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ON THE CONSTRUCTION AND USE OF CHEAP DIGITALIZED CALORIMETER
Measurement of specific heats of foods

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The physical properties of electrical calorimeter constructed at Mendel University and the corresponding data processing are presented. The calorimeter is used for measurement of the specific heats, namely foods. It is built from widely used equipment, the main parts are frequent digital multimeters and an older computer. Its main advantage is low costs, simplicity, rate of the measurement and digital data output and storage. Lower accuracy of the measurement, ~5%, is its partial disadvantage.

Keywords: *C_p of foods, digitalized calorimeter*

Introduction

The requirements on conserving and storing food quality are continuously increasing these days. These rising demands are conditioned by exact knowledge of food specific heats [1, 2]. Such knowledge enables correct designing of food producing and storing technological equipment. On that account we have built a cheap calorimeter, which quickly measures the specific heats of given products. The use of calorimeter significantly lowers the measuring costs and makes the whole process much easier in comparison to existing methods.

Description of the calorimeter

The calorimeter is assembled from several digital multifunctional multimeters, older computer recording data measured by multimeters, vacuum flask, power supply, spiral heating wire with possibility of power supply change and stirring propeller.

The most important and the most expensive part of the equipment are two digital multimeters with the RS232 interface. It is important to notify, that it is not possible to use the couple of equal multimeters, because the corresponding software is not able to run simultaneously (Fig. 1).

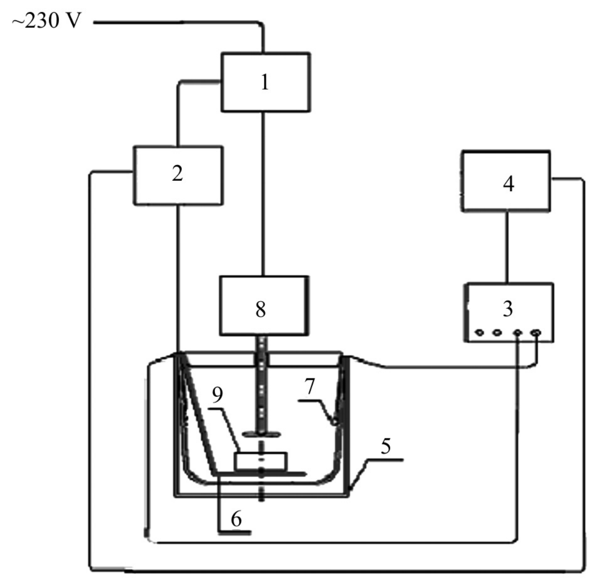

Fig. 1 Block of calorimeter. 1 – the source of power for the drill we use the second power output of the PC power unit. Such PC power supply is able to feed both the heating wire and stirring propeller, 2 – the first multimeter ‘UNI-T, UT 60A’ is supervising heating current–heating power, 3 – the second multimeter ‘METEX, M-3860D’ is supervising temperature of the filling of the calorimeter, 4 – data are collected and saved in the computer’s hard disc drive, 5 – the body of the calorimeter is a vacuum flask, 6 – the heater consists from the kanthal wire insulated by the silicon pipe. We used the PC fan cover as a supporting plate. Earlier we used a common ceramic resistor as a heating, but the overheating quickly damaged it, 7 – the four thermosensitive resistors KY 110 connected parallely measure temperature, 8 – as a stirring devise we use old baby drill with the propeller from the scale model of the boat, 9 – specimen

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Results and discussion

Description and evaluation of measurement

Determination of food's specific heat by use of our calorimeter is based on measuring of calorimeter (flask) specific heat, when calorimeter is filled by known quantity of water and under given heating power. We assume the knowledge of water specific heat. Considering that fit standard deviation is smaller than one half of thermometer sensitivity, the neglecting of calorimeter losses is possible (Fig. 2).

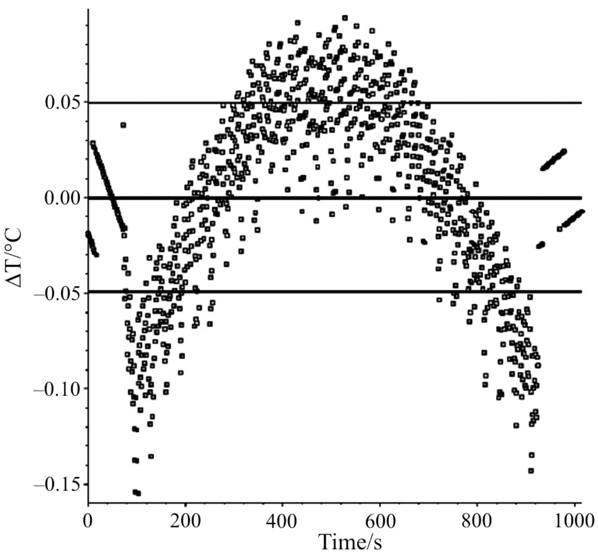

Fig. 2 Standard deviation of the regression functions

Measured values (temperature *vs*. time dependence) are then fitted by three lines by use of least square method [3, 4]. The first line describes the temperature development in calorimeter before heating. The second line – middle one – describes temperature – time dependence during heating. The third line shows the temperature development in the calorimeter after end of heating.

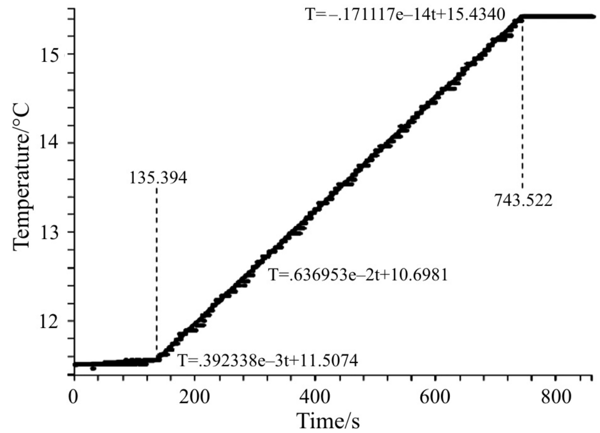

Fig. 3 Temperature of the filling as a function of time

Heat capacity of calorimeter (including filler) may be determined from the equation: $p=Kk$, where k is a central line tangent from the Fig. 3. With knowledge of flask specific heat capacity, obviously flask of given water content, the measurement of tested food specific heat is possible [5, 6]. It means that water volume that has been used to determine flask capacity must be identical as a volume of water-tested food solution. These resulting capacities are to be subtracted and we can find a specific heat capacity of tested food.

Verification and first results

The reliability of results was checked by mesuring the specific heat of brass. Figure 4 shows value from the thermodynamic tables and results of our measurement with standard deviation. The standard deviation was calculated as from set of 5 measurements, the difference between sets was volume of water in calorimeter, 0.6 and 0.65 L. So this standard deviation represents the reproducible accuracy. The detailed data are summarized in Table 1.

The specific heat of selected cheeses is shown in Fig. 5 and the detailed data are seen in Table 2.

Table 1 Specific heats of brass

No.	Set 1 – 0.6 kg H_2O		Set 2 – 0.65 kg H_2O	
	empty without specimen/J K^{-1}	with specimen/J K^{-1}	empty without specimen/J K^{-1}	with specimen/J K^{-1}
1	2560.6	2431.9	2757.2	2663.2
2	2562.6	2451.1	2754.6	2659.9
3	2570.6	2442.3	2770.0	2658.1
4	2568.6	2458.3	2786.8	2647.1
5	2569.1	2448.8	2774.1	2640.8
∅	2566.3±3.9 (0.15%)	2446.5±8.9 (0.3%)	2768.5±11.7 (0.4%)	2653.8±8.5 (0.5%)
	C=378.3±9.7 J kg^{-1} K^{-1} (2.6%)		C=383.4±13.5 J kg^{-1} K^{-1} (3.8%)	

Table 2 Specific heat of selected cheeses

No.	Empty – 0.27 kg H_2O	Eidam		Emental	
	K_0/J K^{-1}	m/kg	K/J K^{-1}	m/kg	K/J K^{-1}
1	1222.4	0.043	2914.3	0.0672	3290.8
2	1219.8	0.044	2988.6	0.0588	3470.6
3	1219.8	0.0435	3151.0	0.0607	3418.7
4	1223.7	0.0475	3003.0	0.062	2988.2
5	1224.7	0.0329	2869.3	–	–
∅	K_0=1222.0±2 J K^{-1} (0.2%)	C=2985.2±96.2 J kg^{-1} K^{-1} (3.2%)		C=3292.1±187.2 J kg^{-1} K^{-1} (5.7%)	

K_0=capacity of calorimeter without specimen

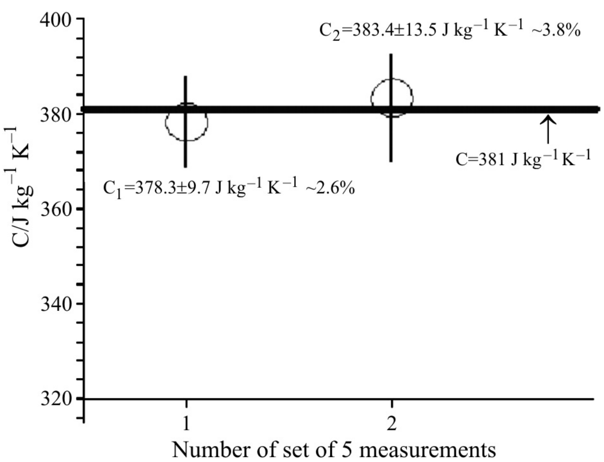

Fig. 4 Specific heat of brass; C=381 J kg^{-1} K^{-1} – K. Ražnjevič, Termodynamické tabul'ky, Alfa Bratislava 1975

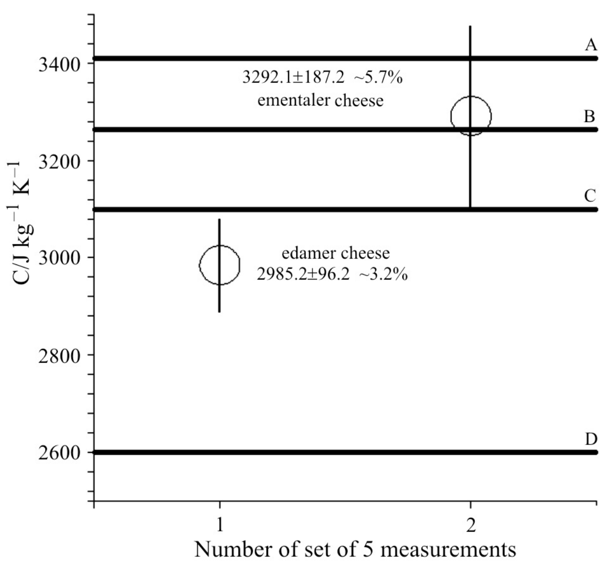

Fig. 5 Specific heat of selected cheeses: A – ceic.unsw.edu.au/staff/Tuan_Pham/bwater.pdf, B – food.oreganostate.edu/energy/t2.html, C – www.aiche.org/conferences/techprogram/paperdetail.asp?PaperID=2078&DSN=annua101 and D – http://www.eng.auburn.edu/~wfgale/usda_course/section1_3.htm

Calorimeter advantages and disadvantages

- low-cost, quickness, easy evaluation
- medium measuring error, approx. 3%

Calorimeter modification proposals

Calorimeter could be equipped with an additional digital multifunctional multimeter, intended for measuring of voltage in heating wire. Employment of this multimeter is not necessary.

The calculations required for experiment performing and evaluating have been processed in Maple 9 program. The method is, at the moment, in the period of experiment and obtained results must be verified.

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