# Thermal properties of selected cheeses samples
# Tepelné vlastnosti vybraných vzoriek syrov

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## Abstract

The thermophysical parameters of selected cheeses (processed cheese and half hard cheese) are presented in the article. Cheese is a generic term for a diverse group of milk-based food products. Cheese is produced throughout the world in wide-ranging flavors, textures, and forms. Cheese goes during processing through the thermal and mechanical manipulation, so thermal properties are one of the most important. Knowledge about thermal parameters of cheeses could be used in the process of quality evaluation. Based on the presented facts thermal properties of selected cheeses which are produced by Slovak producers were measured. Theoretical part of article contains description of cheese and description of plane source method which was used for thermal parameters detection. Thermophysical parameters as thermal conductivity, thermal diffusivity and volume specific heat were measured during the temperature stabilisation. The results are presented as relations of thermophysical parameters to the temperature in temperature range from 13.5 °C to 24 °C. Every point of graphic relation was obtained as arithmetic average from measured values for the same temperature. Obtained results were statistically processed. Presented graphical relations were chosen according to the results of statistical evaluation and also according to the coefficients of determination for every relation. The results of thermal parameters are in good agreement with values measured by other authors for similar types of cheeses.

**Keywords:** cheese, temperature, thermal conductivity, thermal diffusivity, volume specific heat

## Abstrakt

Článok sa zaoberá vybranými tepelnými vlastnosťami syrov (taveného syra a polotvrdého syra). Syr je všeobecný pojem používaný pre rôznorodé skupiny mliečnych potravín. Syry sa vyrábajú po celom svete v rôznych príchutiach, textúrach a formách. V priebehu spracovania syry prechádzajú tepelnou a mechanickou manipuláciou a preto tepelné vlastnosti sú u syrov jednými z najdôležitejších. Poznatky o tepelných vlastnostiach syrov môžu byť využité pri procese hodnotenia ich kvality. Na základe prezentovaných faktov boli realizované merania termofyzikálnych parametrov vybraných syrov vyrobených slovenskými výrobcami. V teoretickej časti článku je uvedená všeobecná charakteristika syra a popis metódy plošného zdroja, ktorá bola použitá pri experimentoch. V rámci merania boli zisťované: tepelná vodivosť, teplotná vodivosť a objemová tepelná kapacity v priebehu teplotnej stabilizácie. Výsledky meraní sú prezentované ako závislosti termofyzikálnych parametrov od teploty, v teplotnom intervale od 13,5℃ do 24℃. Každý bod prezentovaných grafických závislostí je aritmetickým priemerom 50-tich nameraných hodnôt pre jednu teplotu. Získané výsledky boli štatisticky spracované a prezentované závislosti boli vybrané na základe štatistického vyhodnotenia výsledkov a tiež na základe hodnôt koeficientov determinácie pre každú grafickú závislosť. Výsledky meraní termofyzikálnych parametrov sú v dobrej zhode s meraniami prezentovanými inými autormi pre podobné druhy syrov.

**Kľúčové slová:** objemová tepelná kapacita, syr, tepelná vodivosť, teplota, teplotná vodivosť

## Detailný abstrakt

V článku sú prezentované vybrané tepelné parametre syrov (taveného syra a polotvrdého syra). Syry sa vyrábajú v rôznych príchutiach, textúrach a formách, sú špecifické svojím zložením. V priebehu spracovania syry prechádzajú tepelnou a mechanickou úpravou a preto sú tepelné vlastnosti jednými z najdôležitejších. Poznatky o tepelných vlastnostiach syrov môžu byť využité ako v procese návrhu technologických postupov spracovania resp. ich zdokonalení, tak aj pri procese hodnotenia ich kvality. Na základe vyššie prezentovaných skutočností boli realizované merania termofyzikálnych parametrov vybraných syrov vyrobených slovenskými výrobcami. Konkrétne boli experimentálne zisťované ich tepelné vodivosti, teplotné vodivosti a objemové tepelné kapacity.

V teoretickej časti je pozornosť venovaná všeobecnej charakteristike syrov a popisu metódy plošného zdroja, ktorá bola použitá v rámci realizovaných experimentov. Princíp metódy plošného zdroja spočíva v generovaní prúdového impulzu, ktorým je zohrievaný plošný zdroj. Meracia sonda obsahuje plošný tepelný zdroj a termočlánok, ktoré sú v nej integrované. Pri metóde plošného zdroja sa meracia sonda v tvare plošného zdroja vkladá do meranej vzorky. Pred meraním je potrebné realizovať teplotnú stabilizáciu vzorky. V rámci merania boli zisťované: tepelná vodivosť, teplotná vodivosť a objemová tepelná kapacita. Výsledky meraní sú prezentované ako závislosti termofyzikálnych parametrov od teploty v teplotnom intervale od 13,5℃ do 24℃. Z výsledkov prezentovaných v tabuľkách 1 a 2 je evidentné, že pomerne malá zmena teploty má signifikantný vplyv na hodnoty jednotlivých termofyzikálnych parametrov vzoriek syrov. Grafické závislosti prezentované na Obrázkoch 2 až 7 dokumentujú fakt, že vo všetkých prípadoch bol sledovaný lineárny pokles meraných termofyzikálnych parametrov v závislosti od teploty.

Každý bod prezentovaných grafických závislostí je aritmetickým priemerom 50-tich nameraných hodnôt pre jednotlivé hodnoty teploty. Získané výsledky boli štatisticky spracované a prezentované závislosti boli vybrané na základe štatistického vyhodnotenia výsledkov a tiež na základe hodnôt koeficientov determinácie pre každú grafickú závislosť.

Výsledky získané aplikáciou termofyzikálnych meracích metód na vzorky syrov môžu byť porovnané iba s intervalmi hodnôt termofyzikálnych parametrov podobných vzoriek z dôvodu originálneho zloženia meraných vzoriek slovenských syrov.

Poznatky o fyzikálnych vlastnostiach potravín majú rozhodujúci vplyv na monitorovanie kvality potravín a realizáciu mnohých technologických procesov Termofyzikálne parametre môžu determinovať stav materiálu v priebehu teplotnej manipulácie a ich hodnoty môžu byť využité pri identifikácii biologických a chemických procesov v potravinárskych materiáloch.

## Introduction

Cheese is a diary product which belongs to milk-based food products. Styles, textures and flavours depend on the origin of the milk. Flavours, textures, and forms of cheeses are different throughout the world. Cheeses are made from milk, usually the milk of cows, buffalos, goats, or ewes. According to origin of milk, cheeses have different content of proteins and different fat content. Many different types of cheeses are produced. In general, cheeses during processing and storage go through the thermal or mechanical manipulation. So it is convenient to know their physical properties, especially thermophysical and mechanical properties. Characteristics of dairy products was examined by Hlaváčová (2011), Božiková and Hlaváč (2010), Patočka et al. (2006), Kfoury et al. (1989), Robert and Sherman (1988) pointed that rheologic properties of cheeses are twinned with their quality. Based on presented facts was research focused on thermal properties of cheeses especially cheeses made by Slovak producers.

Cheese (in Latin *caseus*) is a generic term for a diverse group of milk-based food products. Cheese is produced throughout the world in wide-ranging flavours, textures and forms. Cheese consists of proteins and fat from milk, usually the milk of cows, buffalos, goats or ewes. It is produced by coagulation of the milk protein casein. The milk is acidified and addition of the enzyme rennet causes coagulation. The solids are separated and pressed into final form. Some cheeses have moulds on the rind or throughout. Most cheeses melt at cooking temperature. Hundreds of types of cheese are produced. Their styles, texture and flavour depend on the origin of the milk (including the animal's diet), whether they have been pasteurized, the butterfat content, the bacteria and mould, the processing and aging. Most cheeses are acidified to a lesser degree by bacteria, which turn milk sugars into lactic acids then the addition of rennet completes the curdling. Cheese is valued for its portability, long life, and high content of fat, protein, calcium and phosphorus. Cheese is more compact and has a longer shelf life than milk. (Fankhauser and Simpson, 1979). Selected characteristics of measured cheeses are described in the following text.

Processed cheese – there exists different modification of processed cheeses produced by many producers around the world. In Slovakia according to “the

Slovakian Food Codex" are processed cheeses made from one type of cheese or different types of cheese by smashing and mixing with smelting salt and then is cheese heated to temperature 70℃ during 30 seconds without influence of other ingredients. Smelting usually takes a few minutes. Smelting salt is the most important ingredient and it is made on polyphosphates base. It has emulsifier function and protects structure of cheese substance. The protection of homogeneity of cheese substance is the function of smelting salt during processing. In Slovakia are made various types of processed cheese with different fat content.

Half hard cheese - is natural, maturing, full cream cheese. It can be produced as smoked or non-smoked. Evaluated Slovak half hard cheese has shape of a roll with length 30-32 cm and with diameter 9–9.5 cm and technological process of production is described in the following text. Milk is heated in temperature range from 73℃ to 79℃. The next process is renneting, curing and curd tension. Then are prepared cheese grains. Commixture of curd and cheese grains are filled in prepared forms. The next process is compression molding of cheese; compression molding time is approximately 80 minutes. After the compression the mechanical hand manipulation with cheese continues. Producers prefer hand manipulation because they want to protect the quality of cheese and the form of cheese. This type of cheese includes: 53.5–58.5% of dry mass, 43.0–47.5% of fat content in dry mass and maximum 2.5% of salt. Tekov cheese is made from pasteurized milk with admixture of acid milk cultures *Lactococcus* or *Streptococcus* (Fankhauser and Simpson, 1979).

## Materials and methods

Two types of cheeses were examined. First sample was special Slovak processed cheese which contains 17 g of fats, 5 g of saccharides and 9 g of proteins in 100 grams. Second measured sample was half hard cheese made in Slovakia which contains 24.5 g of fats, 0.9 g of saccharides and 24.2 g of proteins in 100 grams. Measured samples were stored in special cool box according to required storing conditions 24 hours before the measurement.

For detection of thermophysical parameter was used modification of Dynamic plane source (DPS) method. DPS is one of the transient methods which are convenient for measurement of basic thermophysical parameters as thermal conductivity and thermal diffusivity. Volume specific heat can be calculated from obtained values of thermal conductivity, thermal diffusivity (Cviklovič and Paulovič, 2014).

The DPS method is based on using an ideal plane sensor – PS. The PS sensor acts both as heat source and temperature detector. The plane source method is arranged for a one dimensional heat flow into a finite sample. The theory considers ideal experimental conditions – ideal heater (negligible thickness and mass), perfect thermal contact between PS sensor and the sample, zero thermal resistance between the sample and the material surrounding sample, zero heat losses from the lateral surfaces of the sample (Karawacki et al, 1992). If $q$ is the total output of power per unit area dissipated by the heater, then the temperature increase as a function of time is given by (1) (Beck and Arnold, 2003).

$$\Delta T(x,t) = 2\frac{q\sqrt{at}}{\lambda}\, ierf\left(\frac{x}{2\sqrt{at}}\right) \qquad (1)$$

Where *a* - is thermal diffusivity, *λ* - is thermal conductivity of the sample and *ierfc* is the error function (Carslaw and Jaeger, 1959). The PS sensor is placed between two identical samples having the same cross section as the sensor in the plane $x = 0$. The temperature increase in the sample as a function of time conforms (2),

$$T(0,t) = \frac{q\sqrt{a}}{\lambda\sqrt{\pi}}\sqrt{t} \qquad (2)$$

which corresponds to the linear heat flow into an infinite medium (Karawacki and Suleiman, 2001). The sensor is made of a Ni-foil, 23 μm thick protected from both sides by an insulating layer made of kapton of 25 μm thick made on SAS. Several corrections have been introduced to account for the heat capacity of the wire, the thermal contact resistance between the wire and the test material, the finite dimension of the sample and the finite dimension of the wire embedded in the sample (Assael and Wakeham, 1992; Liang, 1995). Extended dynamic plane source - EDPS method (Figure 1.) which is the modification of DPS) was used for analysis of measured cheeses.

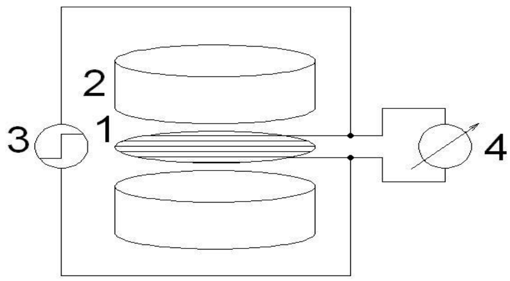


Figure 1. Extended plane source method

Obrázok 1. Rozšírená metóda plošného zdroja

1 – PS sensor, 2 – sample, 3 – electric current source, 4 – milivoltmeter (Malinarič, 2007)

1 – PS sensor, 2 – vzorka, 3 – zdroj elektrického prúdu, 4 – milivoltmeter (Malinarič, 2007)

## Results and discussion

For processed cheese and half hard cheese were obtained relations between thermophysical parameters and temperature. Every thermophysical parameter was measured 50 times for every sample and temperature. Samples of both cheeses were measured during the temperature stabilisation from minimal temperature 13.5°C (temperature after 10 minutes from cool box removing) to maximal temperature 24.35°C (laboratory room temperature).

The values of thermophysical parameters as thermal conductivity, thermal diffusivity and volume specific heat for sample of processed cheese are presented in Table 1. and Figures 2., 3. and 4. All measured relations have linear decreasing progress.

Graphic relations have very similar coefficient of determination approximately from 0.95 to 0.97. These coefficients are near the lower limit value of coefficient of determination which is acceptable. When the coefficient of determination is smaller than 0.95 it is better to choose other mathematical function for graphic characteristics.

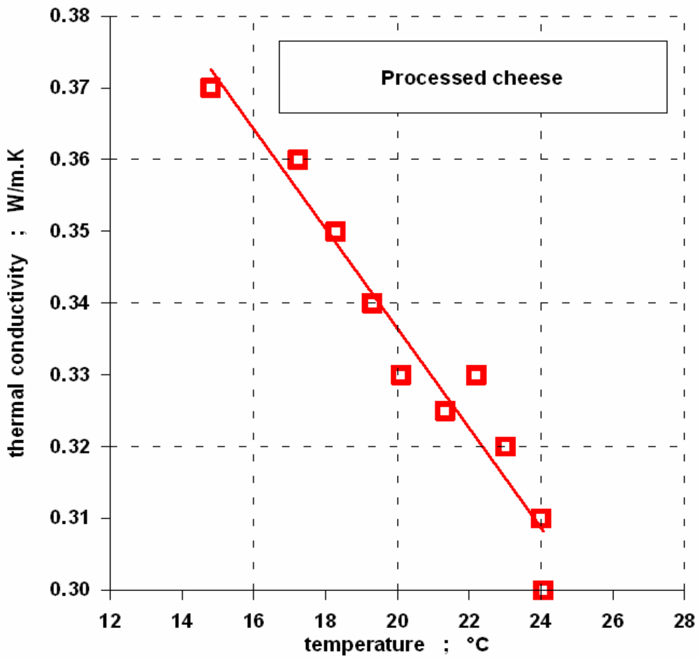


Figure 2. Relation of thermal conductivity to temperature in temperature range 14–24°C - sample of processed cheese

Obrázok 2. Závislosť tepelnej vodivosti od teploty pre teplotný interval 14–24°C – vzorka taveného syra

The graphical characteristics have the highest values of coefficient of determination for linear decreasing progress. For data comparison were calculated averages of thermophysical parameters and results can be summarised in next numbers: average temperature for relation between thermal conductivity and temperature was 20.49°C; average value of thermal conductivity for processed cheese sample was 0.334 $W*m^{-1*}K^{-1}$; average value of thermal diffusivity is $0.109*10^{-6}$ $m^{2}*s^{-1}$; temperature average for thermal diffusivity measurement during the temperature stabilization was 20.43°C ; average for volume specific heat for processed cheese sample was $0.141*10^{6}$ $J*m^{-3}*K^{-1}$ and temperature average during the third parameter measurement was 17.59°C.

Sample of half hard cheese was measured during the temperature stabilisation. Presented graphic relations (Figures 5. – 7.) have linear decreasing progresses. Coefficient of regression for thermal conductivity is 0.956638 and the average from measured values of thermal conductivity is 0.288 $W*m^{-1}*K^{-1}$.

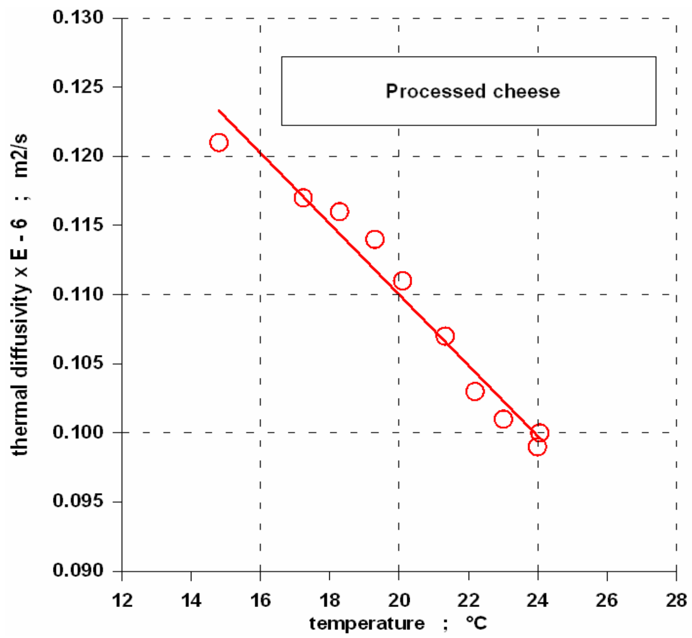


Figure 3. Relation of thermal diffusivity to temperature in temperature range from 14 to 24℃ - sample of processed cheese

Obrázok 3. Závislosť teplotnej vodivosti od teploty pre teplotný interval 14–24℃ – vzorka taveného syra

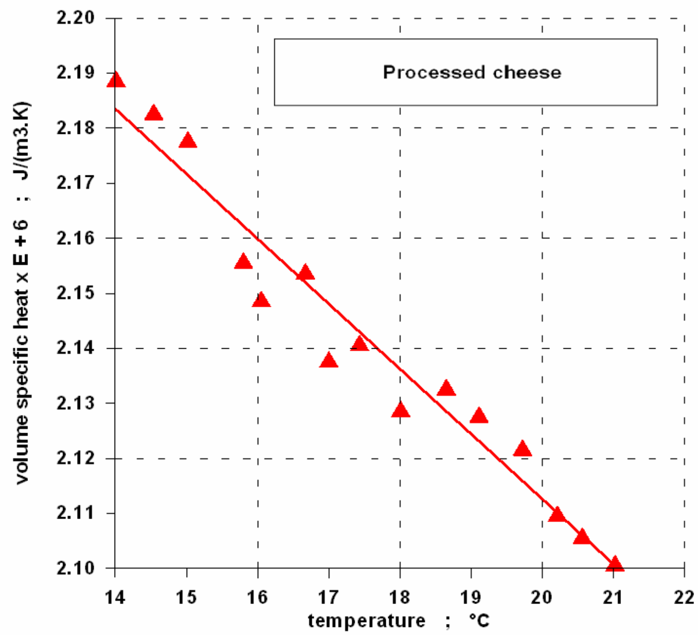


Figure 4. Relation of volume specific heat to temperature in temperature range from 14 to 24℃ - sample of processed cheese

Obrázok 4. Závislosť objemovej tepelnej kapacity od teploty pre teplotný interval 14–24℃ – vzorka taveného syra

Table 1. Values of thermal conductivity, thermal diffusivity and volume specific heat in temperature range 14–24°C for sample of processed cheese

Tabuľka 1. Namerané hodnoty tepelnej vodivosti, teplotnej vodivosti a objemovej tepelnej kapacity v teplotnom intervale 14–24°C pre vzorku taveného syra

| t (°C) | λ, W*m$^{-1}$*K$^{-1}$ | a (m$^2$*s$^{-1}$) | t (°C) | cρ (J*m$^{-3}$*K$^{-1}$) |
|---|---|---|---|---|
| 14.80 | 0.370 | 0.121*10$^{-6}$ | 14.01 | 2.189*10$^6$ |
| 17.23 | 0.360 | 0.117*10$^{-6}$ | 14.54 | 2.183*10$^6$ |
| 18.28 | 0.350 | 0.116*10$^{-6}$ | 15.02 | 2.178*10$^6$ |
| 19.30 | 0.340 | 0.114.10$^{-6}$ | 15.80 | 2.156*10$^6$ |
| 20.10 | 0.330 | 0.111*10$^{-6}$ | 16.05 | 2.149*10$^6$ |
| 21.33 | 0.325 | 0.107*10$^{-6}$ | 16.67 | 2.154*10$^6$ |
| 22.19 | 0.330 | 0.103*10$^{-6}$ | 17.00 | 2.138*10$^6$ |
| 23.01 | 0.320 | 0.101*10$^{-6}$ | 17.43 | 2.141*10$^6$ |
| 23.99 | 0.310 | 0.099*10$^{-6}$ | 18.01 | 2.129*10$^6$ |
| 24.06 | 0.300 | 0.100*10$^{-6}$ | 18.65 | 2.133*10$^6$ |
| | | | 19.11 | 2.128*10$^6$ |
| | | | 19.72 | 2.122*10$^6$ |
| | | | 20.21 | 2.110*10$^6$ |
| | | | 20.56 | 2.106*10$^6$ |
| | | | 21.02 | 2.101*10$^6$ |

Thermal conductivity – regression equation $\lambda = -0.00694485t + 0.475376$, Thermal conductivity average: 0.334 W*m$^{-1}$*K$^{-1}$, Coefficient of determination: 0.955669.

Thermal diffusivity – regression equation $a = -0.00255409\,t + 0.160977$, Thermal diffusivity average: 0.109*10$^{-6}$ m$^2$*s$^{-1}$, Coefficient of determination: 0.969536.

Volume specific heat – regression equation $c\rho = -0.0118186\,t + 2.34898$, Volume specific heat average: 2.141*10$^6$ J*m$^{-3}$*K$^{-1}$, Coefficient of determination: 0.952612.

Tepelná vodivosť – regresná rovnica $\lambda = -0.00694485t + 0.475376$, Priemerná tepelná vodivosť: 0.334 W*m$^{-1}$*K$^{-1}$, Koeficient determinácie: 0.955669.

Teplotná vodivosť – regresná rovnica $a = -0.00255409\,t + 0.160977$, Priemerná teplotná vodivosť: 0.109*10$^{-6}$ m$^2$*s$^{-1}$, Koeficient determinácie: 0.969536.

Objemová tepelná kapacita – regresná rovnica $c\rho = -0.0118186\,t + 2.34898$, Priemerná objemová tepelná kapacita: 2.141*10$^6$ J*m$^{-3}$*K$^{-1}$, Koeficient determinácie: 0.952612.

Relation of thermal diffusivity has also linear decreasing progress but with better coefficient of determination 0.966221. Thermal diffusivity average of half hard cheese was 0.110*10$^{-6}$ m$^2$*s$^{-1}$. Values of volume specific heat were calculated from known thermophysical parameters and density and for data reliability comparison they were also measured by thermal analyzer Isomet 2104. Thermophysical parameters of measured Slovak half hard cheese are not known from literature, so obtained results were compared with values obtained by other author for similar samples.

Table 2. Values of thermal conductivity, thermal diffusivity and volume specific heat in temperature range 13.5–24.35°C for sample of half hard cheese

Tabuľka 2. Namerané hodnoty tepelnej vodivosti, teplotnej vodivosti a objemovej tepelnej kapacity v teplotnom intervale 13,5–24,35°C pre vzorku polotvrdého syra

| t (°C) | λ ($W*m^{-1}*K^{-1}$) | a ($m^2*s^{-1}$) | cρ ($J*m^{-3}*K^{-1}$) |
|---|---|---|---|
| 13.50 | 0.330 | $0.116*10^{-6}$ | $2.789*10^{6}$ |
| 14.80 | 0.320 | $0.115*10^{-6}$ | $2.783*10^{6}$ |
| 16.05 | 0.318 | $0.114*10^{-6}$ | $2.740*10^{6}$ |
| 16.87 | 0.303 | $0.112*10^{-6}$ | $2.699*10^{6}$ |
| 17.54 | 0.300 | $0.112*10^{-6}$ | $2.689*10^{6}$ |
| 18.44 | 0.296 | $0.111*10^{-6}$ | $2.675*10^{6}$ |
| 19.07 | 0.293 | $0.110*10^{-6}$ | $2.668*10^{6}$ |
| 19.60 | 0.290 | $0.109*10^{-6}$ | $2.651*10^{6}$ |
| 20.00 | 0.287 | $0.109*10^{-6}$ | $2.649*10^{6}$ |
| 20.43 | 0.281 | $0.109*10^{-6}$ | $2.633*10^{6}$ |
| 20.68 | 0.277 | $0.108*10^{-6}$ | $2.628*10^{6}$ |
| 21.10 | 0.268 | $0.107*10^{-6}$ | $2.622*10^{6}$ |
| 21.67 | 0.259 | $0.106*10^{-6}$ | $2.612*10^{6}$ |
| 22.14 | 0.254 | $0.104*10^{-6}$ | $2.609*10^{6}$ |
| 23.35 | 0.248 | $0.104*10^{-6}$ | $2.605*10^{6}$ |

Thermal conductivity – regression equation $\lambda = -0.00849991\,t + 0.449901$, Thermal conductivity average: 0.288 $W*m^{-1}*K^{-1}$, Coefficient of determination: 0.956638.

Thermal diffusivity – regression equation $a = -0.00128751\,t + 0.134217$, Thermal diffusivity average: $0.110*10^{-6}$ $m^2*s^{-1}$, Coefficient of determination: 0.966221.

Volume specific heat – regression equation $c\rho = -0.0210118\,t + 3.06969$, Volume specific heat average: $2.670*10^{6}$ $J*m^{-3}*K^{-1}$, Coefficient of determination: 0.960669.

Tepelná vodivosť – regresná rovnica $\lambda = -0.00849991\,t + 0.449901$, Priemerná tepelná vodivosť: 0.288 $W*m^{-1}*K^{-1}$, Koeficient determinácie: 0.956638.

Teplotná vodivosť – regresná rovnica $a = -0.00128751\,t + 0.134217$, Priemerná teplotná vodivosť: $0.110*10^{-6}$ $m^2*s^{-1}$, Koeficient determinácie: 0.966221.

Objemová tepelná kapacita – regresná rovnica $c\rho = -0.0210118\,t + 3.06969$, Priemerná objemová tepelná kapacita: $2.670*10^{6}$ $J*m^{-3}*K^{-1}$, Koeficient determinácie: 0.960669.

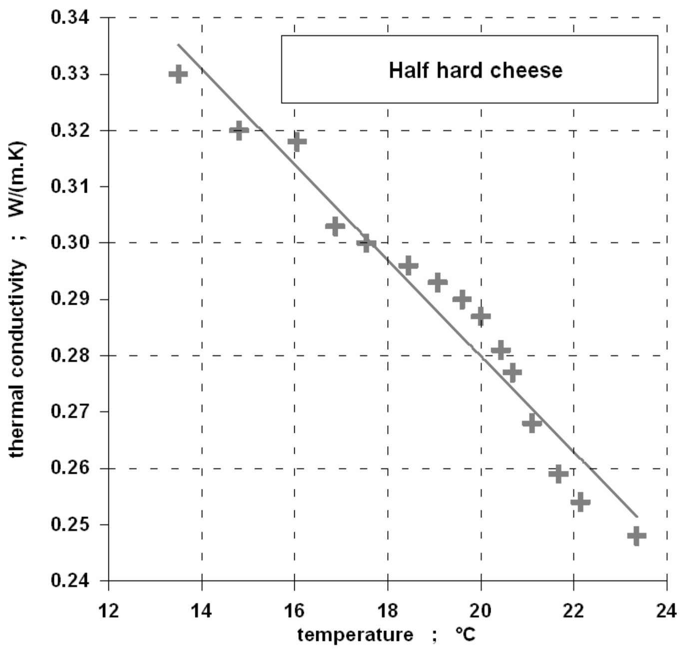


Figure 5. Relation of thermal conductivity to temperature in temperature range 13.5–24.35°C - sample of half hard cheese

Obrázok 5. Závislosť tepelnej vodivosti od teploty pre teplotný interval 13,5–24,35°C – vzorka polotvrdého syra

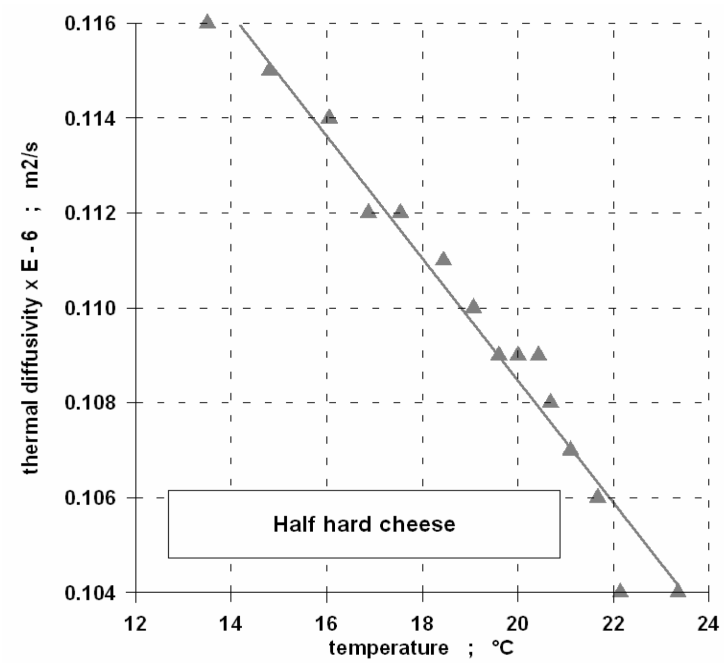


Figure 6. Relation of thermal diffusivity to temperature in temperature range 13.5–24.35°C - sample of half hard cheese

Obrázok 6. Závislosť teplotnej vodivosti od teploty pre teplotný interval 13,5–24,35°C – vzorka polotvrdého syra

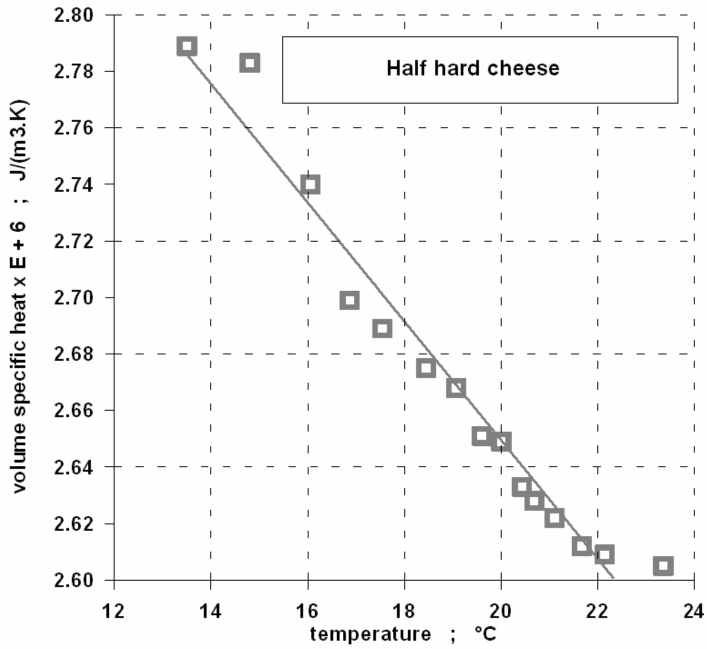


Figure 7. Relation of volume specific heat to temperature in temperature range 13.5–24.35℃ - sample of half hard cheese

Obrázok 7. Závislosť objemovej tepelnej kapacity od teploty pre teplotný interval 13,5–24,35℃ – vzorka polotvrdého syra

## Conclusions

Knowledge of food physical properties has a decisive importance for monitoring of food quality and for the realization of many technological processes. Thermophysical parameters are one of the most important parameters which can determine status of material during thermal manipulation and their values can be used in identification of biological or chemical processes in food materials. Based on the presented facts research was realised and were identified basic thermal properties of cheeses samples made in Slovak republic. From results presented in Table 1. and 2. is evident that small temperature changes had significant influence to thermal conductivity, thermal diffusivity and volume specific heat of measured cheeses samples. In all cases were obtained linear decreasing progresses presented on Figures 2. – 7. which can be described by linear regression equations and by coefficients of determination. From physical point of view changes of temperature are the cause of heat transport. Parameters as thermal conductivity and thermal diffusivity can inform about ability of food material to conduct heat and also about temperature equalization and the intensity of the temperature changes in the food material.

## Acknowledgements

This work was co-finances by the European Union no 26220220180 „Building Research Centre „AgroBioTech“ and by research project VEGA 1/0854/14 of Ministry of Education, Science, Research and Sport of the Slovakia.

## References

Assael, M. J., Wakeham, W. A. (1992) Measurement of the transport properties of fluids. International Journal of Thermophysics, 13, p. 223–229. DOI: 10.1007/BF00504433

Beck, J. V., Arnold, K. J. (2003) Parameter estimation in engineering science. John Wiley, New York.

Božiková, M., Hlaváč, P. (2010) Selected Physical Properties of Agricultural and Food Products. Slovak University of Agriculture in Nitra, Nitra.

Carslaw, H. S., Jaeger, J. C. (1959) Conduction of Heat in Solids. 2. edition, Oxford University Press, London.

Cviklovič, V., Paulovič, S. (2014) Using selected transient methods for measurements of thermophysical parameters of building materials. Acta technologica agriculturae, 17(1), 21-23. DOI: 10.2478/ata-2014-0005

Fankhauser, D. B., Simpson, D. P. (1979) Cassell´s Latin Dictionary. 5. edition. Cassell LtD., London.

Hlaváčová, Z. (2011) Electrical Properties of Agricultural Products. In: Encyclopedia of Agrophysics. Gliński, J., Horabik, J., Lipiec, J., eds. (2011) Dordrecht : Springer Science and Business Media, p. p. 237-241. DOI: 10.1007/978-90-481-3585-1_47

Karawacki, E., Suleiman, B. M. (2001) Dynamic Plane Source Technique for study of the thermal transport properties of solids. High Temperatures - High Pressures, 23, 215-223.

Karawacki, E., Suleiman, B. M., Ul-Hang, I., Nhi, B. T. (1992) An extension to the dynamic plane source technique for measuring thermal conductivity, thermal diffusivity and specific heat of Solids. Review of scientific instruments, 63, 4390-4397.

Kfoury, M., Mpagne, M., Hardy, J. (1989) Effect of cheese ripening on rheological properties of Camembert and Saint – Paulin cheeses. Lait, 69(2), 137–149. DOI: 10.1051/lait:1989211

Liang, X. G. (1995) The boundary induced error on the measurement of thermal conductivity by transient hot wire method. Measurement Science and Technology, 6(5), 467-471.

Malinarič, S. (2007) Uncertainty Analysis of Thermophysical Property Measurements of Solids Using Dynamic Methods. In International Journal of Thermophysics, 28(1), 20-32. DOI: 10.1007/s10765-006-0134-2

Patočka, G., Červenková, R., Narinea, S., Jelen, P. (2006) Rheological behaviour of dairy products as affected soluble whey protein isolate. International dairy journal, 16(5), 399-405. DOI: 10.1016/j.idairyj.2005.05.010

Robert, F., Sherman, P. (1988) The influence of surface friction on the calculation of stress relaxation parameters for processed cheese. Rheologica Acta, 27(2), 212-215. DOI: 10.1007/BF01331909