

MEASUREMENT OF SPECIFIC HEATS OF FOODS STUFFS WITH THE AID OF CHEAP DIGITALIZED CALORIMETER

MĚŘENÍ MĚRNÝCH TEPEL POTRAVIN POMOCÍ LEVNÉHO DIGITÁLNÍHO KALORIMETRU

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ABSTRACT

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: electrical calorimeter, calorimeters capacity, specific heat, digital multimeter, PC interface, nonlinear least squares method, piecewise defined function, MAPLE.

ABSTRAKT

V příspěvku se zabýváme zjišťováním měrných tepelných vlastností potravin, pomocí kalorimetru vlastní konstrukce. Mezi hlavní části kalorimetru patří dva digitální multifunkční multimetry, napájecí zdroj z vyřazeného PC a starší počítač, který ukládá výstupní data z multimetrů. Výhody kalorimetru: levnost, jednoduchost a rychlost měření. Kalorimetr měří s přesností ~5%.

Klíčová slova: elektrický kalorimetr, kapacita kalorimetru, měrné teplo, digitální multimetr, PC interface, nelineární metoda nejmenších čtverců, po částech definované funkce, MAPLE.

INTRODUCTION TO FOOD THERMAL PROPERTIES MEASURING

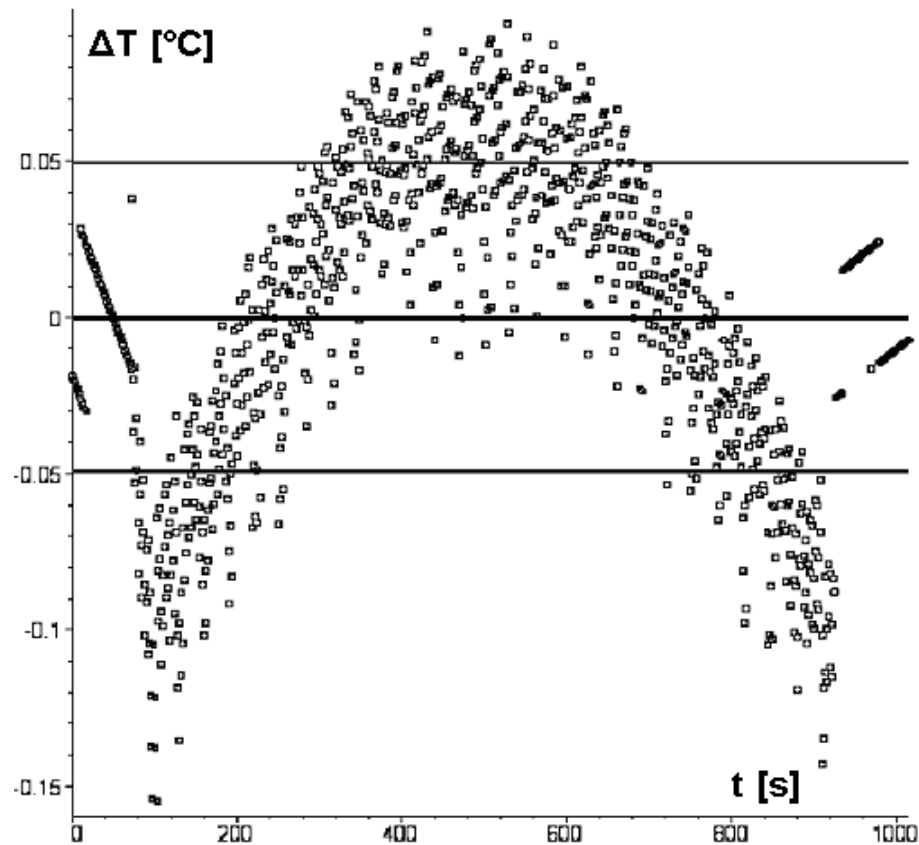
The calorimeter is assembled from several digital multifunctional multimeters, older computer recording data measured by multimeters, vacuum flask, power supply, spiral heating wire with possibility of power supply change and stirring propeller.

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

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.: Standard deviation of the regression functions

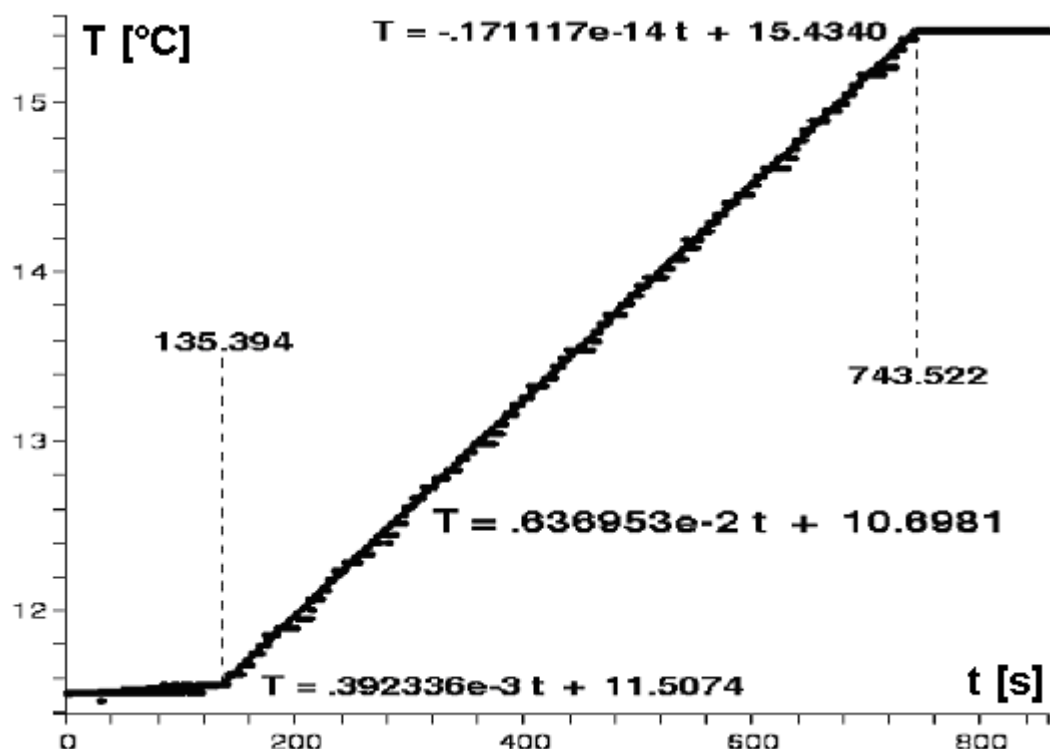
Fig 2.: Standard deviation of the regression functions



Measured values (temperature vs. time dependence) are then fitted by three lines by use of least square method. 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 cf. Fig 3.: Temperature of the filling as a function of time.

Heat capacity of calorimeter (including filler) may be determined from the equation: $p=K*k$, 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. 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 by use of:

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



VERIFICATION AND FIRST RESULTS

The reliability of results was checked by measuring of the specific heat of brass. The Figure No. 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 specific heat of selected cheese is shown at next Figure. No. 5.: Specific Heat of Selected Cheeses

CALORIMETER ADVANTAGES AND DISADVANTAGES

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

CALORIMETER MODIFICATION PROPOSALS

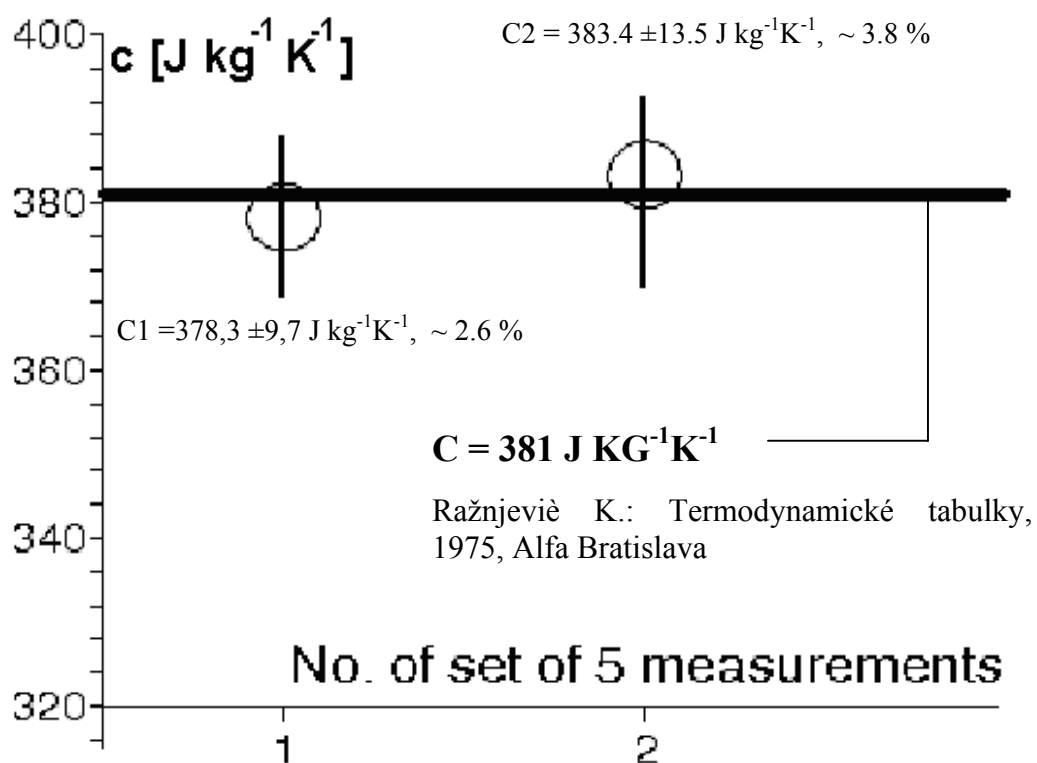
Calorimeter could be equipped with an additional digital multifunctional multimeter, intended for measuring of voltage in heating wire. Employment of this multimeter is not necessary.

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.

Tab 2.: – Verification – Specific Heat of Brass

N	Set 1 – 0,6 kg H ₂ O		Set 2 – 0,65 kg H ₂ O	
	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
Ø	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 %)	

Fig. 4.: Verification – Specific Heat of Brass

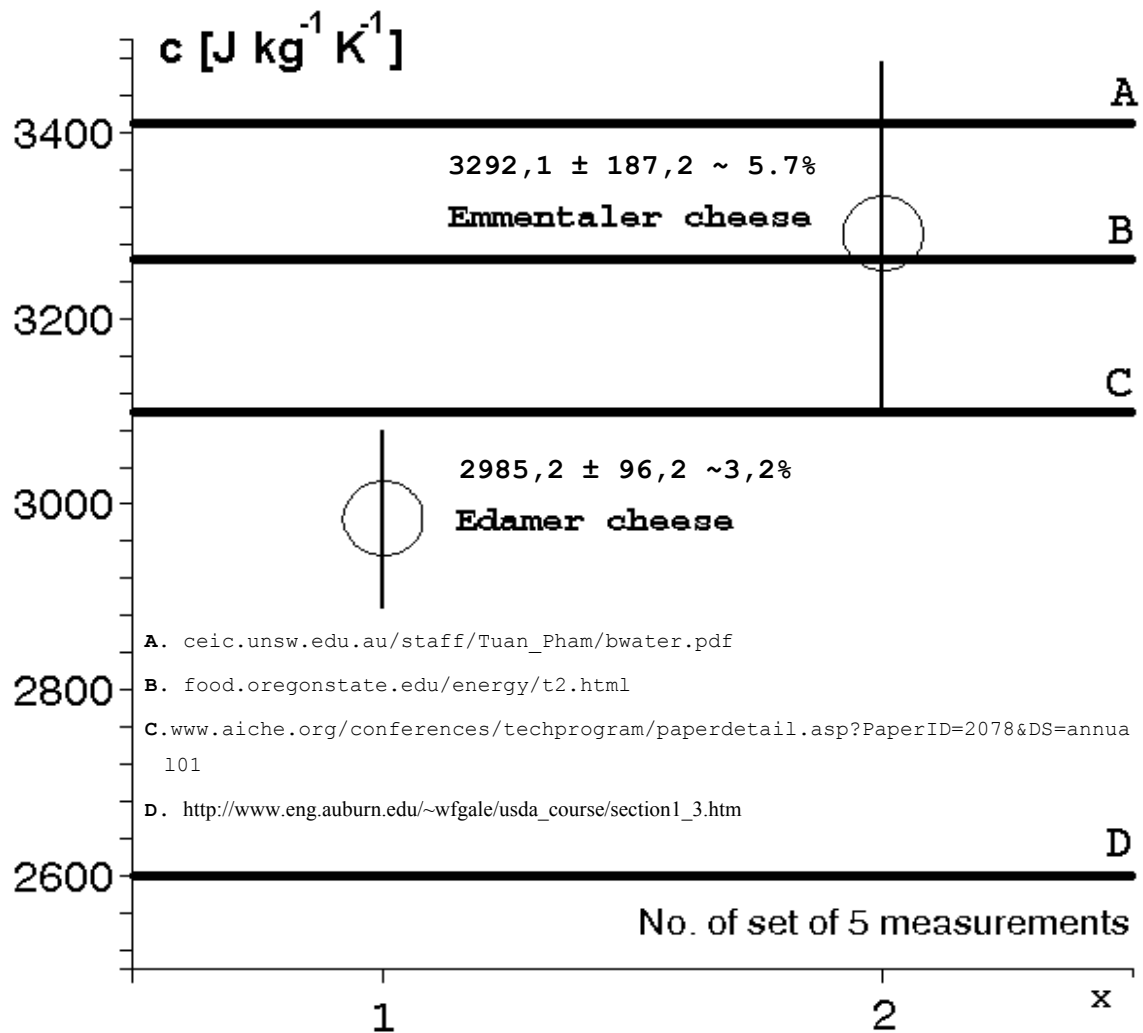


Tab 3.: – Specific Heat of Selected Cheeses

N	Empty - 0,27 kg H ₂ O	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%)	

K₀ = capacity of calorimeter without specimen

Fig. 5.: Specific Heat of Selected Cheeses



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