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REFERENCE METHODS FOR WATER HOLDING CAPACITY IN MEAT AND MEAT PRODUCTS: PROCEDURES RECOMMENDED BY AN OECD WORKING GROUP

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INTRODUCTION

Despite many efforts over the years, there is still little consensus regarding methods of measuring quality of meat and meat products. Published literature on methods is legion but only one has attempted to give procedures that have been agreed upon internationally, and then only for beef (Boccard *et al.*, 1981).

Standardisation of methods is essential, if research carried out by different groups is to be directly comparable and future quality control programmes built on a common methodology base.

At the OECD workshop held in Helsinki 1992, under the research project "Management of Biological Resources", Karl Honikel again suggested that some agreement should be made regarding methods of measuring water holding capacity in meat and meat products. As a spin off from this workshop, a group of eight scientists with many years of research experience, convened at the German Federal Meat Research Institute in Kulmbach to discuss the drafting of recommended methods for determining water holding capacity (WHC).

There is a multitude of methods for measuring WHC of meat and meat products. We have chosen to divide the methods after type of meat product and after the process the meat is subjected to:

- drip loss in raw, whole meat
- water loss in cooked, whole meat
- water loss in heated, comminuted meat products

The discussion was restricted to red meats only. Indirect methods, although these are often used in practical experiments with large numbers of animals were not included. It is the intention, incidentally, that future groups, not necessarily with the same participants, will convene to discuss reference methods for other important meat quality characteristics.

For each of the three areas mentioned above, recommended methods were agreed upon, including sample preparation and methodology, Recognised pitfalls were also mentioned. It is our hope that the methods listed in the following will form the basis for discussion in the international scientific community and finally to a standardised methodology for future research work.

DRIP LOSS IN RAW WHOLE MEAT

Principle

The mechanism of drip formation in raw, whole meat has been reviewed by Offer and Knight, 1988. Losses of water originate from volume changes of myofibrils caused by rigor, where myofibrils shrink owing to pH fall and the attachment of myosin heads to actin filaments and the fluid thus expelled accumulates between fibre bundles. When a muscle is cut, this fluid will drain from the surface under gravity if the viscosity of the water is low enough and the capillary forces do not retain it.

This means that the method chosen for measuring drip loss must conserve the integrity of muscle before the initial sampling takes place and that no external force other than gravity is applied, when measuring drip. Orientation of the fibres with respect to cut is also important. Surface evaporation has to be prevented and the method of supporting the meat piece should minimize the state of tension (suspended from above) and compression (supported from below), respectively.

Equipment

A balance of sufficient accuracy (±0.05g), and appropriate closeable containers with net bottoms.

Procedure

Meat samples are cut from the carcass and immediately weighed. The samples are then placed in the container, which is closed after filling. After the required storage time at the temperature under investigation, samples are again weighed and the percentage drip loss calculated on the basis of the initial weight. The same samples can be used for further drip loss measurements eg. after 1, 2, 7 days etc., but in every case the initial weight is used as reference point. A weight of 80g is recommended but other sample sizes may be used too.

Meat samples can either be commercial cuts for practical experiments or standardised pieces for more basic studies. For standardised meat samples the following should be noted: type of muscle, where on the muscle the sample is taken, muscle fibre orientation, surface area/weight-ratio, time post-mortem and ultimate pH.

To avoid/minimize loss of drip before first weighing sampling must be immediate, minimum previous manipulation must be employed and strict temperature control is necessary.

Condensation/evaporation losses during storage is minimized by appropriate closing of containers and strict temperature control during storage.

WATER LOSSES IN WHOLE, COOKED MEAT

Principles

During heating the different meat proteins denature, though at varying temperatures (37-75∘C). This causes structural changes such as the destruction of cell membranes, transversal and longitudinal shrinkage of meat fibres, the aggregation of sarcoplasmic proteins and the shrinkage of the connective tissue. All these events and especially the last one give rise to cooking losses in meat, when heat is applied. Good reviews on the effect of heat on muscle proteins and structure have been given by Hamm (1977) and Offer (1984).

Samples for heat loss measurements cannot be used for drip determination first. As the meat structure and the extent of shrinkage during cooking is controlling water loss all the precautions taken with regard to the geometry of the specimen for the drip loss of raw meat is as valid for the cooked meat. Heating conditions must also be strictly defined and controlled, such as heat transfer, heating rate within the sample and the end point temperature at the centre.

Equipment

A balance of accuracy ±0.05g, a water bath allowing the introduction of a sufficient number of samples, a vacuum packaging machine with packaging material and sufficient thermocouples to allow for temperature recording in the core of at least one sample.

Procedure

Samples should be freshly cut for the initial weight (see drip loss). Individual samples are placed in thin walled polyethylene bags in the water bath with the open bag end extending over the water surface. Sample weights should be such that bags have close adhesion to the sample surface. Thermocouples are placed in the core of meat samples and rates of temperature increase are registered or, in the event of a limitation in the number of thermocouples, in one sample per group of similar surface/weight ratios. Treatments are stopped after reaching the specified core temperatures of 55°C (rare): 65°C (medium), 80°C (well done) and 95°C (thoroughly cooked). Samples are removed from the waterbath and cooled for 30 minutes in running tap water at about 15°C, after which time the meat is taken from the bag, mopped dry and weighed. The heating loss is expressed as g loss/g initial weight or as percent heating loss (based either on the original weight or on the original water content of the sample). Sample sizes and weights are recommended as described for drip loss.

WATER LOSSES IN HEATED COMMINUTED MEAT PRODUCTS

Principles

For the water holding of highly comminuted and heated meat products the swelling of myofibrils is of less importance, where instead the ability of the meat proteins to form different types of gels is the crucial factor (Hermansson, 1986). The gel forming ability of comminuted meat systems increases water holding compared to that of cooked whole meat so that an external force, like centrifugal force, has to be applied in the method. The centrifugal force applied should be high enough to press out some measurable water but low enough not to destroy the internal gel structure of the system. The methodology must be so constructed that the expelled water and fat should be fluid and separated from the gel so that reabsorption into the gel system is avoided.

Equipment

A centrifuge (e.g. Hettich, Universal) waterbath, balance (max 800g with ±0.05g accuracy), plexiglass tube assembly

consisting of a top, a middle and a bottom section. (Is obtainable from the Swedish Meat Research Institute for 300 Sw.Cr. per plexiglass assembly), and a syringe for filling the meat batter into the top plexiglass tube.

Procedure

Figure 1 shows a diagram with phases of the procedure 1-7. This procedure was first worked out by Hermansson and Luciano (1982) for blood plasma gels. About 10g of comminuted meat batter system is gently stuffed, avoiding air bubbles, in an upper plexiglass tube (1) and sealed with a top and a bottom rubber. The top rubber has a hole throughout to balance internal pressure. The tube and contents are heated in a waterbath according to the time-temperature-history under study and suitable for the product (2). After heat treatment the tube is cooled so much as to stop gel formation but the fat and water phase should still remain fluid i.e., temperature 40-45°C (3). After cooking and cooling, the bottom rubber is removed and the test tube is attached to a middle section (4 and 5). This section has a filter in the bottom allowing drainage of the released juice to the bottom section after turning upside down. The whole assembly is kept at a temperature of about 40°C and is then centrifuged at 550xg for 15 minutes (6). The bottom sections with the released juice are allowed to cool to solidity any fat that has been expelled. The amount of fat and water-juice is weighted (7).

Water loss can be calculated as the percentage weight of water-juice released based on the original weight of the batter or on the original content of water in the batter.

GENERAL REMARKS

When carrying out measurements of water holding capacity, it is essential that factors that can affect the values obtained are defined as far as possible, e.g., animal material, meat quality parameters such as ultimate pH, etc. Factors in the slaughter process that can affect weight loss previous to the initial weighing must be noted, the chilling process (which affects chilling losses) being particularly important.

Finally, for meaningful interpretation of results the variability in quality, including drip losses, should be characterised for the muscle sections used.

REFERENCES

BOCCARD, R., BUCHTER, L., CASTEELS, E., COSENTINO, E., DRANSFIELD, E., HOOD, D.E., JOSEPH, R.L., MACDOUGAL, D.B., RHODES, D.N., SCHÖN, I., TINBERGEN, B.J., and TOURAILLE, C. 1981. Procedures for measuring meat quality characteristics in beef production experiments. Report of a working group in the Commission of the European Communities'(CEC) Beef Production Research Programme, *Livest. Prod. Sci.* 8:385-397.

HAMM, R. 1977. In: HOYEM, T., and KVALE, O. (eds). *Physical, Chemical and Biological Changes in Food caused by Thermal Processing.* Appl. Sci. Publ. p.101.

HERMANSSON, A.-M. 1986. Water and fatholding. In: HITCHELL, J.R., and LEDWARD, D.A. (eds). *Functional Properties of Food Macromolecules.* Elsevier Appl. Sci. Ltd., London. p.273.

HERMANSSON, A.-M., and LUCIANO, M. 1981. Gel characteristics and water binding properties of blood plasma gel and methodological aspects of the water binding systems. *J. Food. Sci.* 47:1955.

OFFER, G. 1984. Progress in the biochemistry, physiology and structure of meat. *Proc. 30th European Meeting of Meat Research Workers, Bristol, UK.* p.87.

OFFER, G., and KNIGHT, P. 1988. The structural basis of water-holding in meat. In: LAWRIE, R. (ed). *Developments in Meat Science - 4.* Part 2:173.