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ESTIMATION OF LEAN MEAT IN HAMS BY MEANS OF TOBEC

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Introduction

Carcass composition can be assessed in various ways. In many countries in the European Union (EU) carcasses are evaluated by optical probes, like the Hennessy Grading Probe (HGP) and Fat-O'-Meater (FOM). Regulations of the EU (Commission Regulation No 3127/94) prescribe a.o. that classification of pigs should be based on lean meat percentage and that the accuracy of the estimation formulae in terms of the root mean square error must be lower than 2.50%. In general, in the EU member states the √mse for one or two probing sites lies between 2.00 and 2.50%. For the Danish classification centre, allowing nine probing sites, the accuracy is about 0.50% lower. With this device also an estimation of lean meat percentages of the joints may be given. Because of strong relationships between the various lean parts of the body, one may deduce the lean meat percentage of the ham from single site probing with the HGP as shown by Hulsegge et al. (1994), but with less accuracy than with multiple fat measurements. For application in practice costs of instruments have to be balanced against accuracy of measuring. A non-invasive technique like total body electrical conductivity (TOBEC) has potentials, not only for carcasses, but also for joints. The MQI-Primal Cut System was tested in a commercial plant to evaluate its application for estimation of lean meat in hams.

Materials and methods

Various types of TOBEC-machines have been constructed. The larger MQ-25 (Meat Quality Inc., Springfield, IL, USA) has a smaller version meant for measuring primal cuts. A MQI-PRIMAL CUT System was installed in a commercial slaughter and cutting plant (Jansen Group, Apeldoorn, The Netherlands). Carcasses were selected in the slaughter-line regardless of sex, but based on the the usual range of carcass weight and lean meat percentages as measured by HGP. After one night of chilling, 209 hams were collected from the carcasses at the start of dissection.

Hams were measured by TOBEC with and without foot (*ossa metatarsalia*). Before weighing the temperature of the ham surface (over the *m. semimembranosus*) and the inner muscle temperature (5 cm inwards from the cut surface of the *m. semimembranosus*) were measured. After weighing the hams with foot were measured by TOBEC, the foot was then sawn off just proximal to the tarsal joint and the hams were weighed without foot and again put through the machine. Dissection of the hams followed according to the plant's standard method. Hams were dissected into muscles (including fascia and intermuscular fat), bones and subcutaneous fat (including skin and some intermuscular fat).

While moving through the electromagnetic field of the TOBEC a specific response curve develops. The curve rises unto a peak and drops when the ham leaves the chamber. The values measured by TOBEC are expressed as area under the curve and PMA value. The latter stands for peak mean average, which is an average of readings around the peak of the curve. These values, whether or not in combination with weight and temperatures, are used in regression analyses as dependent variables to predict lean in the hams.

Results

Mean values for the main characteristics measured are given in Table 1. The measurements in the slaughter-line, i.e. carcass weight and HGP measurements, are in line with normal values found.

Table 1. Mean values and standard deviation of characteristics measured.

	Mean	s.d.
Hot carcass wt (kg)	88.9	6.3
Backfat thickness HGP (mm)	16.8	3.9
Lean meat HGP (%)	55.7	3.1
Inner muscle ham temp. (°C)	5.6	0.8
Surface ham temp. (°C)	5.7	0.7
Ham without foot (g)	12772	1015
Lean meat in ham (g)	9195	816
Fat in ham (g)	2325	579
Bone in ham (g)	1249	118
TOBEC PMA value	200	34
TOBEC area value	3910	703

Table 2. Prediction of lean in hams (mass as well as percentage) by TOBEC MQI Primal Cut System measurements and in combination with other characteristics (n = 209).

Dependent variables	Lean mass R^2	Lean mass RSD	Lean % R^2	Lean % RSD
PMA	.881	282	.270	2.92
Area	.888	274	.256	2.94
PMA + area	.888	273	.310	2.84
Wt of ham	.665	473	.005	3.41
PMA + wt	.918	234	.763	1.66
PMA + area + wt	.918	234	.762	1.66
PMA + wt + PMA*wt	.919	232	.769	1.64
PMA + area + wt + T_i + T_o	.928	220	.780	1.60

Correlation coefficients were also calculated. The mutual coefficients between PMA and area values are all very high: almost 1.00. Total ham weights show correlations of 0.71 to 0.73 with PMA and area values. Inner and outer temperature do not correlate with TOBEC values (r = 0.09 - 0.12). Hot carcass weight and HGP lean meat % have correlations with the TOBEC values of r = 0.45 - 0.50. Lean meat % in ham has a slightly higher correlation (r = 0.51 - 0.52) with TOBEC values, while lean weight in ham correlates very highly with TOBEC values (r = 0.94).

Regression analyses show that hams measured by TOBEC with or without foot give identical results; the measurements without foot are slightly higher in terms of R^2 and slightly lower in terms of residual standard deviation (RSD). The

RSD in this type of analysis is the same as √mse.
Various characteristics and combinations have been introduced into regression analyses to predict lean mass or lean meat % in the hams. Results are given in Table 2. The results presented refer to hams measured by TOBEC *without* foot, but calculation of the lean meat % is based on ham weight *including* foot. This gives slightly better results in terms of R^2 and RSD, especially for RSD.
PMA and area values show identical results and combining them does not improve the results. The weight of the ham as such predicts reasonably well the lean mass, but has no predictive value with respect to lean meat %. The combination of PMA (or area, not given in the Table) and weight of the ham improves the result considerably in case of prediction of lean meat %. A further small improvement is obtained by adding the arithmatic product of PMA and ham weight. Other calculations by trying PMA and area values as square roots or as logarithms, however, did not further improve the accuracy. Only by introducing the inner muscle and surface temperature better results were obtained.

Discussion and conclusions

As yet the MQI-Primal Cut System was not on-line. Therefore, hams could be passed through TOBEC both with and without foot. Dependent on the results a choice could be made afterwards where to install the instrument on-line. Although the results are only slightly different there is a preference for measuring hams by TOBEC without foot and calculation of lean meat % in the ham based on the total weight of ham *including* foot. So, ham weight should be weighed before the foot is sawn off and the ham without foot runs through TOBEC.
On account of auto-correlation ham weight as such already predicts lean mass reasonably well (R^2 = 0.67). The TOBEC measurements predict lean mass very well (R^2 = 0.88 - 0.89). Lean meat % in the ham, however, is independent of ham weight (R^2 = 0.005) and the TOBEC measurements as such are not very successful in this respect (R^2 = 0.26 - 0.27). In combination with ham weight, however, the prediction is sufficiently high (R^2 = 0.76). A small improvement is obtained when the arithmatic product of weight and PMA value is introduced. A further small improvement in the prediction accuracy, especially in terms of RSD with respect to lean mass, is reached by introducing ham temperatures. Although there is some influence of temperature, it would not be very practical to use measurements of temperature on-line and the small improvement does not seem to justify the efforts of measuring temperature.
As shown by Hulsegge et al. (1994) lean meat % in hams could also be deduced from lean meat % of the carcass as measured by HGP; accuracy being R^2 = 0.85 and RSD = 2.17. This RSD is much higher than when lean meat % is estimated by TOBEC, which gives a RSD of 1.64. The TOBEC Primal Cut System seems to estimate lean mass and lean % in hams more accurate than the larger MQ-25 developed for measuring whole carcasses. In the latter Berg et al. (1994) found accuracies for lean mass of R^2 = 0.81 or 0.83 and RSD = 660 and 640 respectively. Predictions included whole carcass weight, carcass lenght and temperature or only various preselected segments of the response curve. Forrest et al. (1991) mentioned R^2 = 0.87 and RSD = 600 for lean mass and R^2 = 0.67 and 2.38 for lean % in ham. So, especially with respect to RSD the Primal Cut System is more accurate. With another older type of TOBEC (HP-1, personal communication) Henning et al. (1993) also using ham weight in the prediction formula obtained a R^2 of 0.97 with a RSD of 230, which is about the same result as in the present study. Lean meat % in ham, however, was estimated less accurate with R^2 = 0.63 and RSD only 2.31.
The present study will be followed by a validation test to check whether the prediction formulae are robust and bias is acceptable.
As a result of this experiment under the conditions of dissection mentioned, the best prediction equations would be:
for lean mass in ham: $\hat{Y} = 1085 + 26.88 * PMA + 0.3537 * hamwt - 0.000693 * PMA * hamwt$
and for lean meat % in ham: $\hat{Y} = 72.72 + 0.2035 * PMA - 0.002402 * hamwt - 0\ 00000571 * PMA * hamwt$.
In value-based marketing where customers demand products that have a prescribed condition or value, evaluation techniques should have accuracies as low as possible. Measurements with the TOBEC MQI-Primal Cut System have the potentials to predict lean in joints with sufficient accuracy as is shown here for hams.

Summary

209 hams in the usual weight range were collected in a commercial plant, passed a TOBEC MQI-Primal Cut System, with or without foot, and were dissected according to the plant's standard cutting method. Various regression analyses showed that the best prediction for lean in hams could be obtained by a combination of PMA value, ham weight and the arithmatic product of PMA value and ham weight. The predictions for lean mass were more accurate than for lean meat %. The equations presented have a R^2 and RSD of 0.92 and 232 respectively for prediction of lean mass and a R^2 and RSD of 0.77 and 1.64 respectively for lean meat %. Application of the equations implicate measurement of ham weight including foot, but measurement by TOBEC of hams without foot.

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