Carcass Classification Measurements in Pigs as Affected by the Operator and Abattoir

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Summary

The aim of the present study was to test a possible way of statistical checking of the measurement uncertainty in pig carcass classification; i.e. to monitor deviations between operators when measuring fat and muscle thickness used for meat percentage calculation. For that purpose, data were obtained from the official classification body Bureau Veritas for the year 2009, which comprised eight operators working in five abattoirs. An analysis of covariance was performed using a model with the effects of the operator, carcass weight as a covariate and their interaction. The equality of the regression lines (regression coefficients and intercepts) was tested for various operators. Regression lines differed significantly between the operators, however all pairwise comparisons were not conclusive since the operators work only in one or two abattoirs, the abattoirs have different suppliers i.e. different origin of pigs. In order to differentiate between the operator and the abattoir effect we further compared i) different operators working in the same abattoir and ii) same operator working in different abattoirs. The deviations in measurements of muscle and fat (often reflected also in meat percentage) were more important in the case of the same operator working in different abattoirs, than in the case of different operators working in the same abattoir.

Key words

pig, carcass classification, operator, uncertainty, statistical control

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Received: May 13, 2011 | Accepted: July 11, 2011

ACKNOWLEDGEMENTS
The authors acknowledge the financial support from the Slovenian Research Agency (programme P4-0072 and P1-0164).

Aim

In Slovenia, as well as in other EU countries, pigs are paid with regard to warm carcass weight and carcass meat percentage. The percentage of meat in carcass is calculated based on the measurements of muscle and fat thickness using an approved formula (Commission Decision, 2008). Even though the measurements of muscle and fat thickness are taken by the trained operators using the approved devices on the standardized measurement location, important deviations in the measurements can be observed between different operators. EU legislation (Commission Regulation, 2008) foresees the control over the operators. It prescribes the on-spot checks and the time intervals in which the controls must be carried out, but does not provide any further details in regard to the acceptable error, which is left to the national authority. In the literature, the information concerning the measurement uncertainty in pig carcass classification is scarce. Available literature reports (Šprysl et al., 2007; Olsen et al., 2007) show, that the effect of the operator can be quite important. In the mentioned studies, the effect of the operator was evaluated on the basis of the repeated measurements on the same carcasses, which is difficult to perform in a daily practice. Therefore, the aim of the present work was to test a possible way of statistical checking of the operator effect when measuring fat and muscle thickness using data collected on the slaughter line.

Material and methods

Pig carcass classification data were gathered from the official classification body Bureau Veritas, and comprise information for one-year period (2009) on muscle and fat thickness, carcass weight and meat percentage including eight operators and five abattoirs (229,046 records). Data analysis was carried out using the statistical package SAS (2002). Prior to the statistical analysis, warm carcass weight was rounded to one kg in the range of validity of the formula for the calculation of meat content (50-120 kg). A condition of having at least 20 measurements for each value (kg) of warm carcass weight per operator had to be fulfilled. Due to the lack of a sufficient number of muscle and fat measurements in the case of light and heavy carcasses, warm carcass weight range was limited to the scale from 60 to 115 kg. The effect of the operator was evaluated on the basis of the relationship between carcass weight (independent variable) and muscle, fat thickness or meat percentage (dependent variables). Equality of regression lines (i.e. slopes and intercepts) was estimated using the analysis of covariance (ANCOVA). The statistical model included the effect of the operator, warm carcass weight (as covariate) and their interaction. Firstly, a general comparison of all operators from different abattoirs was performed. After that, we made i) a comparison of different operators working in the same abattoir and ii) a comparison of measurements carried out by the same operator in two different abattoirs.

Results and discussion

General comparison of all operators – General comparison of the main operators (n=8) performing the measurements in different abattoirs (n=5) showed significant differences in slopes and intercepts between certain operators (Table 1). Due to the organisation of work, this crosswise comparison of the operators combines the contribution of both, the operator and the abattoir related factors, which does not permit any firm conclusions about the operator effect.

Comparison of different operators within one abattoir. To extract the effect of the operator from the abattoir effect, a comparison of two or three operators within the same abattoir was carried out for five abattoirs (Tables 2 and 3). Differences in the slopes (significant interaction operator × warm carcass weight) signify that the operators differ in taking measurements along the scale of carcass weights for which the equation is valid. In the case of similar slopes and different intercepts, the operators measure similarly along the weight scale, however different intercepts signify certain systematic deviation. For muscle thickness, significant differences in the slopes appeared in one abattoir and significant differences in the intercepts in two out of five abattoirs. None of these differences affected the final result i.e. meat percentage. For fat thickness, significant differences in the slopes were observed in two abattoirs and significant differences in the intercepts in one abattoir out of five abattoirs. In

Table 1. Comparison of eight operators working in different Slovenian abattoirs

	Muscle$_{DM}$ (mm)		Fat$_{DM}$ (mm)		Meat$_{DM}$ (%)	
Mean±sd	71.9±5.5		13.3±3.2		59.9±1.8	
R^2	0.97		0.98		0.95	
Effect (*P-value*)						
Operator	<0.0001		<0.0001		<0.0001	
Carcass weight	<0.0001		<0.0001		<0.0001	
Operator × Carcass weight	<0.0001		<0.0001		<0.0001	
	Slope	Intercept	Slope	Intercept	Slope	Intercept
Operator 1 (N=56, n=75,348)	0.33^{bc}	41.9^{c}	0.18^{a}	−3.6^{b}	−0.09^{b}	68.6^{bc}
Operator 2 (N=51, n=3,398)	0.26^{a}	49.0^{e}	0.22^{d}	−7.0^{c}	−0.13^{d}	71.9^{e}
Operator 3 (N=56, n=31,746)	0.33^{bc}	44.3^{d}	0.19^{b}	−3.8^{b}	−0.10^{bc}	69.0^{c}
Operator 4 (N=56, n=70,068)	0.33^{b}	43.6^{d}	0.19^{b}	−3.7^{b}	−0.10^{c}	68.8^{bc}
Operator 5 (N=56, n=16,758)	0.37^{c}	40.4^{bc}	0.21^{c}	−3.8^{b}	−0.11^{c}	68.5^{bc}
Operator 6 (N=47, n=2,213)	0.35^{c}	39.7^{ab}	0.18^{a}	−3.1^{b}	−0.09^{ab}	67.9^{b}
Operator 7 (N=52,n=1,703)	0.33^{b}	41.2^{bc}	0.23^{d}	−6.3^{c}	−0.13^{d}	70.4^{d}
Operator 8 (N=56, n=22,911)	0.39^{d}	38.1^{a}	0.17^{a}	−1.8^{a}	−0.08^{a}	66.8^{a}

SD – standard deviation; R^2 – coefficient of determination; N - number of data points in the regression line; n – number of measured carcasses per operator; Muscle$_{DM}$ – muscle thickness; Fat$_{DM}$ – fat thickness; Meat$_{DM}$ – meat %. Values marked with different letters are statistically different (p<0.05).

Table 2. Analysis of covariance

	P-value		
	Carcass weight	Operator	Operator × Carcass weight
$Muscle_{DM}$ – Abattoir A	<0.0001	0.2650	0.8498
$Muscle_{DM}$ – Abattoir B	<0.0001	0.1438	0.2421
$Muscle_{DM}$ – Abattoir C	<0.0001	0.1368	0.5803
$Muscle_{DM}$ – Abattoir D	<0.0001	<0.0001	<0.0001
$Muscle_{DM}$ – Abattoir E	<0.0001	0.2652	0.7911
Fat_{DM} – Abattoir A	<0.0001	0.1369	0.0190
Fat_{DM} – Abattoir B	<0.0001	0.0502	0.2892
Fat_{DM} – Abattoir C	<0.0001	0.0924	0.0476
Fat_{DM} – Abattoir D	<0.0001	0.9008	0.3038
Fat_{DM} – Abattoir E	<0.0001	0.5271	0.6089
$Meat_{DM}$ – Abattoir A	<0.0001	0.3069	0.0534
$Meat_{DM}$ – Abattoir B	<0.0001	0.1996	0.2604
$Meat_{DM}$ – Abattoir C	<0.0001	0.0778	0.0684
$Meat_{DM}$ – Abattoir D	<0.0001	0.2283	0.6105
$Meat_{DM}$ – Abattoir E	<0.0001	0.3065	0.5955

$Muscle_{DM}$ – muscle thickness; Fat_{DM} – fat thickness; $Meat_{DM}$ – meat %.

one abattoir, the differences in fat measurements were reflected also in the differences of slopes of meat percentage that can be ascribed to the fact that fat thickness has more weight in meat percentage calculation.

Comparison of measurements of the same operator working in different abattoirs. In a third part of the analysis, the measurements of the same operator working in two different abattoirs were compared (Tables 4 and 5). This comparison was carried out only for three operators who had sufficient number of measurements in different abattoirs. In general, we can observe a bigger effect on measurements compared to the situation where different operators were working within the same abattoir. Differences in the slopes (significant interaction abattoir × warm carcass weight) signify that an operator measures carcasses of different weight in a different way in two abattoirs. On the other hand, similar slopes but different intercepts signify that an operator measures similarly, but with certain systematic deviation

Table 4. Analysis of covariance

	P-value		
	Carcass weight	Abattoir	Abattoir × Carcass weight
$Muscle_{DM}$ – Operator 1	<0.0001	<0.0001	<0.0001
$Muscle_{DM}$ – Operator 6	<0.0001	0.0056	0.0359
$Muscle_{DM}$ – Operator 8	<0.0001	0.0001	<0.0001
Fat_{DM} – Operator 1	<0.0001	0.0384	0.0007
Fat_{DM} – Operator 6	<0.0001	0.1862	0.1914
Fat_{DM} – Operator 8	<0.0001	0.8963	0.0816
$Meat_{DM}$ – Operator 1	<0.0001	0.0075	0.0001
$Meat_{DM}$ – Operator 6	<0.0001	0.5893	0.4902
$Meat_{DM}$ – Operator 8	<0.0001	0.2732	0.0027

$Muscle_{DM}$ – muscle thickness; Fat_{DM} – fat thickness; $Meat_{DM}$ – meat %.

Table 3. Comparison of operators working in the same abattoirs (A-E)

	$Muscle_{DM}$		Fat_{DM}		$Meat_{DM}$	
	Slope	Intercept	Slope	Intercept	Slope	Intercept
Abattoir A – Operator 1 (N=41, n=789)	0.27	48.0	0.23[a]	−6.0	−0.13[a]	71.1
Abattoir A – Operator 2 (N=56, n=3,497)	0.26	49.0	0.22[a]	−7.0	−0.13[a]	71.9
Abattoir A – Operator 7 (N=45, n=1,263)	0.27	46.0	0.26[b]	−8.9	−0.16[b]	72.9
Abattoir B – Operator 1 (N=56, n=74,479)	0.33	41.8[ab]	0.18	−3.4[a]	−0.09	68.4
Abattoir B – Operator 6 (N=35, n=1,416)	0.34	40.2[a]	0.19	−3.7[a]	−0.09	68.4
Abattoir B – Operator 8 (N=36, n=1,528)	0.32	43.1[b]	0.19	−1.9[b]	−0.10	67.4
Abattoir C – Operator 5 (N=56, n=16,758)	0.37	40.4	0.21[a]	−3.8	−0.11	68.5
Abattoir C – Operator 7 (N=15, n=190)	0.39	34.7	0.15[b]	−0.4	−0.06	64.8
Abattoir D – Operator 6 (N=37, n=679)	0.29[a]	46.2[a]	0.16	−1.8	−0.09	67.8
Abattoir D – Operator 8 (N=56, n=21,306)	0.39[b]	38.0[b]	0.18	−2.0	−0.08	66.9
Abattoir E – Operator 3 (N=56, n=31,580)	0.33	44.3	0.19	−3.8	−0.10	69.0
Abattoir E – Operator 4 (N=56,n=70,068)	0,33	43.6	0.19	-3.7	-0.10	68.8

$Muscle_{DM}$ – muscle thickness; Fat_{DM} – fat thickness; $Meat_{DM}$ – meat %; N - number of data points in the regression line; n – number of measured carcasses per operator. Values marked with different letters are statistically different ($p<0.05$).

Table 5. Comparison of measurements of same operator working in different abattoirs

	$Muscle_{DM}$		Fat_{DM}		$Meat_{DM}$	
	Slope	Intercept	Slope	Intercept	Slope	Intercept
Operator 1 – Abattoir A (N=41, n=789)	0.27[a]	48.0[a]	0.23[a]	−6.0[a]	−0.13[a]	71.1[a]
Operator 1 – Abattoir B (N=56 n=74,479)	0.33[b]	41.8[b]	0.18[b]	−3.4[b]	−0.09[b]	68.4[b]
Operator 6 – Abattoir B (N=35, n=1,416)	0.34[a]	40.2[a]	0.19	−3.7	−0.09	68.4
Operator 6 – Abattoir D (N=37, n=679)	0.29[b]	46.2[b]	0.17	−1.8	−0.09	67.8
Operator 8 – Abattoir B (N=36, n=1,528)	0.32[a]	43.1[a]	0.19	−1.9	−0.10[a]	67.4
Operator 8 – Abattoir D (N=56, n=21,306)	0.39[b]	38.0[b]	0.18	−2.0	−0.08[b]	66.9

$Muscle_{DM}$ – muscle thickness; Fat_{DM} – fat thickness; $Meat_{DM}$ – meat %; N - number of data points in the regression line; n – number of measured carcasses per operator. Values marked with different letters are statistically different ($p<0.05$)

between abattoirs. For muscle thickness, significant differences in slopes and intercepts appeared for all three operators. For fat thickness, significant differences in slopes and intercepts were observed only in the case of one operator, reflected further also in meat percentage. Deviations in measurements that were observed may result from different conditions within different abattoirs which could affect operators' work, as well as from the differences in pigs (different supplier).

General discussion. The results of the present study showed that different operators working in the same abattoir were taking measurements in a more uniform manner compared to the differences when the same operator worked in different abattoirs. This can be explained by the fact that they share the same (similar) conditions of work, also consider similar pigs (the same breed, same origin). Factors, which may cause deviations between operators in the measurements of muscle and fat thickness can be divided into two groups: i) the effect of the operator and how he or she is handling the equipment when carrying out measurements and ii) the effects associated with abattoir conditions e.g. light, measuring instruments, the abattoir capacity, fast or slow slaughter line, different suppliers or pigs of different origins (farm or enterprises, different breeds or crossings, etc.). Based on the presented results, we can suggest the analysis of covariance as a possible statistical tool for the supplementary control of pig carcass classification. In the Slovenian situation, such a method of supervision has its limitations due to work organization; namely one operator usually works only in one abattoir. It is also important to stress that the deviations, although statistically significant, do not necessary have important practical consequences, i.e. no influence on meat percentage which is the basis for the payment of pigs. However, it is important to monitor the classification results, to find out the reasons for deviations with the aim to improve the accuracy. A constant monitoring and improvement of the accuracy of the classification is important for acquiring a farmer's trust in the system.

Conclusions

Important differences between certain operators were observed, however, comparisons of operators working in different abattoirs were not conclusive. Further analysis showed that differences between the operators working in the same abattoir were less important as the differences within the same operator working in different abattoirs. In order to avoid a possible bias of the abattoir related to the operator, a rotation of operators in different abattoirs is advised. The results of the present study suggest a possible way of statistical control of pig carcass classification.

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