NON-INVASIVE METHODS IN PIG GRADING: A RELIABLE POSSIBILTY FOR CALIBRATION OF GRADING DEVICES

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INTRODUCTION

In future, the estimation of lean meat content for grading of pig carcases in the Federal Republic of Germany will be based exclusively on standardized carcase traits.
Only two carcase traits will be applied: a fat and a muscle depth in the loin at the 2./3. last rib (7 cm beside the midline). Further, the different grading devices shall all use the same prediction equation, in this way facilitating the standardization of estimation results. An essential prerequisite for that is, that technically different devices are able to measure the two tissue depths with a high degree of consistency. Therefore it is necessary to calibrate them against a common baseline. This could be done with a reference measurement, which should fullfill the following conditions:

- measurement within 45 min. after slaughter
- measurement without any influence on the actual fat and muscle thickness.

Under these conditions, evidently, only non-invasive techniques are able to yield correct results of measurement. The present study was carried out with the objective to test the ultrasonic scanning as a reference method for the measurement of the tissue depth beside the split line in pig carcases. The ultrasonic scanner principally has two advantages: it works well under slaughterhouse conditions and even facilitates measurements under experimental conditions using electronic or photographic documentation. The ultrasonic scanner was tested under two different aspects:

- consistency of the single ultrasonic measurements with the measurements of magnetic resonance imaging and
- prediction accuracy of real lean meat content.

Furthermore, three commercial grading probes were included in the study.

MATERIAL AND METHODS

For trial I a random sample was drawn from the market (table 1).

Table 1: Characteristics of the sample in trial I

		n
sex:	♀	53
	♂	67
total		120
		$\bar{x}$	s
hot carcase weight (kg)		85.0	7.28
loin area (cm)		45.4	5.85
lean meat cont.-FOM (%)		52.8	3.67

Within 40 to 90 min. after slaugther the carcases were measured in the loin at the 2./3. last rib (7 cm beside the split line) by the following methods maintaining always the same order indicated below:

- ultrasonic scanner (U-scanner I) - Hellige SSD 256 - Aloka
- magnetic resonance imaging (MRI)-Bruker, Karlsruhe
- Fat-o-Meat'er (FOM) - SFK, Hvidovre, Denmark
- U-scanner with a probe (ca. 5 mm) inserted in the former FOM probe channel as a direction indicator (U-scanner II).

All measurements were obtained from the lying carcases, for better comparison with MRI, which is able to measure carcases only in this position. There was no complete dissection included in this trial, thus correlation to lean meat content could not be calculated.

In trial II, the U-scanner was tested with respect to his precision of estimation of lean meat content and agreement with grading probes. Details of the experiment are described by BRANSCHEID et al. (1989). A total of 393 carcases was studied consisting of the breeds German Landrace (DL), crossbred Piétrain x DL and Hybrids BHZP. The carcases were derived from 4 different regions of West Germany. Carcase weight (5 groups from 65 to 110 kg) and sexes (gilts, castrates) were considered. Every subgroup was represented by almost the same number of animals. Measurements were taken about 45 min. after slaughter at the loin (7 cm beside split-line) in the following way:

- Destron - (Ontario/Canada): 2./3.last rib
- FOM - (SFK, Hvidovre/Denmark): 3./4.last rib

- Hennessy grading probe (HGP, Auckland/New Zealand): 4./5.last rib
- U-scanner: at the same locations as the grading probes (2./3., 3./4., 4./5.last rib).

The analysis of the trials was performed on the basis of the following statistical parameters:

o consistency of methods in fat and muscle measurements:
- r: correlation between measuring methods
- $\bar{d}$: mean deviation between measuring methods
- s_d: standard deviation of the differences of single measurements.

o precision of estimation of lean meat content
- r: correlation between actual and predicted lean meat content
- $s_{y.x}$: standard deviation around the regression line.

RESULTS

Comparison with MRI-measurements

A primary information about the consistency of single measurements of U-scanner and FOM with MRI is given by correlations (Table 2).

Table 2: Correlations (r) between different fat and muscle thickness measurements (n = 120)

method	1	2	3	4
	fat depth			
1. MRI		.94	.94	.96
2. U-scan. I	.89		.95	.98
3. FOM	.85	.83		.96
4. U-scan.II	.90	.96	.86	
	muscle depth			

The correlations between the fat measurements, generally are fairly strong, but somewhat lower between FOM and MRI than between U-scanner and MRI. If using the U-scanner **after** the FOM and adjusting it exactly into the direction of the former probe channel of FOM (U-scanner II), the correlation between FOM and U-scanner increases slightly.

The correlations between the muscle measurements are considerably lower than between fat depth, FOM presenting the lowest correlations. Adjusting the U-scanner to the probe channel of FOM (U-scanner II), the correlation increases again.

Most important for the differences between methods are the mean deviations ($\bar{d}$) (Table 3, 4).

Table 3: Deviation of fat depth measurements of U-scanner and FOM from MRI measurement (n = 120)

method	$\bar{d}$	s_d
U-scanner I	0.06	1.17
FOM	0.35	1.50
U-scanner II	-0.47	1.21

Table 4: Deviation of muscle depth measurements of U-scanner and FOM from MRI measurement (n = 120)

method	$\bar{d}$	s_d
U-scanner I	1.7	2.74
FOM	1.8	3.47
U-scanner II	1.8	2.63

In the case of fat depth the U-scanner I is in almost complete accordance to MRI. Using the U-scanner after FOM (U-scanner II), a higher mean deviation from MRI results. With regard to the standard deviations it is obvious that they were greater in FOM than in U-Scanner I/II measurements.

In the muscle depth measurements there is less agreement. With respect to mean deviations U-scanner I/II and FOM yield nearly the same results, but the variance of the deviations of FOM is obviously higher.

Stratifying the data set according to fat or muscle depth doesn't give further informations (without table).

Prediction of lean meat content by the ultrasonic scanner

In trial II the actual lean meat content has been determined by complete physical dissection (EC-reference method). Thus the precision of estimation of lean meat content by U-scanning could be tested. For comparison the results of FOM are given in Table 5, too.

The accuracy of the two methods is very high, the results of U-scanner are somewhat better than those of FOM.

Table 5: Precision of estimates based on U-scanner and FOM measurements (n =393)

method	R	$s_{y.x}$
U-scanner 1.	.88	2.17
FOM 2.	.87	2.28

1. fat and muscle depths at 2./3.last rib
2. fat and muscle depths at 3./4.last rib

Comparison of single measurements of different grading probes with U-scanner.
Additionally, data of the single measurements of the three grading probes (FOM, HGP, Destron) from trial II were available. Contrary to trial I, in this experiment the carcases generally were measured in the normal hanging position. Every probe measured at its special location as described above. The results are shown in Table 6, 7.

Table 6: Comparison of three commercial grading probes with U-scanner - consistency of the **fat** depth measurements (n = 393)

method	r	$\bar{d}$	s_d
Destron	.92	1.66	1.86
FOM	.98	-1.02	1.00
HGP	.95	0.24	1.70

Table 7: Comparison of three commercial grading probes with U-scanner - consistency of the **muscle** depth measurements (n = 393)

method	r	$\bar{d}$	s_d
Destron	.71	-2.24	5.72
FOM	.91	-2.85	3.20
HGP	.88	-0.75	3.83

Again the fat depth measurements indicated higher consistency than the muscle depths. It's conspicuous that FOM has a high mean deviation despite of very high correlations and relatively lower variance of deviations. With HGP very low mean deviations occured but with respect to r and s_d it takes only a middle position. The correlation of Destron with the U-scanner is relatively low.

CONCLUSION

In a former study (BRANSCHEID et al., 1989) fundamentals of standardization of grading in the Federal Republic of Germany were prepared. As a result grading of pig carcases now will be based exclusively on fat and muscle depth measurements at the 2./3.last rib (7 cm beside the midline). Simultaneously all grading devices have to use the same prediction equation despite of their different technique of measurement. Thus, calibration of the devices with respect to their single measurements against a reference measurement is an essential prerequisite. The reference measurement should be taken with high precision and without any changes of the tissue depth measured. That's the reason why we tested non-invasive methods of measurement. The usefullness of these methods measuring body composition in live animals was revised by ALLEN and VANGEN (1989). Under in vivo conditions they stated some disadvantages of ultrasonic machines. Especially the accuracy in predicting protein, fat and energy content seems to be relatively low in comparison to computer tomography and magnetic reasonance imaging. In our study the ultrasonic scanner was used with somewhat different objectives, because it was intended to test the precision of tissue depth measurements exclusively.

Accordingly U-scanner measurements first were compared with MRI as reference. MRI itself presents best conditions for getting exact measurements in living animals as well as in hot carcases (GROENEVELD et al., 1988; ALLEN & VANGEN, 1989). The main limitation is, that MRI has to measure the carcases in a lying position. However, this fact should not influence the validity of the results presented in this study.

With respect to fat depth measurement a very high consistency between MRI and U-scanner can be observed. In comparison with the muscle depth measurements seem to be less accurate. Partially these problems are reflected in the low correlations to lean meat content described in the literature (SACK et al., 1981; PEDERSEN & BUSK, 1982; SACK, 1983; KÜCHENMEISTER & ENDER, 1984; SCHEPER et al., 1984; KEMPSTER & MONK, 1986; BRANSCHEID et al., 1989).

Measuring the muscle depth is more difficult because especially the transition from the loin muscle to the intercostal tissue is not exactly defined. This is true in the case of MRI as well as U-scanner. Therefore, the border line is determined by a certain subjectivity resulting in inevitable differences. So the question, which method is measuring the true value, remains open. Hence we conclude that the U-scanner is suitable for reference of fat as well as muscle thickness measurements, considering the lower importance

of muscle thickness for estimation of lean meat content.

This is confirmed by evaluation of estimation function based on U-scanner measurements with respect to precision of prediction of lean meat content. Under this aspect the U-scanner gives results with a higher precision than the common grading probes.

Additionally to the testing of the U-scanner with respect to its suitability as a reference system, we compared three commercial grading probes with U-scanner measurements, which are suitable for the future test situation for grading probes. The results demonstrate clearly that probes even giving highly precise estimates of lean meat content may show big mean deviations to the single measurements of U-scanner. Apparently, this depends on the fact that until now the single measurements have been important as a part of the estimation equation, only. Their suitability was expressed exclusively in terms of the precision of estimation of lean meat content. Now the probes should be tested with respect to their accordance with a reference measurement of the tissue depths. At least in a single aspect it is demonstrated that the probes could have higher precision of measurement than the simple comparison demonstrates: using the U-scanner after FOM and adjusting it exactly into the direction of the probe channel (U-scanner II in trial I) results in a certain improvement of consistency between both measurements. This effect is more obvious for muscle than fat depth measurements.

In summary the following conclusions may be drawn:

- The U-scanner measures muscle and fat depths more exactly and with higher accuracy than the common grading probes. It shows strong correlations to actual lean meat content and a high level of consistency to MRI measurements. Therefore the U-scanner undoubtedly is suitable as reference system for the respective tissue depth measurements.

- At the moment the common grading probes are showing partly considerable differences between their single measurements and the U-scanner measurements.

- Using a common estimation formula for all grading devices the agreement between technically different equipments depends mostly on the accordance with their single measurements. Thus, only small deviations between grading probe and U-scanner measurements, as a reference, will be allowed.

- Thus, congruent grading results and comparable price quotations may be guaranteed despite of technically different methods of grading.

- The provided test procedure may be an important step to better transparency of the German pork market.

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