Short communication. Validation of the Spanish equation to predict the lean meat percentage of pig carcasses with the Fat-O-Meat'er

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Abstract

In Spain the lean percentage of pig carcasses is predicted objectively with the Fat-O-Meat'er. Changes in the pig population can affect the accuracy of a prediction formula. The aim of this study was to see whether the present Spanish equation for the Fat-O-Meat'er, that was established after a dissection trial in 1990, is still accurate, using more recent data from a dissection trial conducted in the year 2000. The root mean squared error of prediction of the present equation was calculated. Also, a new equation, obtained with the data of the 2000 trial, was compared with the present prediction equation with respect to the constant terms and coefficients. Finally, possible bias in the present formula was studied by comparing dissection results of the 2000 trial with predictions of the present Spanish equation in relation to fat and muscle depth measurements. The calculations demonstrated that the present equation is still valid to predict the lean meat percentage.

Key words: prediction accuracy, pig carcass classification.

Resumen

Nota corta. Validación de la ecuación española para predecir el porcentaje de magro de la canal mediante el Fat-O-Meat'er

En España el porcentaje de magro de la canal porcina se predice de manera objetiva con el Fat-O-Meat'er. La exactitud de la ecuación de predicción puede verse afectada por cambios en la población porcina. El objetivo de este estudio fue determinar si la actual ecuación española para el Fat-O-Meat'er, que se estableció mediante un ensayo de disección en 1990, es exacta. Para ello se usaron los datos de un ensayo de disección realizado en 2000. Se calculó la raíz del error cuadrático medio de predicción. También se obtuvo una nueva ecuación de los datos del ensayo del año 2000, la constante y los coeficientes de la cuál se compararon con la ecuación oficial. Finalmente, se estudió el posible sesgo de la ecuación actual comparando los resultados del ensayo de disección de 2000 con las predicciones realizadas mediante la ecuación vigente en función de las medidas de espesor de grasa y músculo. Los cálculos han demostrado que la ecuación actual es aún válida para predecir el porcentaje de magro.

Palabras clave: predicción de la exactitud, clasificación de canales porcinas.

The lean meat percentage (LMP) is an essential economical parameter to take into consideration when the value of a pig carcass is established. The LMP is predicted on the basis of objective carcass measurements that are collected on the slaughter line with a classification instrument. The prediction equation is determined in a dissection trial and has to meet certain requirements according to EC regulations (No 3220/84 and 3127/94) (OJ, 1984, 1994b). The regulations specify how the dissection should be performed (Walstra and Merkus, 1995), how the carcasses should be sampled from the pig population and what level of accuracy is required for the prediction formula. The present prediction formula in Spain (Decision 94/337/EC) (OJ, 1994a) is based on carcass measurements collected with the Fat-O-Meat'er (FOM, SFK Technology A/S, Transformervej 9, 2730 Herlev, Denmark) and is derived from a dissection trial conducted in 1990 (Gispert and Diestre, 1994). Changes in the population, for instance changes in the proportions of pigs in subpopulations such as sexes or genetic types (Evans

and Kempster, 1979; Planella and Cook, 1991; Gu *et al.,* 1992; Engel and Walstra, 1993; Daumas and Dhorne, 1997; Gispert *et al.,* 2000; Engel *et al.*, 2004; Zelenák *et al.*, 2004) or changes in the conformation of the pigs due to selection may affect the accuracy of a prediction equation. Although the new dissection data can be used to calculate a new up to date prediction formula, it is worthwhile to see whether the present formula is still acceptable because it saves money and avoids confusion when modification of the reference method and the European regulation is pending.

In this short communication the Spanish prediction equation for the FOM is validated with data from a recent dissection trial conducted in 2000.

Data from the 1990 dissection trial were used to establish the present official equation for the FOM equipment. This equation was obtained by means of double regression (Engel and Walstra, 1991; Causeur and Dhorne, 1998), a cost saving alternative for ordinary linear regression. There were 120 carcasses dissected, which were selected according to 4 groups (Gispert and Diestre, 1994) depending on carcass weight. Within each weight group carcasses were selected on fat thickness, as measured with the FOM, 6 cm from the midline, between the 3rd and 4th last ribs, into 3 fat groups. Forty percent of the carcasses had fat thickness less than the mean minus one standard deviation, 40% had fat thickness higher than the mean plus one standard deviation and the remaining 20% were in between. Dissection was performed following the protocol in EC internal document VI/3860/89 (OJ, 1990), 120 of the carcasses were dissected using the simplified method, in addition 30 of these carcasses, the 15 fattest and the 15 leanest, were also fully anatomically dissected (Scheper and Scholz, 1985). The simplified method, with some appropriate corrections, was actually the basis of the present EC reference method. The present prediction equation was obtained:

$$\hat{y}_1 = 61.56 - 0.878 * fat + 0.157 * muscle,$$
$$n = 120, RMSE = 2.18 \quad [1]$$

where $\hat{y}_1$ is the predicted LMP, *fat* and *muscle* are the FOM fat and muscle depth respectively, as measured 6 cm from the midline between the 3rd and 4th last ribs and RMSE is the root mean squared error.

The 2000 data was collected to obtain the present official equation for the AUTOFOM equipment (Decision 2001/775/EC) (OJ, 2001). This comprised a calibration and a validation set of dissection data (Font

i Furnols *et al.*, 2001; Gispert *et al.,* 2002). For the calibration 144 carcasses were dissected with the present EC reference method described by Walstra and Merkus (1995) and FOM fat and muscle depth were measured, again 6 cm from the midline between the 3rd and 4th last ribs. Carcasses were selected from 3 weight groups. Within each group the selection was made according to the 40-20-40% scheme for FOM fat thickness as described above. For the validation set, 118 carcasses were selected according to 3 weight groups. Within each group, carcasses were selected proportionally with respect to LMP predicted with the AUTOFOM. Hence, the validation set resembled a random sample. Fat and muscle depths were also measured with FOM and carcasses were dissected with the present EC reference method.

According to the EC regulations, the present formula [Equation 1] is required to meet a criterion for the RMSE. Future regulations, based on recommendations of the EUPIGCLASS project (EC project G6RD-CT-1999-00127, www.eupigclass.org), will probably change to the root mean squared error of prediction (RMSEP). For details about these criteria we refer to statistical handbook for carcass grading (Causeur *et al.*, 2004). The RMSEP of the present formula was calculated with the data from the 2000 dissection trial as:

$$RMSEP = \sqrt{\frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{n}}$$

Here, $\hat{y}_i$ is the predicted LMP by Equation 1 and y_i is the dissected LMP. When this equation was applied to the 2000 validation data set (n = 118), the RMSEP was 2.21. All calculations in this work were performed with SAS (1999). The equation was also applied to the 2000 calibration data set (n = 144) and the RMSEP was 2.45. The difference in the value of RMSEP shows the impact of the selection method on this parameter, the approximate random sample of the validation set being more appropriate than the over sampled 40-20-40% scheme of the calibration set. The RMSEP calculated for both data sets together (n = 262) was 2.35. In all the cases the RMSEP was below the upper limit of 2.5% as required for the RMSE by the EC regulations.

From the data collected in the 2000 calibration plus validation dissections a new prediction equation for FOM, from now on referred to as Equation 2, was obtained by linear regression:

$$\hat{y}_2 = 57.79 - 0.839 * fat + 0.219 * muscle,$$
$$n = 262, \text{ RMSE} = 2.30 \qquad [2]$$

Here, $\hat{y}_2$ is the predicted LMP and *fat* and *muscle* are the FOM measurements similar to Equation 1. The combined data was used, because a similar equation was obtained with the calibration set (results not shown). Apparently, the selection on weight and on AUTOFOM LMP hardly affected the results of linear regression.

The new Equation 2 was compared with the present Equation 1 by different methods. First the constant and coefficients of the two equations were compared separately. Samples of the 1990 and 2000 trials were regarded as samples from the same pig population. When the population has not changed, the constant and coefficients from Equations 1 and 2 are estimates of the same population parameters. To compare for instance constants with associated standard errors, we inspected:

$$t_a = \frac{|a_1 - a_2|}{\sqrt{se(a_1)^2 + se(a_2)^2}}$$

The samples were large enough to use a normal approximation for the distribution of t_a under the null hypothesis of no change in the population. The t-values (and associated P-values) of the comparison between the constants and the coefficients of fat and muscle respectively, were 1.60 (P = 0.11), 0.73 (P = 0.46) and 1.58 (P = 0.11). None of these comparisons were significant at a 0.05 level. Similar results were found when only the calibration set was used to obtain the new equation (results not shown). In addition to the separate tests for constant and coefficients, a joint test was calculated, similar to the Wald test, employing a chi-square distribution with 3 degrees of freedom. The joint test for the constant and coefficients was not significant (P = 0.34) either. These results suggested that the present official equation still shows tolerable prediction error. However, when only the calibration data set was used to obtain the new equation, the Wald test was significant (P = 0.02). This suggests that possibly the population has changed, although the results of these changes are not pronounced and the present official equation is still sufficiently accurate. A closer look at the data revealed that FOM muscle thickness was mainly responsible for these differences, despite the fact that fat depth is by far the most important prediction variable. Some low values of muscle thickness (between 45 and 52 mm) presented higher LMP values than usual (> 59%). Although the common criteria for outliers, like Cook's distance, were not very high, these data points can affect the estimation and results of the joint test. Without these data points, P = 0.05 for the Wald, which is much closer to the result for the calibration set.

Second, to gain further insight in the quality of the present Equation 1, a linear regression of the dissected lean meat for carcasses of the 2000 experiment on the predictions obtained by Equation 1 was performed, initially for the validation trial and then for both data sets together. The constant and coefficient in this regression give an indication of whether there is any possible bias in the present formula. Note that in this approach the results of Equation 1 were considered as fixed numbers. Basically, the results of Equation 1 were employed as the outcomes of a new explanatory variable. The constant and coefficient reflect both bias due to possible changes in the population and sampling bias in the 1994 formula. In principle, it is possible to compare Equations 1 and 2 on a more equal footing employing a so-called errors in variables model (Fuller, 1987). The aforementioned approach, although more strict, was preferred because it is easier to perform. A similar approach was suggested in the EC harmonisation trial in 1990 (G. Cook, personal communication). The equation obtained when only the validation data set was used, was the following:

$$\hat{y} = 0.254 + 0.988 * \hat{y}_1,$$
$$n = 118, \text{ RMSE} = 2.18$$

Here, $\hat{y}_1$ is the prediction by Equation 1. Confidence intervals for the constant and coefficient were [−9.865,7.374] and [0.866,1.110] respectively. The first interval includes 0 and the second interval includes 1. Similar results were obtained when calibration plus validation 2000 data sets were used in the regression:

$$\hat{y} = 0.717 + 0.994 * \hat{y}_1,$$
$$n = 262, \text{ RMSE} = 2.33$$

In that case the confidence interval for the constant was [−3.320,4.754], which includes 0, and for the coefficient [0.924,1.063], which includes 1. So, on the basis of this regression there was little to worry with respect to bias. Also the RMSE was well below 2.5 in both cases.

However, because of the significant result of the Wald test for the calibration set, it was decided to examine the data further. We considered the regression of the differences $d = \hat{y}_1 - y$ between the lean meat
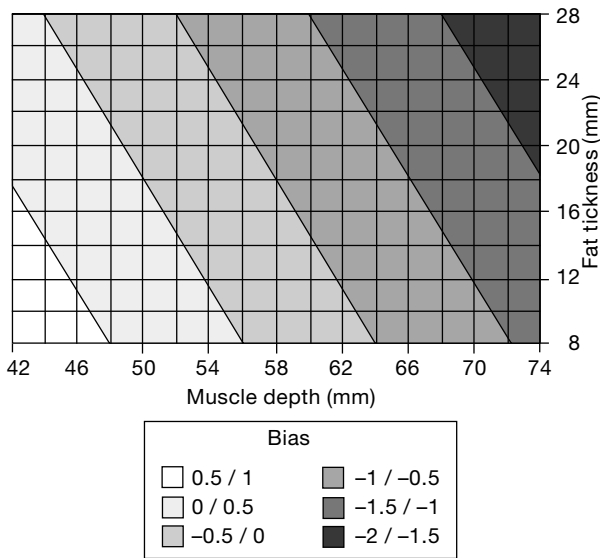
Figure 1. Contour plot of the bias between the dissected lean meat percentage of the calibration plus validation data sets of the 2000 trial and the predicted lean meat percentage with the present equation. Bias is presented as a function of fat thickness and muscle depth.

percentages of the 2000 trial and the associated predictions with the present equation 1 on the separate FOM fat and muscle depths measurements, for the 2000 calibration plus validation trials together. The constant and the (small) coefficient of muscle depth in this regression were significantly different from 0,
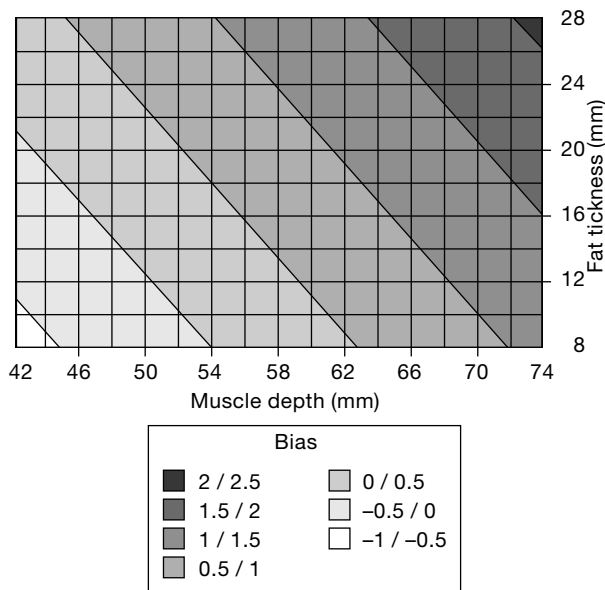
indicating that a modest but statistically significant bias was present. Note that any regression formula, although unbiased when constants and coefficients are regarded as random, would be biased when constant and coefficients were regarded as fixed and the formula was applied to new data (like in this case). A comparison between a contour plot of the bias in $\hat{d}$ as a function of fat and muscle depth (Figure 1) and plots obtained by simulation, assuming no changes in the population (Figure 2), indicated that most of the bias was likely to be sampling bias.

After testing the validity of the present equation using different statistical procedures, it was concluded that the equation from the 1990 trial is still valid for predicting the lean meat percentage of the present Spanish pig population.

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Figure 2. Contour plot of the bias obtained after a simulation study with the present equation. Bias is presented as a function of fat thickness and muscle depth.

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