DEVELOPMENT OF AN ULTRASONIC DEVICE IN LIVE PIG CLASSIFICATION

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Introduction

In pig breeding application of ultrasonic techniques is widely used to select animals for their ability for lean meat production (Alliston et al., 1982; Molenaar, 1985). Classification of slaughter pigs in the EU requires objective measurements enabling estimation of the lean meat percentage with a *r*oot *m*ean *s*quare *e*rror (or residual standard deviation (RSD) in standard regression) < 2.50%. In member states mainly optical probes are in use. In the Netherlands slaughter pigs are uniformly classified using the Hennessy Grading Probe (HGP). However, 11% of the pigs produced for slaughter are exported alive, without information about their lean meat percentage. The export industry for live animals felt it necessary to classify these pigs also. Slaughter pigs to be exported alive are routinely collected at central places and weighed before transportation. In live pigs classification by means of ultrasonic techniques is the obvious way.
An ideal construction would be a short type of restrainer through which animals go and above which the ultrasonic instrument is installed. Liu and Stouffer (1995) found that automatic depth measurements taken with a computerised longitudinal real-time system were more accurate at predicting lean percentage than careful manual measurements. Particularly in live pigs the measuring positions had to be determined first in order to develop an automatic classification system with approximately the same accuracy as the current system with HGP in the slaughterlines. As outlined by Walstra et al. (1994) the 50% point would be a good reference point to be used in live classification. After that a classification system for live slaughter pigs was developed further.

Material and methods

Positioning

Ultrasonic (US) measurements were made with the Renco LM (Renco Lean-Meater type 1m-8, Renco Corp. Minneapolis, MN, USA). Several measurements on pigs (n = 86) were carried out along the backfat layer 6 cm off the midline (as in operation in the slaughterlines), starting at the last rib (LR) into cranial direction at intervals of 2 cm. The total distance from tail implantation to a point just between the ears was measured. The 50% point of this distance was expected to be workable in practice.
All pigs were slaughtered the day after the measurements were taken. In the slaughterline the last rib (tattood) position was checked at the carcass and various distances were measured again. Correlation coefficients were calculated between HGP classification results and every single measurement point and combinations of two of them.

Automatic measuring device

Based on the information obtained from the positioning study, a classification system for the live slaughter pigs was developed further. A construction is built on top of a restrainer with a frame along which a positioning system can quickly move by means of air-driven cylinders (NAWI, B.V., Borculo (NL)). This system includes an ultrasonic transmitting system (Hennessy Europe Service and Development B.V., Rijswijk (NL)). On command it stops at the 50% point, which is found when the distance between the tail implantation and the base of the ears is determined by two laser beams. The US transmitter consists of three small transducers (modified PIG-SCAN, produced by SFK, Søborg (DK)) fixed at a distance of 2.5 cm from each other. The middle one should measure at the 50% point.
After measuring (n = 377) pigs were slaughtered and classified by HGP. The distance between the 50% point (marked alive) and the HGP measuring position at 3rd/4th from LR (3/4LR) was measured as well. Left carcass sides (n = 88) were dissected according to the jointing procedure of the new EU reference method (Walstra and Merkus, 1996), but the joints were not further dissected, only defatted by trimming off the subcutaneous fat. The weights of (defatted) ham, loin, shoulder and tenderloin were considered as the lean parts.

Results and discussion

Positioning

Average carcass weight at slaughter was 88.4 kg and the HGP lean meat percentage amounted to 57.0%. There was a gradual increase in backfat thickness from 9.6 mm at LR to 12.5 mm at 26 cm cranially from LR, also found by Fortin et al. (1980) on cold carcasses. The backfat depth at the 50% point fitted well between the 14LR (14 cm cranial from LR) and 16LR position. This 50% point happened to be very close to the 3/4LR from last rib position.
The average backfat depths of 4LR and 6LR were taken together as 5LR; 6LR and 8LR as 7LR etc. The correlation coefficients between the pairs of backfat thicknesses and the HGP backfat depth were only slightly lower than with the Renco LM measurements at 14LR and 16LR. The correlation coefficients again increase with onward positions in cranial direction. The relationships with HGP backfat depth (at 3/4LR) were highest around the 50% point (r = 0.88 to 0.89) for the combinations of adjacent backfat depths. Zhang et al. (1993) found similar values. The correlation between the 50% point and HGP lean meat percentage amounted to -0.83. Terry et al. (1989) found about the same (r = -0.81) for the same phenomenon. Since the 50% point is around the regular probing position for the HGP at classification and the correlation coefficient (-0.83) with HGP lean meat percentage is sufficiently high, it was concluded that an ultrasonic classification system for live pigs could be developed. To ensure sufficient accuracy in a classification system for live pigs transducers should give an integrated US signal from two or three measuring points around the 50% point.

Automatic measuring device

The results of the backfat measurements and the dissections are listed in Table 1. Hot caracss weight and HGP measurements are normal values. Backfat thickness again increases in cranial direction. Backfat thickness at the 50% point as well as that -2.5 cm cranial is thicker than the HGP measurement at 3/4LR, while that on +2.5 cm caudal is thinner ($P < 0.05$). The 50% point marked at the live animals deviated from 3/4LR in the carcass by 1.9 cm and 1.3 cm in the caudal and dorso-ventral direction respectively, which is tolerable, but may be large in individual cases due to biological reasons (shifts in anatomical positions) and wrong fixation in the restrainer.
The correlation coefficients between the US measurements and the HGP backfat depth were around 0.70; the ones between the US measurements and the HGP lean percentage were a little lower. They are lower than mentioned in the positioning trial and lower than reported by Zhang et al. (1993), which could be due to a different measuring device. The accuracy (in terms of RSD) for the prediction of the HGP lean meat percentage by single US measurements was between 2.05 (the 50% point) and 2.17%. Krieter and Kalm (1991) found similar values for the prediction of the Fat-O-Meat'er lean meat percentage. The contribution to the prediction of more than only the US

Table 1. Means and standard deviations (s.d.) of fat thicknesses, lean meat percentages and weights.

	x̄	s.d.	n
live animal			
weight (kg)	110.7	7.4	376
backfat thichkness 1* (mm)	18.9	4.0	372
backfat thichkness 2* (mm)	18.4	3.6	366
backfat thichkness 3* (mm)	17.1	3.5	375
carcass			
hot carcass weight (kg)	88.0	6.0	337
HGP backfat thickness (mm)	17.8	3.8	377
HGP lean meat (%)	55.0	3.0	377
lean meat dissected (%)	44.2	2.4	88
length marked 50 % point - 3/4LR, axial axis (mm)	1.9	2.3	320
length marked 50 % point - 3/4LR, dorso-ventral axis (mm)	1.3	1.2	320

*2 = measuring position at 50 % of the distance tail implant to ear base (50% point)
*1 = *2 -2.5 cm (cranial); *3 = *2 +2,5 cm (caudal)

measurement at the 50% point was significant ($P < 0.05$); likewise was the contribution of live weight, but the latter lowered the RSD only by 0.02%.

The correlation coefficients between the US measurements and *dissected* lean meat percentage were a little higher than 0.70 and thus better than with HGP lean meat percentage. Kanis et al. (1986) reported similar coefficients with a comparable dissection method. The accuracy for the prediction of the dissected lean meat percentage by the US measurements was between 1.59 (the 50% point) and 1.74% in terms of RSD. Again the contribution to the prediction of more than only the US depth at the 50% point was significant ($P < 0.05$); but now there was no significant contribution of live weight to the prediction. Based on two backfat measurements Busk (1986) reported an RSD of 1.48% for the prediction of lean meat percentage. He also did not find a contribution of live weight. Kanis et al. (1986) and Krieter and Kalm (1991) mentioned values of 2.74 down to 1.75%.

Since the dissection procedure was limited to only jointing with trimming off the subcutaneous fat, so leaving intermuscular fat and bone in the joint, the actual amount of lean meat is not known without full separation of the tissues. Besides the level according to the limited dissection procedure would be 10% lower (see Table 1). Therefore it was decided to establish a prediction formula for tentative use in practice based on the lean meat percentage as estimated by the HGP. The prediction formula is:

HGP lean meat% = 66.784 - 0.647 * avUS, (n = 370; RSD = 1.95%)

in which avUS means the average of the three US measurements or the average of two measurements in whatever combination (when one value is missing). If only one valid measurement is obtained no percentage is calculated.

Summary

In the Netherlands slaughter pigs are uniformly classified using the Hennessy Grading Probe (HGP). However, 11% of the pigs produced for slaughter are exported alive, without information about their lean meat percentage. The export industry for live animals felt it necessary to develop a system comparable with the national classification. Live animals for export are routinely collected at central places and weighed before transport to the markets, so it would be feasible to apply a non-invasive grading technique at these locations.

Ultrasonic (US) backfat depths on live animals (n = 86) gradually increase from 9.6 mm at LR to 12.5 mm at 26 cm cranially from LR. The backfat depth at 50% of the length from implantation of the tail to the ear base fitted well between the 14LR and 16LR position, which approximates the HGP measuring point at 3/4LR at carcass classification. The correlation coefficient for this 50% point on the live animal with the HGP lean meat percentage is sufficiently high (r = -0.83).

A semi-automatic system was built for live pigs including a restrainer, a weighing station and a positioning system induced by air-driven cylinders. The middle one of three longitudinal transducers fixed at a distance of 2.5 cm from each other measures at the 50% point. Although the accuracy for the prediction of the dissected lean meat percentage (n = 88) by the US measurements was reasonably good, the dissection procedure used was found to be too limited for a classification system in practice to rely on. A dissection method based on full separation of the lean tissue would be more reliable. Therefore a provisional prediction formula has been calculated to predict the *HGP* lean meat percentage (n = 370). The equation is: HGP lean meat% = 66.784 - 0.647 * avUS, in which avUS is the average of the three or two (in case one is missing) US measurements. The accuracy amounted to an RSD of 1.95%. In this way a system exists concurring with the system on the slaughterlines.

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