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CONSIDERATIONS REGARDING CONTROL MEASURING IN CONNECTION WITH AUTOMATIC MEASURING OF FAT- AND MEAT THICKNESS WITH THE DANISH OPTICAL PROBE.

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SUMMARY.

By automatic measuring of the fat- and meat thickness on the basis of reflection profiles a reference measure is necessary, partly for developing of algorithem and partly for control and determination of measuring error.

A modified fat-periscope was chosen as the fundamental reference measuring equipment. The algorithem is developed by means of profiles determined by a manual equipment with the same measuring principle as the automatic one and tested with the reference measurement of the fat-periscope probe.

Tests have shown that profile measuring is not completely reproducible, as a systematic difference of 0.4 mm (std = 1.4 mm) has been found between the calculation of the fat thickness from two consecutive profile determinations at the same insertion point, and a systematic difference of 1.5 mm (std. = 2.0 mm) between the calculated fat thickness and the control measurement with a fat-periscope probe.

A manual profile determination combined with a fat-periscope probe is in spite of proved deviations the best reference method for the automatic measuring equipment.

INTRODUCTION

The thickness of the fat-layer on the longissimus dorsi muscle and the thickness of the muscle itself has been used for many years as an indication of the meat content of a carcass.

Various measuring systems are used for determination of relevant thickness measurements.

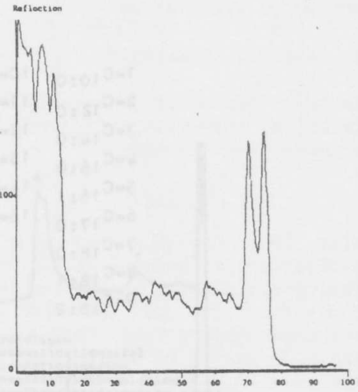
In Denmark a fat-periscope was used, where the fat-thickness was determined by visual reading, later on the present MFA-system (1) was taken into use, which is based on the principle of the conductance.

The F-o-Meater, which is used in several European countries, is based on the principle of light reflection. This principle is also used in the new automatic measuring equipment, which at present is under development and testing in Denmark.

The measuring equipment will automatically make an anatomic measuring for positioning and insertion of 18 measuring probes for determination of especially the thickness of the fat layer at various places on the carcass.

By means of the Danish probe (2) a reflection profile over more than 100 mm can be determined. As fat reflects more light than meat, the profile can be used to determine the thickness of e.g. the fat layer on the long. dorsi muscle and the thickness of the long. dorsi muscle itself.

Figure 1. An example of a reflection profile from the long. dorsi muscle.



The conditions for measuring and interpretation of the profile to be carried out automatically are:

1. Certain determination of insertion point in relation to the anatomic characteristics.

2. A good knowledge of the variation of the types of profiles (dimensions, effect of varying meat quality etc.).

3. A reference measurement, partly for interpretation of the profiles in the development of EDB-programmes, and partly as a tool for determination of measuring error.

In the following, problems in connection with reference measurement and measuring error, will be focused on.

FUNDAMENTAL REFERENCE MEASURE.

An obvious way to get a reference measurement is to make an incision on the spot, where the reflection profile has been taken, and measure the fat thickness and the muscle thickness. The method was used to a small extent early in the phase of development. For practical reasons the incision is made on the cold carcass, and the measurement on a photo of the incision surface.

The method has both disadvantages and advantages:

Disadvantages:

- it is expensive and slow

- the measurement is not made under the same conditions under which the profile is taken (warm hanging and cold cut up carcass)

- it is difficult to place the incision exactly where the profile was taken.

Advantages:

- contrast between fat and meat is larger on the cold carcass than on the warm carcass, and hereby the measurement can be made with a small measuring error.

In connection with the development of a classification system for sows the thickness of the fat on the long. dorsi muscle was among other things determined and a good linear correlation was found to the above mentioned control measuring (r = 0.91). But the thickness determined from the profiles was found to be approx. 0.5 mm larger than the control measurement in light sows and approx. 3 mm less in heavy sows. It is unknown, how large the effect is in the lower weight interval valid for slaughter pigs, for which the automatic measuring system is intended.

Another, and the most weighty reason to consider an alternative control measuring system was the limitation of the number of measurements, which could be carried out with a reasonable use of resources.

FAT-PERISCOPE PROBE. The old method, where the thickness of the fat-layer is read off visually using a fat-periscope probe was resumed again. But the existing instrument, which was developed in the 1960's, has too large a diameter (12 - 13 mm) and too short a measuring interval (20 - 50 mm). Existing endoscopes appeared not to be suitable either, as there cannot be focused on items, which are placed close up to the measuring opening. This resulted in a new fat-periscope probe being developed in accordance with the old principles, but with new optical components. The diameter and the measuring area of the tube were the same as for the optical probe (o.d. 6 mm and length 100 mm).

The end of the tube is round, so that the fat-periscope probe can be inserted in the hole, which is made by profile measuring, without further cutting in the carcass, and in this way ensures that the control measurement is carried out in accordance with the profile.

Preliminary tests showed that, after a short training period, reproducible measurements can be obtained in well defined insertion points with small measuring error both on repeated measuring with the same operator and repeated measuring with several operators. The variationen between repetitions is of the order of (std =) 0.3 - 0.9 mm, depending on where on the carcass the measurement is made.

The measurements are partly made 3 places in the long. dorsi muscle (with the smallest measuring error), but also several places in the ham, the fore-end and the belly. Measurement in areas, where the muscles are thin e.g. pork belly, is subject to the largest measuring error and with largest influence from the operator, as the window is too small for a detailed reading, so that a subjective estimate will often be included in the reading.

Disadvantages:
- it does not operate well in it's present version (it is a strain on the eyes)

- it can usually not be used with PSE-meat, as the frictional resistance is so large that movements occur in jerks, and the contrast between meat and fat is small.

- operator-dependent readings especially when measuring in areas with thin muscles.

Advantages:
- reference measurement taken under the same conditions and at the same place as the profile (warm hanging carcass, and insertion of fat-periscope probe in the hole from the measuring probe)

- relatively inexpensive and quick.

Experience from the first series of measurements will be used to give reading instructions, so that the operator effect can be reduced at the difficult measuring points.

MANUAL PROFILE MEASURING.

New algorithems, which automatically extract the required information on the fat- and possible meat/total thickness of the reflection profiles, are being developed and tested.

As insertions, calculations, and evaluation of the measuring results are to be carried out automatically, it is important that the algorithems are robust over the whole variation spectrum for profiles.

Profiles taken in the correct insertion points in the carcasses with a large contrast between meat and fat, and where muscles and intermuscular fat do not have too small an extent, are relatively simple to treat.

Problems MAY arise, if one or several of the above mentioned conditions are missing. Therefore a large experimental material is necessary as well as a "key" in the form of control measurements, so that a decision scheme can be developed for use in the automatic treatment and calculation of profiles, which are atypical.

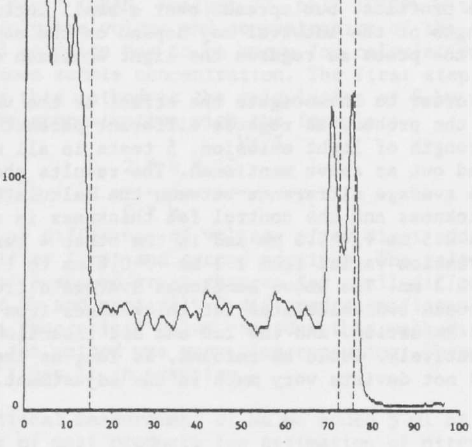
Before the automatic equipment was ready for testing, a number of measurements were made in order to obtain a sufficiently large knowledge of profile variations at different insertion points. The profile determination was carried out with a manual equipment using the same measuring principle as the automatic equipment.

After the profile measurements the relevant thicknesses were measured with a fat-periscope probe.

RESULTS OF THE PRELIMINARY EXPERIMENTS.

Generally there is good agreement between the profile and the corresponding control measurements. However, the fat thickness is usually determined to be larger with the control measurement than the profile shows, a relation which must be expected, as the position- or depth measuring device is different technically on the two instruments. The position- or depth measuring devise consist in both cases of a spring tensioned hollow disk, which comes into contact with the carcass, when the probe and the fat-periscope, respectively, are inserted.

Figure 2. Reflection profile with indication of control thicknesses.



The position of the disk in relation to the measuring opening is read either automatically or by visual reading, and the size of the hollow disk and the spring tension are different on the two instruments. This causes the basis for the thickness measurement to deviate a little from each other, and thus affects the determination of e.g. the fat thickness.

Part of the reason for the difference between the two thickness measurements can, however, be traced to the measuring media. The warm meat and fat are elastic and even if the profile is determined, when the probe is drawn out of the carcass - i.e. when the hole has been made, there will be more friction especially from the meat on the first withdrawal (profile measurement) than during the following measurement with the fat-periscope probe in the same hole.

This can be seen from a reproducibility test for profile measurements, which was carried out in connection with another experiment. The test was arranged so that 3 profiles were determined in the same hole with 2 probes, so that two successive measurements were made with probe A - 1st and 2nd insertion and 2nd and 3rd insertion, respectively, and 1st and 3rd insertion, respectively, were made with probe B.

The measuring series were carried out on 52 carcasses with varying degrees of fatness, so that there were 82 and 75, respectively, sets of 3 profiles from the long. dorsi muscle.

The average difference between the calculated fat thicknesses on basis of the profiles from 1st and 2nd insertion in the same hole with the same probe (A) is 0.4 mm with a 95% certainty interval: 0.1 - 0.7 mm, and is thus significantly different from 0. There is no significant difference between the 2nd and the 3rd insertion, where the average difference is -0.2 mm with a 95% certainty interval: -0.7 - 0.3 mm.

If the calculated fat thickness (1st insertion) is set in relation to the control thickness (determined in the same hole after the 3 profile determinations) an average difference of 1.6 mm with a 95% certainty interval: 1.3 - 2.0 mm is obtained, where the control fat thickness is largest, and shows a significant difference, which can be traced partly to characteristics of the two measuring methods, and partly to the succession of insertions.

The two measuring methods deviate from the above mentioned difference in the depth measuring device also by different evaluation of the transition between meat and fat. The transition is not sharp on the profiles, but spreads over a small interval. The length of the interval may depend on the adjustment of the probe as regards the light emission etc.

In order to investigate the effect of the variation of the probes, as regards different parameters, i.e. strength of light emission, 5 tests in all were carried out as above mentioned. The results showed that the average difference between the calculated fat thickness and the control fat thickness in one test was 0.5 mm +/- 0.3 mm and in the other 4 tests the deviation varied from 1.3 mm +/-0.6 mm to 1.6 mm +/-0.3 mm. The above mentioned average difference between two calculated fat thicknesses from 1st and 2nd insertion, and the 2nd and 3rd insertion, respectively, could be refound, as long as the probes did not deviate very much in the adjustment.

The apparently good accordance with the control measurement in one test is probably not real. The probes in this test gives profiles with the least contrast between fat and meat, and can be expected as a result of this to be the least suitable for the determination of fat thickness.

As the other four tests show results, which do not deviate significantly from each other, it is concluded that it in reality is more a deviation than a better agreement.

The standard deviation of the difference between the control fat thickness and the calculated fat thickness was of the order of 2.0 mm, while the standard deviation for the difference between two calculated fat thicknesses is of the order of 1.0 - 1.5 mm.

CONCLUSION

The tests have shown that a warm carcass is such that measurement of e.g. the fat thickness by means of profile measurement cannot be completely reproduced and controlled, but will be encumbered with a small systematic deviation. However, the random deviation is satisfying.

Even though the ascertained systematic deviations may seem small:

- a difference between 1st and 2nd insertion of approx. 0.4 mm

- a difference between 1st insertion and control measurement of approx. 1.5 mm, with the chosen adjustment of the light emission etc. for the probe,

it is necessary to be careful with the different parameters, which may influence the measuring results, as even small systematic errors have large consequences, when they later on are used for the prediction of the meat content.

The existence of systematic deviations between primary measuring and reference - or control measurement need not have practical consequences as long as they are known. It is thus possible to show possible changes over a period of time or possible differences between various sets of equipment.

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