STUDY OF PROCESSES AND PROPERTIES OF FOOD MATERIALS DURING THERMAL TREATMENT

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ABSTRACT

The paper deals with the physical properties of food materials and with study of physical processes running in these materials during the thermal food processing technology. Characterization of food materials is presented, processes running in the materials and possible methods of study are introduced.

INTRODUCTION

Food materials are very complicated biological materials – they have complex chemical composition (proteins, lipids, saccharines, additive components), structure, phase (food or their components are dispersed systems), conformation, etc. Properties of food materials depend in general on properties of raw materials (agricultural products) and on processing technology (Blahovec, 1993). In generally food materials, namely the grains or seeds of a certain botanic variety is in the macroscopic as well as in the microscopic scale considerably inhomogeneous, capillary-porous and wet dispersed medium. It is well known that the influence of water - existence of free or bound form, difference in binding energy of each water bond (chemical, physicochemical and physical) and sorption properties of the materials dominates among other factors at properties of food materials. The temperature is also an important factor; it is the value which influences nearly each property of the material.

Moisture content and temperature are the most important physical properties that influence physical and physiological processes running in the food materials, for that reason they are some of the main controlling factors used in food processing. Typical thermal food processes - drying, cooling, freezing, boiling, baking, pasteurisation and sterilisation induce some physical and chemical processes in the material such as heat and mass transport, vaporisation, melting, freezing, crystallisation, crystal modification, denaturation, chemical reaction, etc.

Study of physical processes – transport processes and phase transitions – running in the material during thermal treatment requires knowledge of thermophysical properties of material.

Heat and mass transport are processes with direct impact on the food quality. The problem of transport phenomena covers very wide area of physical phenomena connected with the mass and the energy transport and has been elaborated in different kinds of materials (Ingham – Pop, 1998). Biological materials are complicated to describe from the point of view of the transport mechanism. Transport processes are influenced by properties of the material – transport properties. Contribution to the study of the heat transport in the food materials, to the measurement of thermophysical properties and to the study of factors affecting the heat transport in the food material can be found in (Vozárová, 2002, Vozárová, 2005).

Physical and chemical processes running in the material due to temperature changes can be investigated by method of thermal analysis. They are the analytical techniques that measure physical and chemical properties of the sample as a function of the temperature or time (Haines, 1995). The sample is subjected the temperature program and the dependence measured value (heat, mass, volume, specific heat etc.) on the time and temperature are determined. It is provided by using following methods of thermal analyses:

- differential thermal analysis (DTA), differential scanning calorimetry (DSC) – provides information on thermal effects which are characterized by an enthalpy change and by temperature range, such as phase transitions (melting, crystallization etc.)
- thermogravimetric analysis (TGA) – measures the mass (change of the mass), provides information on the content of components.

Interpretation of the obtained TGA, DSC curves provides information about processes running in the materials, changes of physical and chemical properties and conditions of it. The methods of thermal analyses and experimental apparatuses are described in details in (Haines, 1995).

MATERIAL AND METHODS

Measurements of physical properties – specific heat, thermal conductivity and mass as a function of the temperature were realised. Experimental methods of thermal analysis – differential scanning calorimetry, thermogravimetry and hot-wire method were used for an estimation of thermal behaviour of granular materials. Measurements were performed on the samples of colza *Brassica napus,* mixture of cultivars. Bulk density, moisture content and date of sampling are in the table 1.

Table 1 Characterization of samples

Sample	**Moisture content, w.b.** (%, $kg.kg^{-1}$)	**Bulk density** ($kg.m^{-3}$)	**Date of sampling Locality**
Colza, mixture, sample 1	6,75	631	07-17-2003 Hontianske Nemce
Colza, mixture, sample 2	7,78	635	09-12-2003 Hontianske Nemce

Differential scanning calorimeter DSC 822^e (METTLER TOLEDO) was used for measurement of the specific heat of colza as a function of the temperature. Measurements were performed on the sample of colza (sample 2) under nitrogen atmosphere (flow rate 80 ml per minute) in the temperature range from 0 °C to 40 °C with heating rate 5 K per minute. The sample of colza was measured as a whole. Weight of the samples is 3 – 4 mg. The samples were embedded in standard aluminium pans where an empty pan was used as a reference.

Thermogravimetric analysis were performed on the sample of colza (sample 2) on the air (flow rate 80 ml per minute) in the temperature range from 25 °C to 500 °C with heating rate 5 K per minute. Measuring equipment is TGA/SDTA 851^e (METTLER TOLEDO).

The hot-wire method and the home made computer-controlled experimental apparatus, which allows the determination of the thermal conductivity of solid, powders and granular materials was used (Dawis, 1984, Vozár, 1996). Measurements of the thermal conductivity as a function of the temperature were performed on the air at the atmospheric pressure in the temperature range from room temperature up to 100 °C or 140 °C respectively on the samples of colza (both samples) with volume 1 dm^3. Measurements for the given sample were repeated 15 times with the temperature stabilisation (2 hours) meanwhile due to achievement the needed accuracy. The moisture content of the samples was determined by electronic (conduction) moisture meter HE 50 (PFEUFFER).

RESULTS AND DISCUSSION

Fig. 1 presents DSC curve of colza (sample 1) obtained in the temperature range from 0 °C to 40 °C. Specific heat of the sample at the temperature above 0 °C linearly increases up to the temperature 40 °C. Values of the specific heat of materials are significantly influenced by presence of the water. Specific heat of the air, proteins and saccharides are low, between 1,1 - 1,2 $kJ.kg^{-1}.K^{-1}$. Fats have almost double value of the specific heat in the comparison with proteins and saccharides (Blahovec, 1993), which influenced obtained values of colza.

Fig. 2 presents the thermal conductivity as a function of the temperature. Thermal conductivity of the granular food materials (grains and seeds) is influenced by the chemical composition of the material, by the moisture content and by the presence of the air between individual elements. Thermal conductivity of saccharides and fats is between 0,05 – 0,2 $W.m^{-1}.K^{-1}$, thermal conductivity of proteins are lower, values are between 0,02 – 0,05 $W.m^{-1}.K^{-1}$ (Blahovec, 1993). Presence of the water in the sample of colza slightly affects the temperature dependency of the thermal conductivity due to low moisture content of the both samples. Changes of the progress of the thermal conductivity of colza as a function of temperature in the temperature about 70 °C can be caused not only by releasing of the water or other unstable ingredients (oil), but by phase transition of the starch as well.

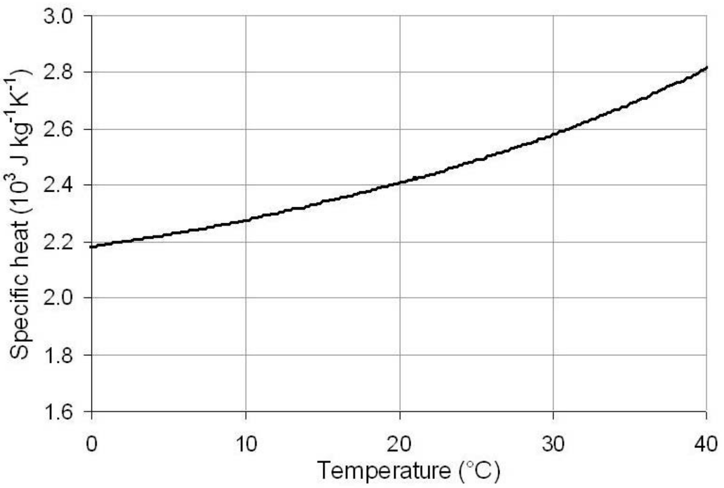
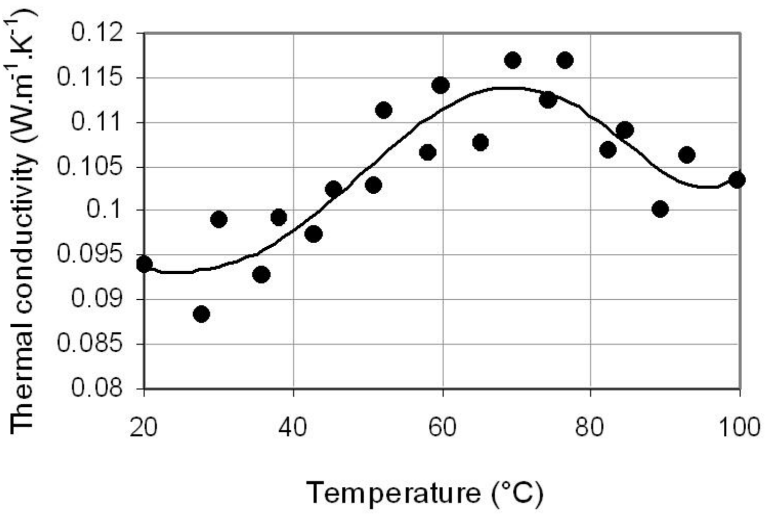


Fig. 1 Specific heat at the constant pressure of the colza (sample 2) as a function of the temperature

Fig. 3 presents TGA curve of the sample of colza (sample 2). Slow decreasing of the sample mass above temperature 100 °C is caused by releasing of the water and other unstable ingredients of seeds (oil). Stronger decrease of the sample mass between 350 °C and the 400 °C is caused by combustion.

CONCLUSION

The paper presents results of the measurement of the specific heat at the constant pressure, thermal conductivity and mass of colza as a function of the temperature. It is shown that the temperature is one of essential factors that influence processes and properties of the food materials during thermal treatment. Monitoring of the thermal behaviour of materials provides the important information for the analyses of the optimal food processing regime proposal.



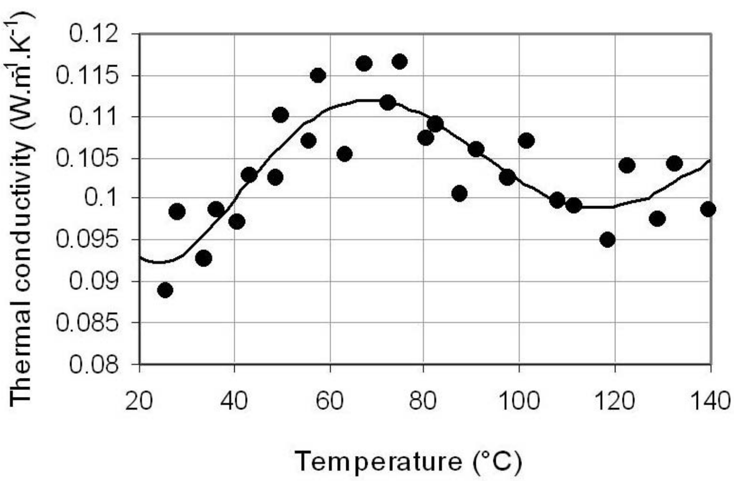


Fig. 2 Thermal conductivity of colza (sample 1-on the left, sample 2-on the right) as a function of the temperature

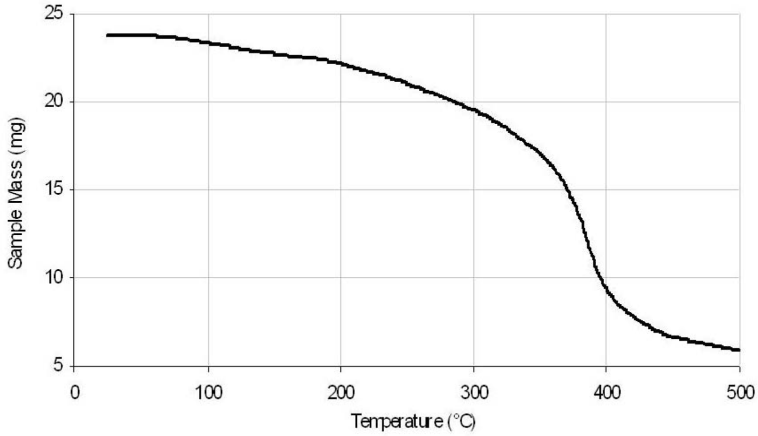


Fig. 3 TGA curve of the colza (sample 2)

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