# Methods and equipment for estimating carcass lean content in European countries

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# Methods and equipment for estimating carcass lean content in European countries

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*The estimation of carcass composition can be done with very different degrees of sophistication according to the technical and labour investment made. The oldest and still most accurate method is complete physical dissection of a carcass side into muscle, fat, bones and the rest. This is so labour intensive, however, that it can only be used for control samples of very limited size. The most sophisticated method, which can even be used for measuring live pigs, is computer tomography. This was originally done with X-rays but now uses nuclear magnetic resonance techniques.*

*These methods have not yet been completely investigated for all of their practical applications for animal breeding, which by far exceed the pure estimation of carcass or live body composition. In this paper, we will not deal with these methods, because for the near future they will not be used on slaughter lines or in many research institudes or testing stations, as the investment costs are still very high.*

*We will deal here with carcass composition estimates in research projects and in slaughter houses for carcass classification. We will deal briefly with estimate procedures in research experiments, where carcass measurements or partial dissection results are utilized in prediction equations. Our main interest, however, will be directed towards carcass evaluation methods on the slaughter line: under highly variable conditions, reliable results must be made quickly available given the major financial consequences for both market partners.*

## I - Estimation of carcass composition in scientific experiments and testing stations

Hammond (1933) and McMeekan (1941) pioneered the use of carcass dissection to find the most representative cuts and measurements for the tissue composition of whole carcasses. In more recent years, the British Meat and Livestock Commission and the Danish Pig Testing Board have done extensive carcass dissections in order to develop estimation equations for carcass composition of their sib station testing procedures. Evans and Kempster (1979) and Diestre and Kempster (1986) have published regression equations for lean percentages from data of 1,060 carcasses of nine genetic sources, both sexes, two feeding regimes and three slaughter weight classes from British CPE tests. These were compared with lean content of sample joints, with and without the best single backfat measurement $P_2$, (probe 6.5 cm dorsal of the midline at the last rib), in regression to total carcass lean percentage. With all joints, the inclusion of $P_2$ in a multiple regression improved the precision and, out of all seven joints, the ham, plus $P_2$ in a multiple regression offered the best compromise between cost of dissection and precision. This regression equation reached a correlation of r = 0.92 and a pooled residual standard deviation in estimating the carcass lean content of 1.25%. Particularly useful was the finding that the multiple regression slopes were stable over genotypes and sexes for all sample joints. For the ham, the intercepts were not significantly different between genotypes. The partial regression coefficients pooled for three slaughter weight classes were within genotype, sex and feeding regime:

| Live weight class | Intercept | Partial regression coefficient | |
|---|---|---|---|
| | | Ham | $P_2$ |
| Pork (61 kg) | 11.84 | 0.69 | - 2.3 |
| Bacon (91 kg) | 7.73 | 0.73 | - 1.7 |
| Heavy (118 kg) | 14.91 | 0.65 | - 2.1 |

In Germany, Schulte *et al.*(1979) analyzed 600 pigs of six diferent multiple crosses of which 116 were completely dissected. In completely dissected animals, the strongest correlation to lean content of the whole carcass (r = 0.88) was reached by the percentage of lean cuts without cover fat, but the ham without fat cover already reached r = 0.80. In comparison, the average backfat thickness on the split carcass had r = 0.49, the best side fat over the loin r = 0.68, and the lean fat area ratio at the cross section of the 12th rib, r = 0.77.

In all 600 animals only the percentage of prime cuts (without fat cover) was measured and here the ham percentage without fat cover reached the highest correlation of r = 0.88 compared with the lean fat area ratio of the cross section of r = 0.76. The authors developed multiple regression equations to estimate the lean content of the whole carcass with uncovered ham and two cross section measurements reaching r = 0.89 and a precision of $r^2$ = 79%. The authors concluded that, in testing stations and product evaluation tests, at least the ham should be weighed without fat cover. If only cross section measurements are available, as in German test station routine, the lean fat area ratio is the best single estimator of lean content in the carcass. Very interesting in this study was the fact that the whole ham weight (including the leg, as in the German station routine), only had a correlation of r = 0.43 to the lean content of the carcass and carcass length of virtually r = 0. There are many more dissection experiments in different countries but only a few results of very different pig populations were presented here as examples. A good reference of dissection methods and estimation equations is the EEC study by De Boer *et al.* (1979).

## II - Estimating carcass grade on the slaughter line

### 2.1. Grading on Backfat and Type

This is the traditional German interpretation of the EEC-grading scheme, which caused considerable problems in German pig breeding. The basic grouping into classes E, I, II, III and IV is on carcass weight and backfat thickness, but the grader can, according to subjective judgements of type or meatiness, classify carcasses one to three classes down. Subjective judgements of ham, loin and shoulder shape could override objective backfat measurements, although many investigations in various populations have clearly shown that shape and type scores are much less reliable than even very simple backfat measurements in estimating the real lean meat content of carcasses. The German practice turned out to be very convenient for slaughter houses, because the completely subjective type of classification by graders, which were their own employers, best matched the daily supplies with demands at the expenses of pig producers. But the negative results of this procedure were that all pigs were underpaid (Schmitten, 1980) by increasing amounts, price distances between classes went up all the time and reached more than three times as much as in Holland or Denmark. Meat quality also deteriorated in alarming dimensions because only Belgian type breeds could fulfill the high standards.

### 2.2. Grading on objective backfat and muscle measurements

1) Simple Backfat Probes

The old $P_2$ probe measurements, recommended by Kempster and Evans (1979), were significantly more accurate in estimating the carcass lean content than any backfat measurements at the split carcass. But the optical probe was inferior to the modern automatic Hennessy grading probe and the Danish Fat-O-Meater instrument as Kempster *et al.* (1981) proved, even under British conditions. We will therefore not deal in any detail with the simple optical probe.

2) Automatic Fat - and Muscle Probes

With the Danish KSA, a new generation of automatic carcass probes started and was mainly developed and promoted by Danish research institutes. Since the KSA was quickly replaced by the FOM of the same company, we will not deal with the international research results of the KSA but concentrate on the new automatic FOM probes and its competitor from New Zealand, the Hennessy Grading Probe (HGP). Large experimental comparisons of these two were made in Britain by Kempster *et al.* (1985) with the simple optical probe and in Germany by Scheper *et al.* (1983) (see also Kallweit and Averdunk, 1984), who compared them with a new German development, the SKG, which will be discussed in detail in the next section. Among the many other experimental tests, which cannot all be discussed here, Desmoulin *et al.* (1984) in France, Hansson (1980) in Sweden and Seidler *et al.* (1984) in Germany, may be mentioned.

The British Meat and Livestock Commission has tested the HGP on 4,642 carcasses and the FOM on 5,760 carcasses from nine slaughter houses and both on 130 fully dissected carcasses. The residual standard deviations for the prediction of carcass lean content in g/kg for the two automatic probes in comparison with the simple optical probe are given in **Table 1**.

The authors also present multiple regression equations for both automatic probes and conclude from their results:"If muscle measurements are included in the estimation, the FOM is the most accurate device, but its superiority to HGP is not large enough to discount the HGP probe". But there seemed to be indications of abattoir-probe interactions, which show that personnel has to be trained well enough even with so-called automatic probe devices.

In Germany, two experiments at the same abattoir were conducted in which the KSA, FOM and the new German probe SKG I were compared with the traditional method of classification on 900 pigs (of which 450 were dissected into lean, fat and bones) from three different types (DL, PI * DL, BHZP) in Part I; and FOM, HGP and SKG I on 1,555, randomly selected pigs without type identification in Part II. Where as in Part I the exact comparison between estimate and real lean content was the main objective, in Part II the practicability under typical slaughter house conditions was also tested. In both tests, the internal standard regression equations of the instruments were used, but from the data of the test, new and better fitted regression equations were also developed and applied to the same data. This procedure caused bitter discussions later on. The results from part I of the comparison are given in **Table 2**.

In comparison, the residual errors of five different subjective classifications with the traditional German method ranged between 3.14-3.67%.

The differences between pig types in this experiment as bias to the dissected lean content and error of estimate are given in **Table 3**.

In the second part of the experiment, the HGP-probe was compared with FOM and SKG. The residual estimate errors are given in **Table 4**.

The general conclusions from these results were:

- all internal formulae were not well adapted to the pig sample of the test market in Hannover, but it remained doubtful whether it was at all a representative market for Germany.

- with the adapted formulae the FOM was by far the most accurate device even over the wide range of pig types and carcass weights included in experiment I.

- the SKG, a device which also included type measurements to some extent, was in no instance better than HGP and FOM, which ignore type aspects completely.

**2.3. Grading on Lean Content and Type**

Despite nearly all experimental findings in Britain (Kempster and Evans, 1981), and the German results just described, there is still a strong movement towards including additional type scores again in carcass classification. This is mainly advocated by carcass wholesalers and butchers, who of course would like to have another subjective downgrading instrument, as with the old EEC-grading system. Unfortunately, one of the most deserving experts of EEC-carcass grading research, Dr. De Boer from Holland, has also recently promoted this idea in the light of some experimental findings with extreme Belgian type carcasses (De Boer, 1984). This was probably more a result of his desire to apply common general grading principles for all species of cattle, sheep and pigs.

In order to accomplish this objectively in pig grading, the Breitsameter-SKG-system was developed in Germany. The idea was to have a totally automatic video-electronic estimate of the following four parameters of a carcass: backfat thickness at the loin of split carcass, the greatest ham width, the ham angle and the smallest width of waist. With these measurements, internal formulae estimated the true carcass lean content at the precision levels given in **Tables 2, 3** and **4**. It is true that the formulae had to be changed several times, and in the official machine testing only a revised version with hardly any weight on the type measurements got the license. In the meantime, SKG has also incorporated FOM-like backfat probes in order to stay in business. My conclusion from the very unpleasant SKG story is that the whole system - by far the most expensive of all - is not at all necessary. This is because all the type variables do not contribute much but cause a lot of disturbances in the practical application, without ever reaching the same precision in predicting the lean content of a carcass as FOM.

### 2.4. Estimation of lean content and meat quality for carcass grading

The experience in Germany of a drastically deteriorating meat quality due to an extreme type of classification can be seen from the data of a national study by Averdunk *et al.* (1983a) in **Table 5**.

If meat quality on German markets is going to be improved in the future, this trend can only be broken by ignoring type in classification and - even more successful - by incorporating meat quality measurements in the grading procedure as Pedersen (1984) has proposed. There are some interesting experiments with a Danish Meat Quality Probe (Barton-Gade and Olsen, 1984), and FOM-reflexion values by Sack *et al.* (1984) at the BAFF in Germany. This may soon lead to combined lean content and meat quality probes at the slaughterline. In Germany, Seidler *et al.* (1984a) have discussed the practicability of methods for measuring meat quality at the slaughter line and proposed the MS-Testron method for measuring the dielectric loss factor (d-value), instead of $pH_1$-values for the slaughter house application (Seidler and Thunel, 1983). In addition, Schmitten (1985) has promoted conductibility measurements as a useful tool to discriminate between normal and PSE-carcasses at the slaughter line, which are already in experimental use in some German slaughter houses.

The measuring techniques are fairly developed and should be applied at markets for the benefit of consumers who must be educated on what real meat quality is. This would also benefit producers who could thereby keep their market shares and also use more profitable breeding stocks in the future.

## III- Discussion and conclusions

Carcass grading provides the basis for payment in most developed countries and therefore decides the income a pig farmer earns. Although income over cost is deciding the profitability of pig production, most farmers, particularly small and poorly organized farmers, tend to overrate the obvious income because they have no accurate figures of their production costs. This is why incorrect or deliberately wrong grading on the market gives misleading signals to breeding policy, as has been shown for Germany, among others by Schmitten (1980). Glodek (1985) has pointed out that such market signals must include lean content and meat quality and that "type" or "shape" not only lacked an own direct value but also played a major indirect role in deteriorating viability of pigs and eating qualities of pig meat. Bichard (1984) has dealt with the relative importance of carcass traits in a worldwide framework and points to the importance of lean content and carcass weight. Whether grading schemes are important in the future, Bichard finds depends on the production structure and the degree of integration between pig producers and carcass buyers. If producers are very big (as is the case in Yugoslavia) or are integrated into large supplier organizations, (as the EEC promoted producer co-operations), then they may have mutual contracts with the large carcass buyers on their whole output and both may even cooperate in specifying breeding and production goals as well as data collection for its realization.

Individual carcass grading will, however, be the rule where producers want to continue their individual independence to sell to different buyers according to daily or weekly price changes. This is still the case in most Western European countries. Under such conditions, the following requirements, which have been selected from a much longer list by Kallweit and Averdunk (1984) should be imposed on any grading scheme:

– Carcass, or also live pig, grades must agree with the overall carcass value, including quantitative, e.g. lean content, and quality aspects and sometimes even technological requirements, weight, length etc.;

– Grades must be determined by objective and repeatable measurements only, and these should be documented;

– If grading machines and complicated estimation formulae are to be used, these must undergo official approval and/or calibration with any manipulation by operators being impossible;

– Under present Western European market conditions, where lean content and meat quality are the most important carcass traits, semi-automatic probe systems like the Danish FOM and the HGP seem to best fulfil these requirements for slaughter houses that are not too small.

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**Table 1: Residual standard error of estimating carcass lean content in British MLC-experiment**

| Measuring position | | OP | FOM | | HGP | |
|---|---|---|---|---|---|---|
| | | Fat thickness | Fat thickness | Fat and muscle thickness | Fat thickness | Fat and muscle thickness |
| Last rib (LR) | a | 30.8 | 36.0 | 36.1 | 40.9 | 40.2* |
| | b | 30.8 | 37.1 | 36.8 | 40.6 | 39.9* |
| 3rd/4th from last rib (3/4 LR) | a | 30.8 | 31.5 | 28.8** | 37.2 | 36.3** |
| | b | 30.8 | 31.4 | 29.1** | 36.6 | 35.9* |

a = within abattoir estimate
b = overall

**Table 2: Residual standard error of estimating carcass lean content in German experiment**

| Instrument | % lean content carcass | |
|---|---|---|
| | Old formula | New formula |
| KSA | 2.86 | 2.26 |
| FOM | 2.43 | 2.13 |
| SKG | 2.99 | 2.72 |

**Table 3: Bias and estimation error of FOM and SKG in three pig types (Experiment I)**

| Instrument | Pig-Type | Dissection | | Old formula | | New formula | |
|---|---|---|---|---|---|---|---|
| | | n | Lean % | ± Bias | Error | ± Bias | Error |
| FOM | DL | 147 | 50.6 | +2.78 | 2.26 | +0.80 | 2.00 |
| | PI * DL | 153 | 52.1 | +1.70 | 2.26 | -0.36 | 1.95 |
| | BHZP | 147 | 52.1 | +1.42 | 2.57 | -0.42 | 2.23 |
| Total | | 447 | 51.6 | +1.97 | 2.43 | 0.00 | 2.13 |
| SKG | DL | 146 | 50.2 | +1.10 | 2.91 | +0.65 | 2.58 |
| | PI * DL | 149 | 52.0 | +0.71 | 2.45 | -0.28 | 2.34 |
| | BHZP | 142 | 52.0 | - 0.63 | 3.35 | -0.37 | 3.03 |
| Total | | 437 | 51.5 | +0.44 | 2.99 | 0.00 | 2.70 |

DL : German Landrace; PI : Piétrain ; BHZP : German Hybrid

**Table 4: Residual standard error of estimating carcass lean content in German experiment II**

| Instrument | n | % lean content carcass | |
|---|---|---|---|
| | | Old formula | New formula |
| FOM | 940 | 1.94 | 1.74 |
| HGP | 759 | 2.55 | 2.32 |
| SKG | 437 | 2.90 | 2.52 |

**Table 5: Meat quality on German markets according to type grading classes**

| Grading class | Average $pH_1$ | % $pH_1 < 5.8$ (= PSE) |
|---|---|---|
| E | 5.65 | 77 |
| I A | 5.78 | 61 |
| I B | 6.03 | 32 |
| II A | 5.71 | 72 |
| I C | 6.17 | 17 |
| II B | 6.02 | 31 |
| III A | 5.72 | 67 |
| All Type A | 5.72 | 69 |
| All Type B | 6.03 | 31 |
| All Type C | 6.17 | 17 |
| Mean | 5.89 | 48 |

$PH_1$: PH, one hour after slaughter