EAAP-55th Annual Meeting, Bled 2004. Session P4.1
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The accuracy of Slovenian method for pig carcass classification

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Abstract: Our objective was to evaluate the accuracy of Slovenian method for meat percentage evaluation of pig carcasses (fat and muscle measurements at the level of *m. gluteus medius* at the carcass split-line using electronic caliper). The study was performed within EU funded project EUPIGCLASS as a part of the study of the accuracy of the on-line methods used in European countries. Therefore, the common experimental plan and ISO 5725 standard were respected. According to later, the accuracy refers to the closeness of agreement between test results under repeatability or reproducibility conditions, and is expressed as standard deviation (sd). The aim was to assess the repeatability sd and reproducibility sd of meat percentage evaluation, and to identify influence of the copy of the equipment and of the operator. For Slovenian method, repeatability sd was 0.4%, indicating we can expect 1% difference for the same carcass made by the same operator with the same copy of the equipment; reproducibility sd was 0.7%, indicating 1.8% difference can be expected for the same carcass due to factors related to the abattoir. The variation due to the copy of the equipment was minor (sd=0.1%) compared to the operator's effect (sd=0.5%). Slovenian results are situated somewhere in the middle, if related to the results for other methods (an article in preparation). In general, results point out the necessity for regular maintenance of instruments and training of operators in order to maintain the precision at an acceptable level. The recommendations (QAP) have been proposed by EUPIGCLASS project (www.eupigclass.org).
Keywords: pig, lean meat content, meausrement uncertainty, repeatability, reproducibility

Introduction

In EU, pigs are payed according to the lean meat content of carcass, which is evaluated on-line indirectly via measurement of predicting variables i.e. backfat and longissimus muscle thickness. Various methods and/or instruments for assessing lean meat content are used in different EU countries, but all of them must comply to EU legislation [1,2], laying down detailed rules concerning the dissection trial (reference method [6], sample size) and prediction ability of the method. However the accuracy on on-line meat percentage evaluation is not related solely to the prediction ability of the method. It depends also on the uncertainty of measuring, which is caused by many factors i.e. differences in operators and how they are handling the instruments, working conditions, maintenance of instruments etc. Within EU funded project [7] (G6RD-CT-1999-00127 EUPIGCLASS), partners representing twelve european countries (i.e. different methods) participated in a trial which aimed at evaluating uncertainty of the indirect measurements (an article in preparation). The objective of the present paper is to present one example – the uncertainty in measurements and lean meat content evaluation in case of one Slovenian method for pig carcass classification.

Material and methods

On-line method for pig carcass classification. The examplary Slovenian method for pig carcass classification is a non-invasive method which consists of measuring fat and muscle thickness at the level of *m. gluteus medius* taken at the carcass split-line using an electronic caliper MD02 (IMK, Ljubljana, Slovenia) (Fig.1).

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Fig. 1: Example of electronic caliper and the measuring locations

Repeatability and reproducibility of measurements (ISO 5725 approach). In order to assess the uncertainty in measurements it was decided to follow ISO 5725 principles [3], and estimate the repeatability (sd_r) and reproducibility (sd_R) of measurements. The repeatability represents a closeness of agreement between independent test results obtained under repeatability conditions (identical items, same method, same operator, same equipment, short interval of time) and reproducibility a closeness of agreement between independent test results obtained under reproducibility conditions (identical items, same method, different operators, different equipment). Repeatability and reproducibility are, according to ISO 5725 definition, expressed in terms of standard deviation.

Experimental plan. In order to evaluate uncertainty in measurements and its consequences for accuracy of lean meat content prediction due to the on-line factors, three separated trials were carried out. In the first trial conducted under repeatability conditions, each participating operator performed two consecutive (repeated) measurements on the same carcass using the same instrument. The trial was conducted in two abattoirs, with three different operators, altogether 348 carcasses were measured (close to 120/operator). The second trial was aimed at evaluating uncertainty in measurements caused by the instrument. Due to the technical limitations, two copies of the same equipment were not available (caliper MD02 is not transferable and is linked to the processor in the balance), so a reference caliper (Mitutoyo IP65) was used for parallel measurements. In that trial the operator performed two repeated measurements on each carcass using two instruments. The second trial was conducted in three abattoirs with one operator. Altogether 360 carcasses were measured (120/abattoir). The third trial, conducted under reproducibility conditions, was aimed at evaluating the uncertainty due to the operator. Operators working in pairs took two repeated measurements on the same carcass using two calipers (IMK-MD02 and Mitutoyo IP65). Halfway through experiment they exchanged the instruments in order to exclude the effect of the instrument. The trial was conducted with four operators (six different pairs) in two abattoirs. Altogether 1912 carcasses were measured (318/pair). All trials were conducted under industrial conditions but in abattoirs with low speed line (50-150 carcasses per hour).

Statistical analysis. Differences between two replicates (repeated measurements) for fat, muscle thickness and lean meat content were analyzed using procedure MIXED by SAS [5] with random effects. In case of the first trial, we were interested only in the residual standard deviation (sd_r) which represents the repeatability of test results for the method. In case of the second trial, we were interested in the component of variance which was due to the instrument (sd_i). In case of the third trial, we were interested in the component of variance due to the operators' effect (sd_o). From results, reproducibility (sd_R) was estimated as $\sqrt{}$ sum of variances

of random effects and random error (repeatability).

Results and discussion

The results for the three trials are presented in Table 1. In the first trial, intended to evaluate the repeatability of measurements, the results show lower repeatability standard deviation i.e. better precision for measurements of fat than muscle thickness (0.53 mm and 0.80 mm, respectively). The results indicate that, within operator, fat thickness was more repeatable measurement than muscle thickness. This uncertainty in measurements of fat and muscle thickness resulted in 0.4 % repeatability sd for lean meat content. In the second trial, designed to evaluate the measurement uncertainty due to the instrument, the standard deviation which can be ascribed to the instrument turned out to be 0.36 mm for fat and 0.41 mm for muscle measurement. These results indicate that the contribution of the instrument to the uncertainty in measurements was similar in case of fat and muscle measurement. As a consequence, the uncertainty in measurements due to the equipment resulted in 0.1 % sd for lean meat content. The third trial was designed to evaluate the uncertainty due to the operator. Standard deviation which can be ascribed to the operator effect was 0.76 mm for fat and 0.50 mm for muscle measurement, denoting that the contribution of the operator to the uncertainty in measurement was more important for fat than muscle measurements. The result also implies that between operators fat measurement was less reproducible than muscle measurement, contrary to the result obtained within operator. As a consequence, the uncertainty in measurements due to the operator resulted in 0.5 % sd for lean meat content.

Table 1.

Uncertainty[†] of on-line measurements and lean meat content evaluation (the case of non-invasive two-point calliper method)

	Trial 1 Repeatability	Trial 2 Instrument	Trial 3 Operator
Number of carcasses	348	360	1912
Fat thickness, mm	0.53	0.36	0.76
Muscle thickness, mm	0.80	0.41	0.50
Lean meat content, %	0.4	0.1	0.5

[†]Expressed in terms of standard deviation (sd)

The principal objective of this work was to demonstrate that daily measurements vary and that part of this variation is natural and unavoidable (pure random error, the repeatability). The reproducibility, which includes uncertainty coming from various factors, was only studied in respect to operator and instrument effect. Thus in case of present method and according to obtained results, two “identical” pigs classified at two different places by approved operators and instruments can be expected ($\approx\sqrt{2}\, t_{2.5\%}\, sd_R$) to differ 1.8 % points just because of factors related to the abattoir (operator, instrument, working conditions etc.). However the main factor is operator itself in interaction with other factors especially working conditions in abattoir. It is important to be aware of these uncertainties and to develop and maintain a system which enables to minimize the factors influencing the precision of on-line measurements.

If compared to the results for other methods (Olsen et al., in preparation [4]), the presented results are situated somewhere in the middle. They confirm the necessity for regular maintenance of instruments and training of operators in order to maintain the precision at an acceptable level. The recommendations (QAP) have been proposed by EUPIGCLASS project (**www.eupigclass.org**).

Acknowledgement
This work was done under the EC funded project G6RD-CT-1999-00127 EUPIGCLASS of the Measurements and Testing Activity (Competitive and Sustainable Growth Programme).

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