Subgroup 2

Techniques for processing control

THE MEATLOGGER – A CORDLESS THERMOMETER

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Background

Development of temperature is an extremely important parameter in the food industry. Measurement of temperature is used for documentation of meat quality, process control and for analysis of intramuscular post mortem metabolism. Conventionally, determination of temperature has included a temporal sampling procedure determined by the slaughter process due to the use of wire based insertion probes. This restriction has somewhat complicated the determination of early post mortem temperature profiles during slaughter. Furthermore, a repeated insertion procedure is inevitably introducing position inaccuracy in practical field applications. Due to the importance of the parameter for the development of final meat quality traits as drip loss and PSE, we have designed a cordless, self-contained temperature logger intended for registration of intramuscular temperatures. This device, the MeatLogger, is developed for measurement of even very early post mortem development of temperature, fully independent of any slaughter process.

Objectives

Apart from the claim on wireless operation, the ease of use has been a major design goal. Thus an easy insertion and extraction procedure has to be provided by the logger. Data handling of large temperature profiles can be quite time consuming in large experimental set-ups. Therefore an extremely easy data handling and presentation has been a high priority design topic. The data handling has been developed for analysis in widely used commercial environments as Excell and Unscrambler, but data may easily be transferred into application specific software. As designed for food applications, materials for the logger have to be approved by FDA.

Methods

Design

The MeatLogger is made with a polystyrene body, potted with polyurethane to form an IP67 sealing (watertight to 1 m immersion). The Li-cell powered electronics can store up to 2048 consecutive measurements obtained with a user defined time slot from 1 min. This leaves the unit able to monitor a process for more than 34 hours with the minimum sampling period. The interface to computer is made with a PC-Link through the standard serial COM-port. The connector is an industry standard, IP67 sealed, 4-pin male plug. For documentation applications the MeatLogger includes a unique serial number to cope with the risk of data confusion. Within the 10x16x50mm, 7 gram of total weight device, shown in Fig. 1, a status light emitting diode is provided for the operator's convenience.

Operation

The PC-link software is designed for easy data handling in plain ASCII-format. Data organisation is selectable in rows or in columns for optimum versatility. The MeatLogger measurement mission may be initiated by applying a magnet to an internal reed switch or initiated from a PC. The latter feature provides that measurements may be made synchronously. This is an important feature when using the MeatLogger in meat biochemistry experiments. Assuming that intramuscular temperature development is a result of metabolism and external temperature [Aaslyng and Støier, (2002)], the MeatLogger may provide important information of metabolism differences in different positions within one single muscle, evaluated at synchronised time slots.

Results and discussion

The MeatLogger is adjusted to a 0.25°C precicion at 40°C and 0°C, traceable to a reference Hg thermometer. The resolution is 0.5°C and the unit has a linear (within the resolution) operating range of –20°C to 70°C. When a MeatLogger of temperature T_0 is inserted into an object of temperature T_1, the measurement error $T_{err}(t)$ will show an exponential decay with time. The following expression is found: $T_{err}(t) = (T_0 - T_1)\exp(-16.83\times10^{-3} s^{-1} \times t)$. E.g. for a 5°C temperature difference between MeatLogger and object, T_{err} is less than 10 % within 2.5 min. after insertion. A measurer for the repeatability is found as the standard deviation of 10 different units in an experiment measuring water in two tanks, each with a temperature of 29°C and 36°C, respectively. 30 min. in tank 1, then 30 min. in tank 2, repeated 6 cycles. The SD is found to be 0.24°C as an average over all measurements. The heat capacity of the MeatLogger is approximated to 8.2 J/K, using table values for polystyrene.

As an example of use of the MeatLogger we have measured the temperature development in porcine carcasses during slaughter. The experiment included pigs in three groups A, B and C. Group A (n=29) was exercised in a treadmill for approximately 15 min just before stunning to make a physical stress impact to the pigs. Group B was the control group (n=21) and group C (n=9) was treated with andrenaline approximately 24 hours prior stunning to ensure a very low level of energy at the time of slaughter. The background for this set up is given elsewhere [Henkel, Karlsson, Oksbjerg and Petersen (2000)] One MeatLogger was inserted in *m. Longissimus Dorsi* during bleeding, 1-2 min after sticking, approx. 5 cm cranial to the last rib, and remained in position during the entire slaughter process, including scalding and singeing. The effect of the treadmill is clearly seen in the temperature development in Fig. 2. The exercised group A shows, as expected, a higher temperature than the two other groups. The intramuscular energy production is higher for this group during the thread mill exercise and thus when the chilling mechanism of the animal is lost during bleeding the temperature increase is higher for this group. Conventional temperature probes introduces a sampling error due to the repeated insertion process. Using the MeatLogger, contributions to the SD comes mainly from biological variation. Due to the fixed position of the MeatLogger during the entire measurement sequence the sampling effect of repeated insertion is eliminated. Therefore it is interesting to calculate the standard deviation between animals within each of the three groups. For each group A, B and C, the SD between iso-temporal measurements is shown in Fig. 3 as 5 minutes rolling average values. It can be deduced that the biological variation has a distinct minimum 15 minutes post mortem in this experiment, where the 15 min timeslot corresponds to opening the carcass. Furthermore it is found that the exercised group exhibits a significant higher biological variation, which might be due to individual sensitivity to physical stress, imposed in the treadmill. In some of the carcasses, two MeatLoggers were inserted, a few cm. apart to measure the reproducibility in a practical experiment. The temperature difference between two such loggers was less than the logger resolution of 0.5°C. One drawback using the MeatLogger is the physical size; thus the exact measurement spot is only sparsely defined, no matter the fixed position of the electronics within the polystyrene body, the temperature is measured within an area of approximately 15x15 mm. Furthermore, the thermal resolution of 0.5°C might not be sufficient for some applications.

Pertinent literature
Henckel, P., Karlsson, A., Oksbjerg, N., & Petersen, J. S. (2000). Control of post mortem pH decrease in pig muscles. Experimental design and testing of animal models. Meat Science, 55, 131-138.
Aaslyng, M. D. and Støier, S. (2002): The effect on drip loss of showering of pigs during lairage, 48'th ICOMST, Rome.

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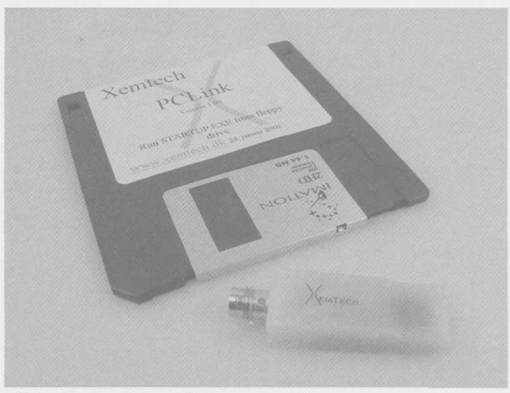

Fig 1. Photo showing the MeatLogger. The diskette is shown for comparative reasons.

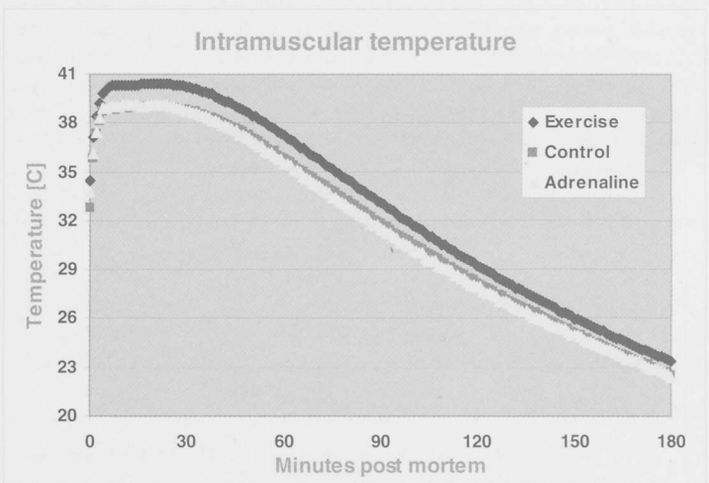

Fig. 2. The figure shows a continuous logging of the average temperature development during the first three hours post mortem. The curves show the result for the three groups: A, exercised on a treadmill, B, control group and C, injected with adrenaline, approximately 20 hours prior slaughter.

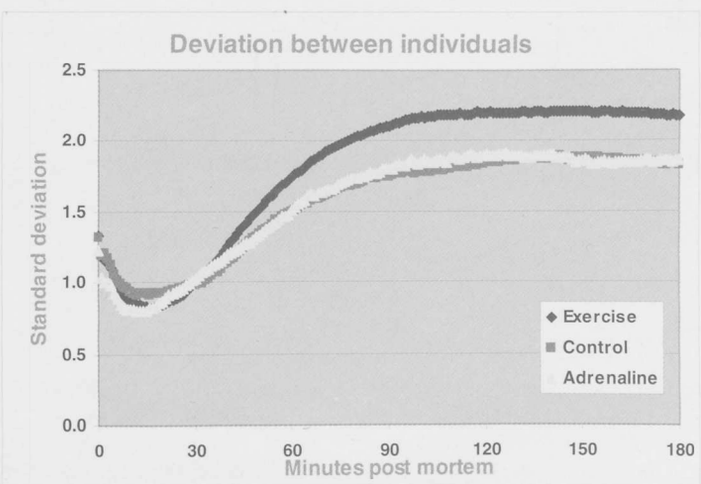

Fig. 3. The curves show the biological variation in temperature development within each group of animals as function of time. Using the MeatLogger the measurements here generates no sampling error from a repeated insertion associated with conventional temperature probes. Therefore, the residual standard deviation between animals is due to biological diversity.