FURTHER DEVELOPMENT OF THE MQM-EQUIPMENT FOR MEASURING WATER HOLDING CAPACITY AND INTRAMUSCULAR FAT ON-LINE

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INTRODUCTION

In Denmark great efforts were made over a number of years in order to minimize the occurrence of PSE (PSE= pale, soft, exudative meat, i.e. muscles with poor water holding capacity and consequently low soluble protein concentrations (see below)in pork meat. These efforts have been successful in removing stress susceptible animals from the Danish pig breeding programme.

The breeding work combined with improvements in the treatment of pigs immediately prior to slaughter has resulted in a reduction in PSE frequency in Denmark to levels of about 5 pct in the longissimus dorsi and 8 pct in the biceps femoris muscle on a yearly basis. (Muscles with soluble sarcoplasmic and myofibrillar protein concentrations below 0.15 AU/g as determined by the Biuret method are identified as PSE).

As the Danish meat industry wishes to deliver superior quality pork products to consumers around the world, it is necessary to be able to sort out the poor quality PSE meat. Another quality factor of major importance is the intramuscular fat (IMF) content. The ability to deliver meat according to IMF content would constitute a significant advantage for the industry.

Development of an instrument for the rapid determination of PSE and IMF in pork has had high priority for the Danish meat industry in the past 10 years.

An instrument known as the MQM (meat quality, marbling) was developed by the Danish Meat Research Institute in the mid 80'ties and it has been deployed mainly in the breeding program and for research purposes.

The equipment has recently been greatly improved. The new version called MQM mk.II differs from the old MQM in several ways.

1. The probes now used are of better quality than those used in the earlier version of the MQM.

2. Signal conversion is much less noisy in the new version.

3. A standard PC is now being used for performing calculations. This gives greater flexibility in modifying software to meet individual requirements.

4. Use of multivariable statistical techniques (partial least squares) have produced a more robust algorithm for predicting laboratory results.

5. New stability checking techniques have been developed for the instrument making it possible to compare results between instruments.

INSTRUMENTATION

The MQM mk.II consists of the following items:

1. Hand held pistol for measuring.

   The unit contains a stainless steel probe 6mm in diameter. A knife is mounted on the tip for easy insertion into the carcass.

   Near the tip a light emitting diode (centre wavelength: 945 nm) embedded in an epoxy resin is positioned. It sends light perpendicular to the line of insertion into the carcass.

The amount of reflected light is then measured by a detector which is also embedded in the epoxy, separated from the light emitting diode by an optical wall (see Figure 1).

Individual reflection data are presented to the calculating unit as positive numbers between 0 and 255.

The pistol also contains a system for continuous measurement of the depth of insertion into the carcass. This makes it possible to measure the reflection values for every 0.125 mm inside the carcass.

Finally, the pistol has a 7 digit display for passing information to the operator.

2. A data processing unit.

For this purpose a standard IBM AT compatible PC is used. The Danish Meat Research Institute has chosen a COMPAQ SLT/286 as it is small and has a very low energy consumption. This PC can be placed in an aluminium case (about the size of a small suitcase) together with the power supplies for the pistol and PC. The case also contains the pistol-PC interfacing unit (the RS232 is used for this purpose).

A built-in ventilator removes excess heat from the case. Connections to external power mains and to the pistol are provided through the sides of the aluminum case. Measurements can consequently be made with the processing unit in a closed splash-proof casing.

For more demanding communications with the processing unit it is possible to add a water-proof industrial keyboard. This is convenient when it is necessary to save extra information such as carcass identification numbers prior to measurements.

THE PROFILE (RAW-DATA)

A typical reflection profile from the longissimus dorsi muscle is shown in figure 2. The profile is interpreted from the left towards the right in the following way:

from 0 to 13mm:
In this region very low (or zero) reflection values are obtained as the detector has not yet entered the carcass.

from 13 to 26mm:
The high reflection values in this region correspond to the detector passing through the layer of back-fat.

from 26 to 100mm:
In this region the probe is passing through the lean. We see that the reflection level in this part of the profile is much lower than in the back-fat.

Furthermore we can see the small spikes on this part of the profile corresponding to marbling fat.

THE SOFTWARE

In order to calculate the water holding capacity / soluble protein content - and the IMF content in the lean it is necessary to find the transition between fat and lean on the profile. When this is done calculations can be made on the relevant (lean) part of the profile. In figure 2 the lean part is found between the 26 mm mark and 100 mm.

After a mathematical preprocessing the profile of the lean is used as input for a statistical (partial least squares) treatment together with laboratory values for IMF-content (sox-tec H^+) and WHC/soluble protein content (Biuret method).

The results of the calculation with the standard software are the following:

1. The average reflection value in

indicator for the homogeneity of the lean.

2. A measure of the variation of the reflection values across the profile. This can be used as an the muscle.

3. A direct prediction of the soluble protein content as determined in the laboratory by the Biuret method.

4. A direct prediction of the IMF. Due to inhomogenieties in the meat, results are given only after two insertions have been made in the same region.

THE RESULTS

WHC

At present software has been developed enabling measurements to be made in the longissimus dorsi muscle between the 2nd and 3rd lumbar vertebræ, and in the middle part of the biceps femoris muscle perpendicular to the surface. It is possible to develop software for a wide range of measuring points in the pig carcass.

In Denmark measurements are presently carried out 24 hours after slaughter. However, it has been shown that measurements concerning identification of PSE can be carried out as early as 2 hours after slaughter, still maintaining a satisfactory confidence level in the sorting capability.

Figure 3 shows the calculated soluble protein content from the reflection-profile compared with the laboratory values for 252 biceps femoris muscles. This plot contains only validation data,- calibration has been done on another data set.

R^2 values for the prediction of WHC are typically better than 0.81 for both longissimus dorsi and biceps femoris muscles.

In Figure 4 the reproducibility of the measurements are tested. Measurements with two different probes were carried out on 54 loins. The predicted soluble protein content with probe no. 1 is plotted versus the predictions using probe nr 2. The distance between the to probe insertions is approx. 5 cm.

In inter-probe plots R^2 values of 0.90 or better are commonly seen.

IMF

At the present stage of development surprisingly good results have been achieved using the MQM mk.II to predict the IMF content in the longissimus dorsi muscle.

In figure 5 is shown the predicted IMF content versus the laboratory determined (sox-tec H^+) fat content of the lean for 49 loins. It should be emphasized that this is a plot of the calibration set used in building the model for determining the IMF with the MQM mk.II. (Validation was done using a cross validation technique).

It must also be pointed out that the calibration set is not a flat distribution across the range of IMF being modelled, thus conditions for building a model are far from optimal.

Validation was carried out using only predictions based on single measurements. The results are seen in figure 6. The R^2 is 0.69 .

Because of the inhomogeneity of the marbling, R^2 should increase by performing calculations on the basis of two insertions rather than one.

FUTURE DEVELOPMENTS

As a standard IBM AT 3 compatible PC is used for processing the profile data, the MQM mk.II possesses a great deal of flexibility. The software can easily be modified to suit the needs of any meat processing plant or research institute.

Furthermore, encouraging results have been achieved using multivariable calibration techniques.

At the Danish Meat Research Institute several future developments are foreseen:

1. Extension of the range of IMF measurements. At present, only limited amounts of profile-data from carcasses with IMF content > 3% have been collected.
2. Measurement of IMF on the killing line i.e. on the warm carcasses.
3. Detection of localized PSE-phenomena causing severe problems in the meat processing industry.
4. Measurement of IMF content in veal and beef.

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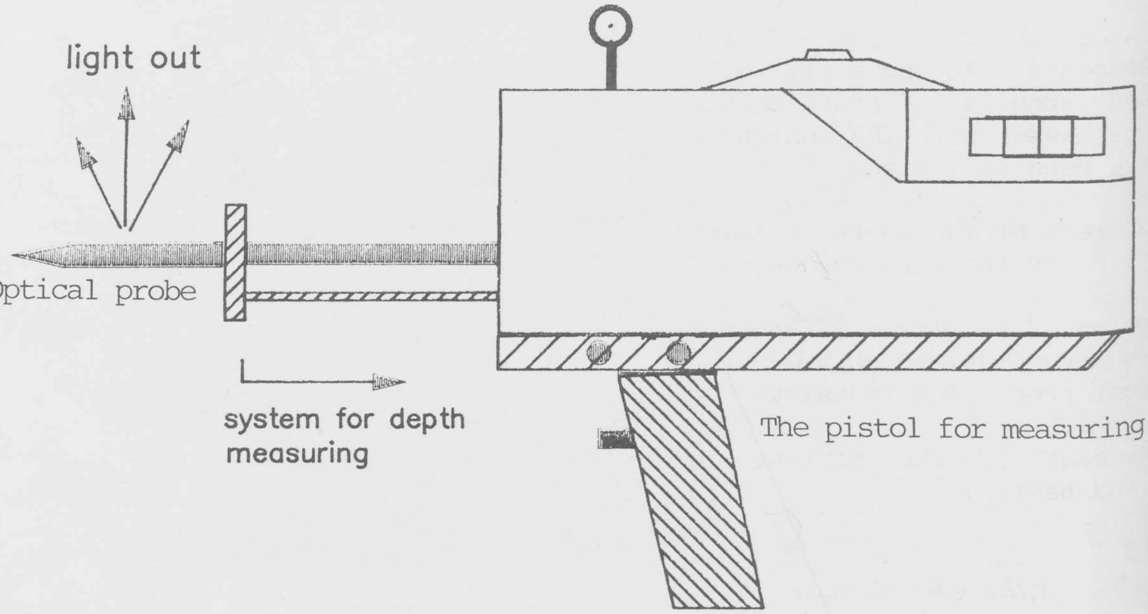
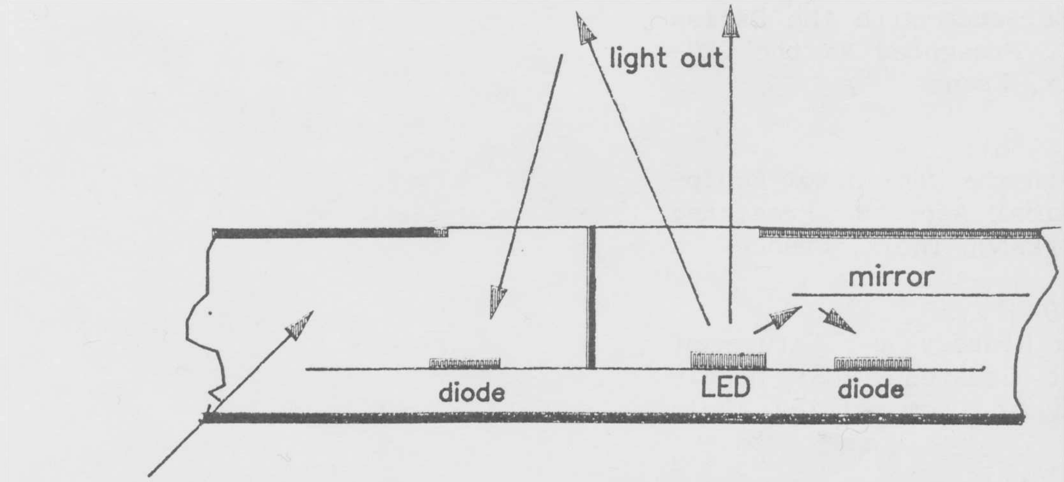
FIGURE 1.





cross section
of
optical probe

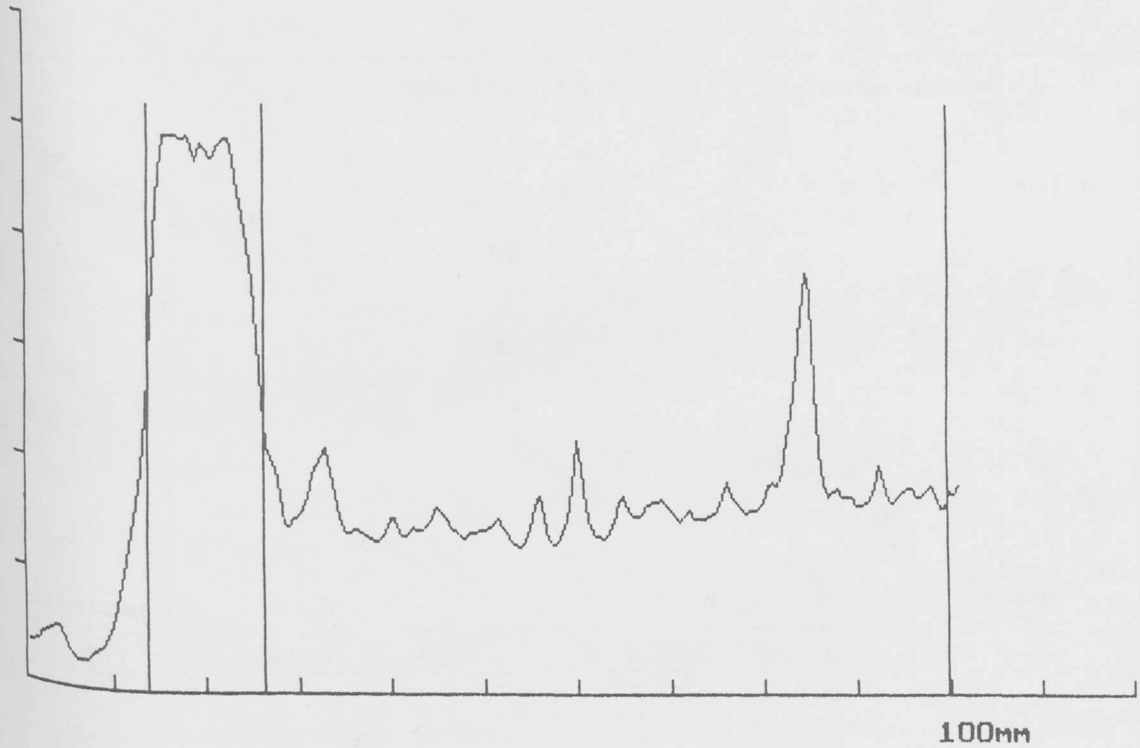


figure 2

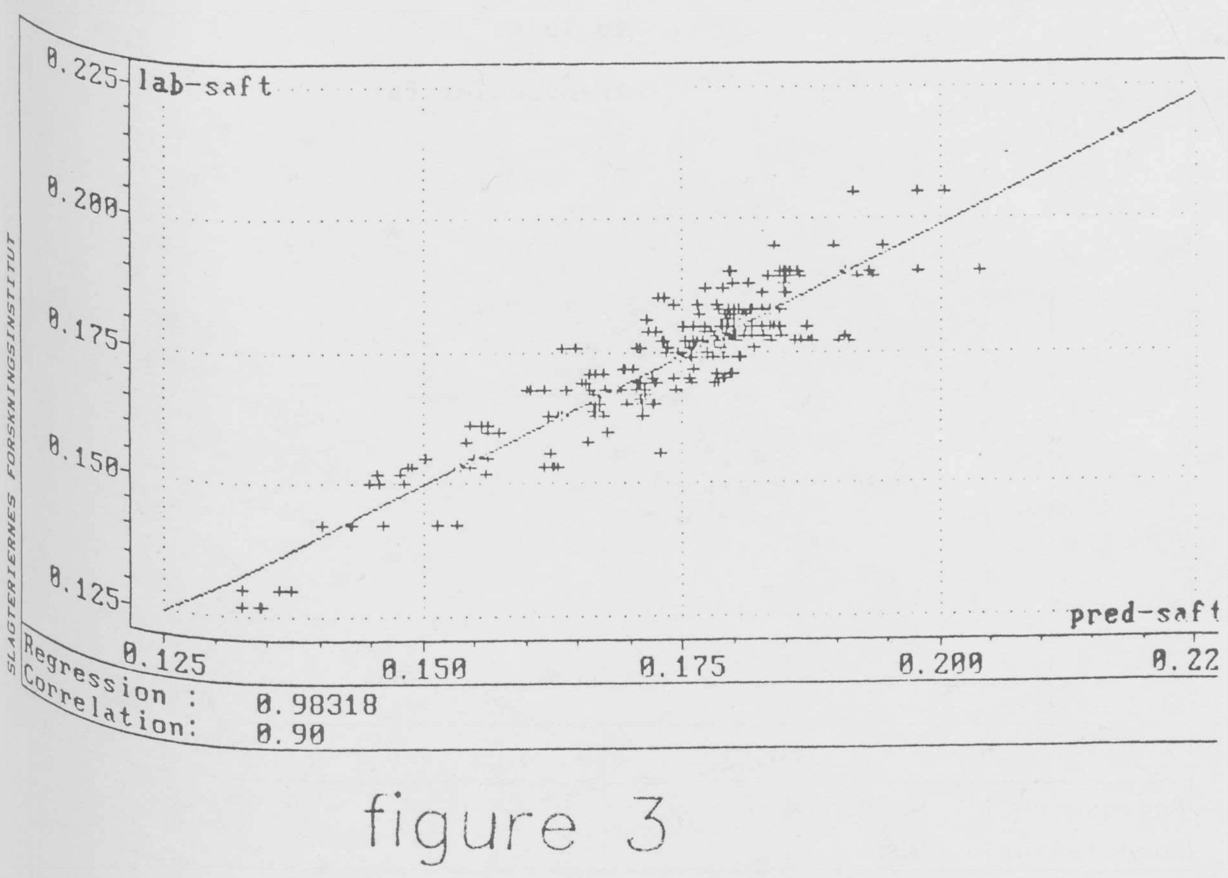


figure 3

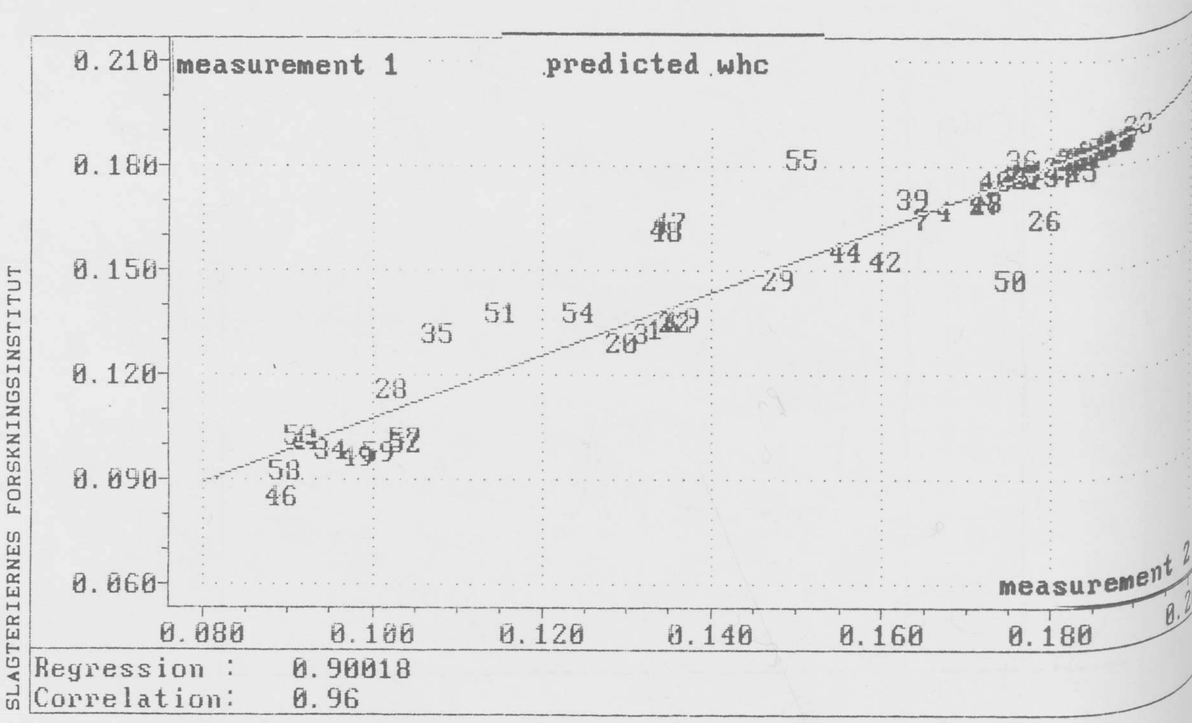


figure 4

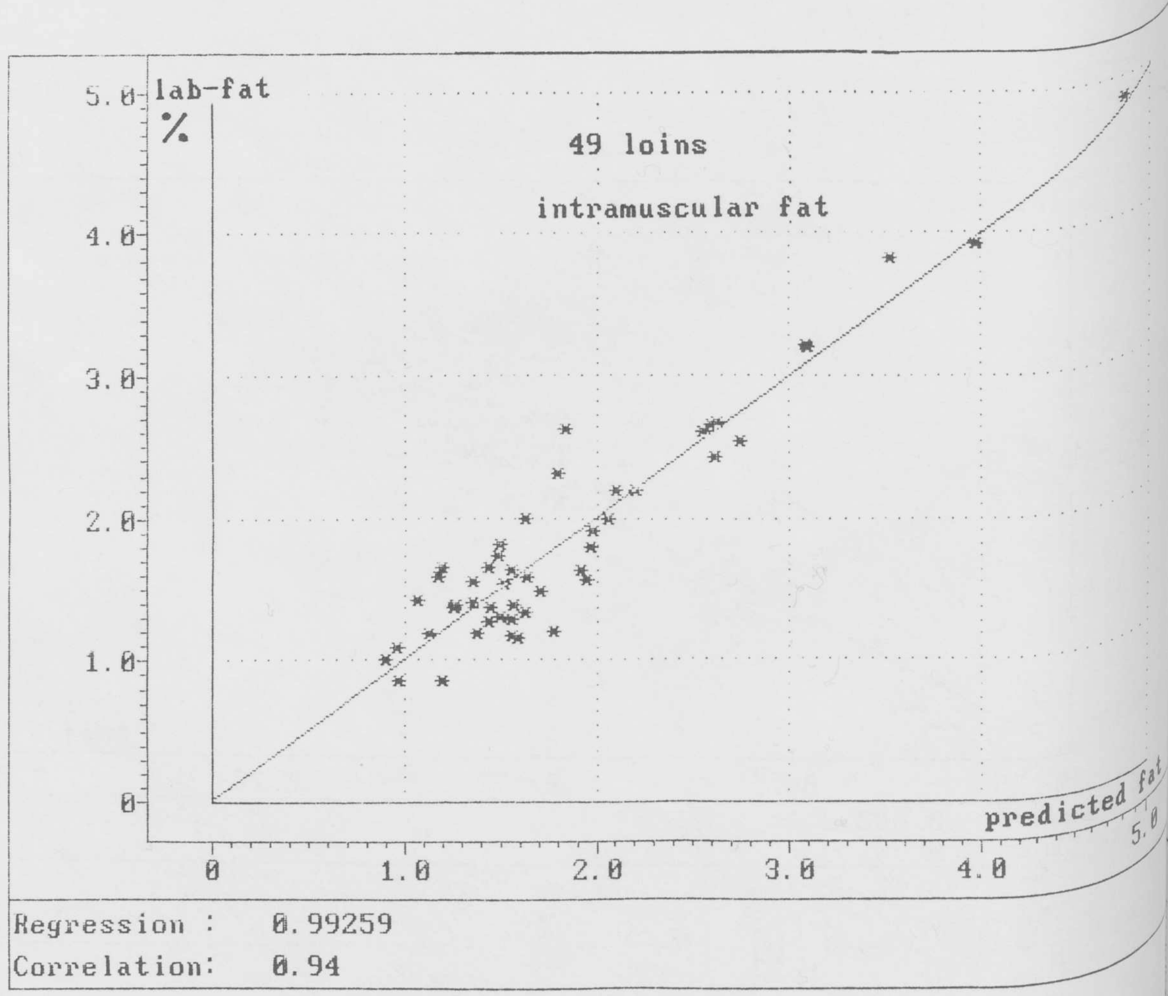


figure 5

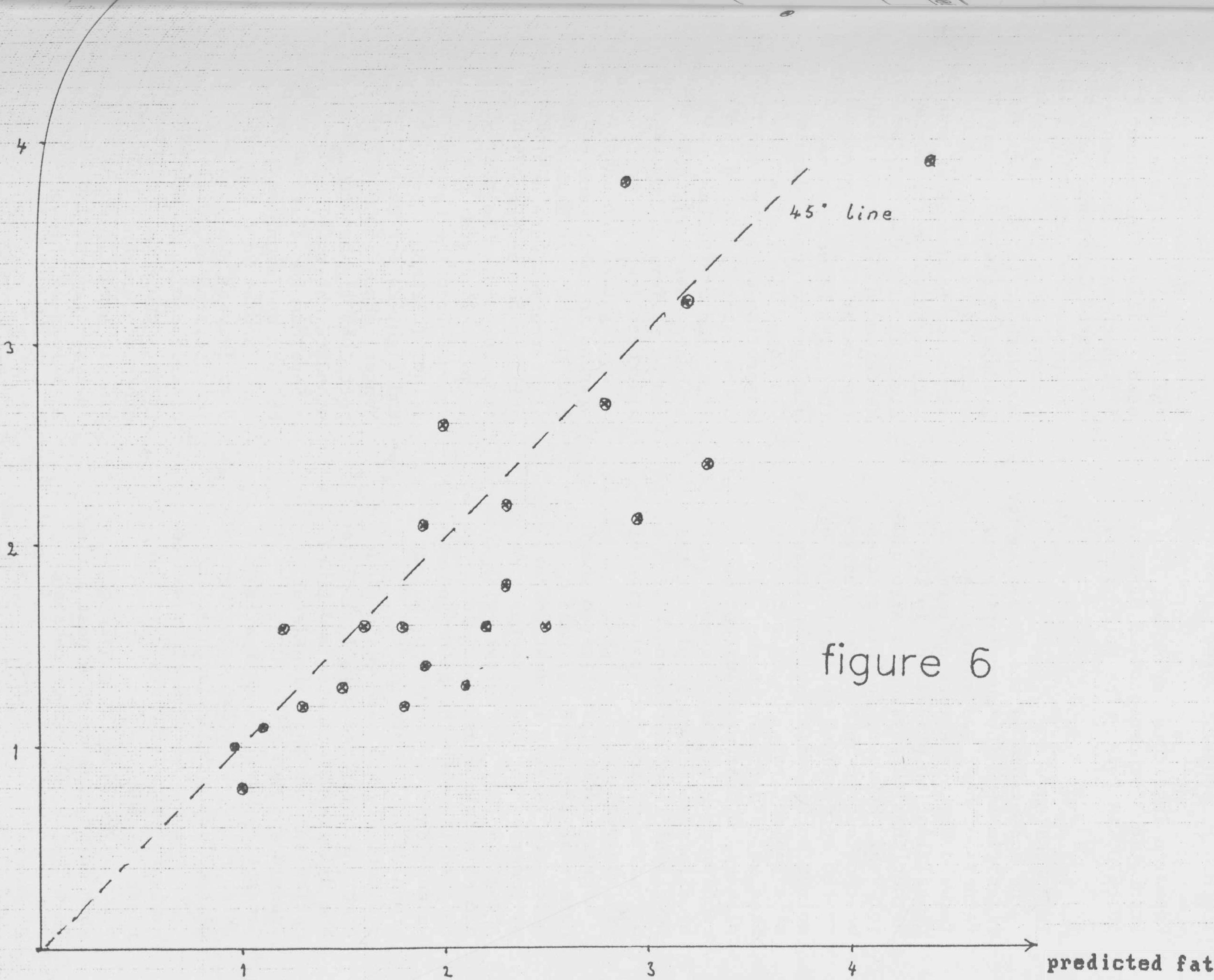


figure 6