slaughter-line is time consuming and in the case of inaccuracy of the weighing device, can lead to overestimation/underestimation of meat percentage. Although the equation for the "ZP"-method used in Slovenia from 1995 (Kovač *et al.*, 1995) includes warm carcass weight as am independent parameter, the MP4 and MP5 equations were excluded from further analysis because of the above reasons. In the equations MP2, MP3, MP4 and MP5 the estimated parameters S, logS, $\sqrt{S}$ and S/M had statistically significant influence (P<0.001), whereas the parameter $\sqrt{M}$ in the equations MP2 and MP4 had no statistically significant influence on the prediction of meat share determined by the EU referent method.

Table 1. Evaluated equations for lean meat percentage

Acronym	**Equation**
EU_ref	Lean meat percentage by dissection
MP1	$y=47.978+26.0429\frac{S}{M}+4.5154\sqrt{M}-2.50181\log S-8.4212\sqrt{S}$
MP2	$y = 63.90877-63.17733\frac{S}{M}+1.06056\sqrt{M}-67.20033\log S+18.44824\sqrt{S}$
MP3	$y = 71.51047-84.03306\frac{S}{M}-79.38676\log S+23.64163\sqrt{S}$
MP4	$y = 68.24315-87.49132\frac{S}{M}+0.51658\sqrt{M}-79.49504\log S+24.55191\sqrt{S}-0.04371T$
MP5	$y = 71.91552-94.29002\frac{S}{M}-83.44451\log S+26.24555\sqrt{S}-0.041555T$
MP6	$y = 36.97681 - 0.46424\text{Sdt} + 0.32207\text{Mdt}$

*T=warm carcass weight

Table 2. Basic statistics for lean meat percentage and statistical criteria for equations

	EU_ref	MP1	MP2	MP3	MP4	MP5	MP6
N	144	144	134	134	134	134	134
Mean	51.47^a	55.47^c	51.66^a	51.37^a	51.54^a	51.53^a	51.15^a
Min.	37.21	41.79	39.24	38.09	38.17	37.91	37.21
Max.	67.57	69.65	64.49	65.49	64.90	65.24	65.54
*RMSE	-	-	2.2051	2.2167	2.0992	2.0925	2.5192
**R^2	-	-	0.8166	0.8153	0.8209	0.8206	0.7355

Means within row with different superscript (a, c) differ at P < 0.01; *RMSE – root mean square error; **R^2 – determination coefficient

The average lean meat percentage in dissected pig carcasses was 51.47% (EU_ref). The lean percentage estimated by equations obtained from dissection experiment did not differ statistically from meat percentage in Croatian pig population. On the other hand, the meatiness estimated by the equation MP1 differed statistically (P<0.01) from lean meat percentage objectively determined by the EU referent dissection. This suggests that formula, approved by Croatian regulation, obviously overestimates the lean share of investigated pig population.

In former regulations of EU countries there were two principles that had to be fulfilled for the meat yield estimation equations: RMSE<2.5 and R^2>0.8. Although today the only criterion is RMSE<2.5, the determination coefficient was also calculated to establish the prediction power of developed equations. In table 2 it is shown that the RMSE of equations MP2-MP5 was below 2.5, whereas the RMSE of MP6 formula was slightly higher than prescribed by EU regulation. The determination coefficient between objectively determined (EU_ref) and estimated meat yield for equations MP2, MP3, MP4 and MP5 was higher than 0.8, whereas for the equation MP6 was below the recommended value (R^2=0.74).

CONCLUSION

The results of this research lead to following conclusions:
The meatiness estimated by the equation MP1 differed statistically (P<0.01) from lean meat percentage objectively determined by the EU referent dissection; the current formula significantly overestimates the meatiness of pig carcasses from Croatian population.
The lean percentage estimated by equations obtained from dissection experiment did not differ statistically from meat percentage in Croatian pig population.
Root mean square error of the MP6 equation was slightly higher than 2.5 and therefore can not be recommended for on-line estimation of lean percentage at Croatian slaughterhouses.
The equations MP2, MP3, MP4 and MP5 have RMSE less than 2.5. Although the formulae MP4 and MP5 satisfy this statistical criterion, they include the warm carcass weight, measuring of which is time consuming and presents the source of estimation error. Due to these reasons the equations MP2 and MP3 can be recommended as more convenient for on-line lean share estimation of Croatian pig population.

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