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ANALYSIS OF BOUND WATER IN PUMPKIN PUREE PROCESSED UNDER HIGH PRESSURE

V. Sukmanov, Doctor of Technical Sciences, Professor;
N. Herman, Associate Professor
(Poltava University of Economics and Trade)

***Introduction**. The aim of the study was to determine the nature of high pressure impact on bound water in the pumpkin puree. **Purpose.** The subject of investigation is bound water in pumpkin puree processed under high pressure. The character of high pressure impact on the bound water contained in pumpkin puree has been defined. **Results.** It was experimentally proved that the treatment with high pressure did not bring to releasing of bound water according to the derivative-graph analysis. **Conclusions.** There were considered the changes occurring in the researched samples, exposed to the derivative-graph analysis, and shown that the properties and performance of the product after treatment with high pressure remained unchanged.*

***Keywords:** high pressure, pumpkin puree, derivative-graph analysis, bound water, free water.*

Formulation of the problem in general and its correlation with the most important scientific and practical tasks. The fruit of ordinary pumpkin (Cucurbita pepo, L.) is a valuable nutritional product, having dietary, prophylactic and therapeutic value, being at the same time a raw material for processing industry. This is a complex of such biologically active substances as carbohydrates, polysaccharides, proteins, polysugars, dietary fiber, vitamins, organic acids, fatty oils, sterols, peptides, minerals, etc. The structure of pumpkin vitamin complex consists mostly of ascorbic acid, carotenoid, 60-70 % of the latter are biologically active, and produce the same effect on the humans as carotene.

The pharmacological action of pumpkin seed oil is due to its biologically active substances such as carotenoids, tocopherols (α-, β-, γ-, τ- isomers), phospholipids, sterols, phosphatides, flavonoids, vitamin A, vitamin C, vitamin F, vitamins B1, B2, B6, vitamin PP, saturated, unsaturated and polyunsaturated fatty acids (palmitic, stearic, oleic, linoleic, linolenic, arachidonic), mineral compounds, trace elements. The high amount of tocopherols and carotenoids has a strong antioxidant effect, inhibiting lipid peroxidation processes in biological membranes. For a normal human life it is necessary to consume annually 134 kg of vegetables, including pumpkin consumption in the amount of 20-23 kg [1].

Conservation technologies used nowadays in the production of pumpkin puree, unfortunately, cannot preserve all the nutrients and they do not have necessary organoleptic characteristics. One way of solving this problem is to use a method of processing food under high pressure, which allows to get qualitatively new products without preservatives, minimum loss of vitamins and valuable nutrients, improved flavor and aromatic properties to ensure microbiological safety of food for prolonged storage [2].The research of a number of previously published scientific studies [3–5], enables to conclude that the impact of high pressure on the bound water in food has not been well investigated.

The object of our research is pumpkin puree, which quality largely depends on the conditions of its production. So, it is important to make a derivative-graph analysis of the researched product.

Formation of the article purposes. The aim of study is to determine the nature of high pressure impact on bound water in the pumpkin puree. The subject of investigation is bound water in pumpkin puree processed under high pressure.

Analysis of recent research and publications in which there is a solution of the submitted problem. The method of processing food under high pressure allows maintaining the properties and characteristics of the product that in its quality can be compared to fresh fruits and vegetables [2]. Unlike other types of treatment, this method enables to keep flavor, aroma and nutritional values of puree products and reduce water loss. The high pressure of approximately 500 MPa together with low temperatures create favorable conditions for microbial sterility. The growth of microorganisms in the following conditions occurs by nearly 1,000 times slower than in conditions close to the natural ones [6].

Among the existing methods for determining bound water most widely is used the method of centrifugation. But the results of measurements obtained by this method depend on technical excellence of the centrifuge used and differ from the identically studied samples. This makes it difficult to check the objectivity of the data, and therefore reduces the reliability of measurement results. In recent years electronic and proton magnetic resonance techniques (EMR and NMR) are actively used for determining the bound water. However, they are financially costly and not suitable for the equipment of a small laboratory [7]. One of the rational methods of determining the bound water is derivative-graph method of analysis.

The method of derivative-graph analysis is a type of thermo gravimetric researches, based on determining the rate of drying the researched material. This method is, in vitro, fixes the boundary between the area of constant speed of drying and the area where the speed is reduced, which characterizes the transition from free to bound water in the drying process. The reactions that occur in the sample while heating, are characterized with endogenous (heat absorption) and exothermic (heat release) effects. The effect resulting from chemical reactions is mostly accompanied by changes in the mass of substance. **Table 1** shows the types of processes accompanied by endo- and exothermic effects on derivative-graph analysis.

Table 1

The processes of heat absorption and heat release by derivativegraph analysis [7]

Type of process	Type of effect	
	endothermic	exothermic
Physical:		
- adsorption, absorption	-	+
- polymorphic transformation	+	+
- consolidation of crystals	-	+
- desorption	+	-
- melting	+	-
- transition from amorphous to crystalline state (scattering)	-	+
- sublimation, evaporation	+	-
Chemical:		
- chemical adsorption	-	+
- decomposition	+	-
- dehydration	+	-
- reactions in solid phase	+	+

Presentation of the main studies with full justification of the research results. Processing of pumpkin puree under high pressure were carried out on the installation of high pressure [2] and the results are given in Figure 1. This research installation of high pressure allows:

– record necessary parameters of the object before creating pressure;

– create pressure and temperature of the object exposing it in the chamber of high pressure for a period ranging from several minutes to several days with continuous fixation of temperature and pressure on PC;

– reduce pressure;

– unload chamber;

– explore the transformations in the objects subjected to a given pressure and temperature [2].

Fig. 1. General view of high pressure installation

The unit has the following specifications:

Maximum pressure in a working camera 1 000 *МПа.*

Working pressure in a working camera 800 *МПа.*

Working range of temperature (–20+80 ˚С)

Maximum temperature in a working camera +100 ˚С.

Minimum temperature in the camera of high pressure –40 ˚С.

Sensitivity of the temperature registration system –0,1 ˚С.

Accuracy in temperature registration ± 0,5 ˚С.

Sensitivity of pressure system registration 1 *МПа.*

Accuracy of pressure system registration ±10 *МПа.*

Precision of the system for maintaining temperature in a working camera ± 0,2 ˚С .

Cooling of the working camera – with liquid nitrogen.

Derivative-graph analysis of high pressure treated pumpkin puree was conducted in the laboratory of Institute of the physicist of organic chemistry and coal chemistry NAS of Ukraine. The influence of high pressure on the pumpkin puree was conducted on the basis of non-isothermal (process undergoes at a variable temperature) analysis of the derivativegraph Q-1500d system “Paulik, Paulik and Erde” in the air at a constant heating rate of 10 °C/min to a temperature of complete thermal transformations in the sample (from 20 °C to 1 000 °C). Mass measurement error of ± 1 mg, temperature ± 0,25 °C. Heating rate, mass of sample, measure of test grinding is identical for all experiments.

For the sample research were used pumpkins grown in the Donetsk region. Sampling was carried out in accordance with the requirements of State Standards of Ukraine (DSTU) 3190-95 "Fresh food pumpkins. Specifications" [8]. For the production of puree it was used a Braun MR 400 blender and a sieve for grinding.

The technology envisages the following steps:

– cleaning of pumpkin pulp;

– cutting by pieces of $1 \cdot 10^{-2} m^3$;

– grinding pieces of flesh in a blender (1 liter capacity, 17,000 min^{-1}) to the state of puree for 5 min;

– a single hand sieve -grinding of the puree-type mass (the size of cells is $1{,}5 \cdot 10^{-3}$m) for 3 min;

– puree packaging with a sterile syringe into containers for further research.

Setting parameters for the pumpkin puree processing by high pressure was based on the results of the research set out in the studies [2], proved that to save natural properties of many products, rational pressure is 500 MPa at a temperature of 40 °C and time $15 \cdot 60^1$ sec. For the derivativegraph analysis were used raw pumpkin puree sample of 0,2 g. The samples of quartz sand were put in ceramic crucible and covered with a platinum lid. Then the mixtures were placed in derivative-graph and heated to a temperature at which its further increase does not change the absolute mass of the sample. During the heating it was fixed the change in mass (TG), differential rate of mass change (DTG, mg/sec), thermal conductivity (DTA), temperature (T).

The differential rate of change in mass that characterizes different rate of its loss throughout the experiment was calculated by the formula [9]:

$$DTG = \frac{\Delta m}{\Delta t} = \frac{m_1 - m_0}{t_1 - t_0}, \qquad (1)$$

where t_0 – initial heating of the sample;

t_1 – period of time for heating the sample at the given temperature;

m_0 – initial mass of the sample;

m_1 – the mass of the sample at a specific time, t_1.

After heating to maximum temperature the samples were cooled to 20 °C, with fixing the main settings.

Figure 2 exposes a derivative-graph with the curves showing the phases of transformation determined by the temperature changes in raw pumpkin puree.

The results of the study have shown that the main change in the samples mass (TG curve) from 200 mg to 90 mg occurs at a temperature from 80 ˚C to 180 ˚C at a maximum of the process speed of 0,14 mg / sec (DTG curve) at a temperature 130 ˚C, it means that pumpkin puree loses most of its mass (free moisture) at up to 180˚C in the first 15 minutes (900 sec.) of the experiment. From the 15th to 60th minute of the experiment there is a slight loss of weight and the completion of thermal changes in the sample.

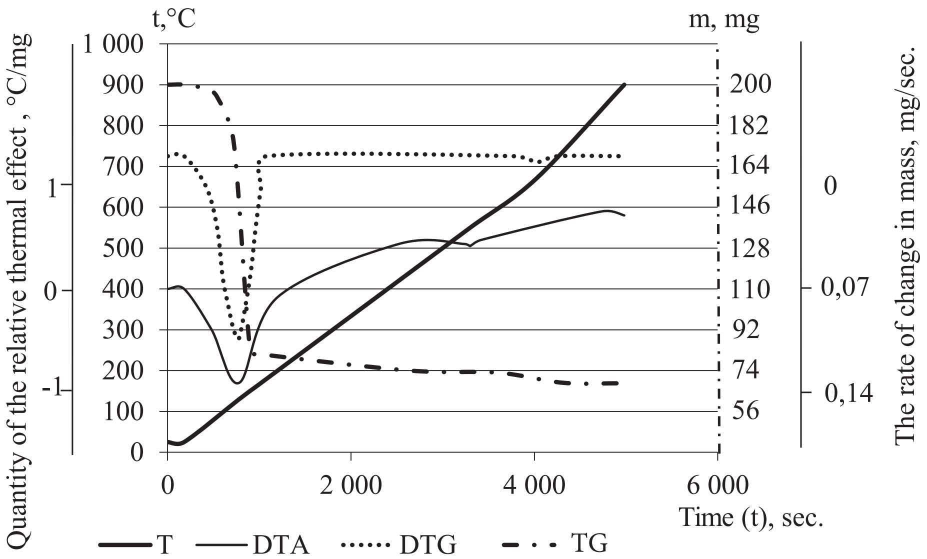

Fig. 2. Derivative-graph curves of the pumpkin puree study

Having studied thermal conductivity (DTA curve), we can conclude that it is characterized by an endothermic effect taking place at temperature up to 130 °C, and then – exothermic effect up to the end of the experiment.

From the results obtained it follows that by increasing the heating temperature of the samples (pumpkin puree) there was a 65 % weight loss (TG), accompanied by absorption of heat from the environment (endothermic effect). This is related to the loss of unbound and crystallized water in the researched samples. The dry residuum of the sample is 35 %, which is 70±1 mg (the total weight loss of each sample is 130±1 mg).

Thus, analyzing the derivative-graph study of pumpkin puree it can be concluded that at the initial stage, the evaporation of free water is taking place, and further exothermic effect can be caused by either interphase change (transfer of matter from one thermodynamic phase to another), or by the process of thermal decomposition of each sample (decomposition of matter under high temperature).

The pumpkin puree samples processed by high pressure were also investigated by non-isothermal analysis. The study shows that after treatment with a high-pressure the indicators of the derivative-graph analysis have not been changed.

The conclusions of the studied issues and the prospects for further research in the filed direction.

Thus, using the method the derivative-graph analysis the impact of high pressure on the bound water contained in the pumpkin puree has been defined. The current studies suggest that treatment under high pressure does not lead to the release of bound moisture according to the derivative-graph analysis. Thus, treatment under high pressure of pumpkin puree-type mass ensures preservation of valuable nutritional properties and unchanged characteristics of the product. Further research in this area will be aimed at defining the parameters of rational processing of pumpkin puree, a study of high pressure impact on changes of nutritional, rheological and other qualitative characteristics in the products processed by high pressure.

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В. О. Сукманов, *доктор технічних наук, професор;* ***Н. В. Герман,*** *доцент (Вищий навчальний заклад Укоопспілки «Полтавський університет економіки і торгівлі»).* ***Аналіз зв'язаної води в гарбузовому пюре, обробленому високим тиском.***

Анотація. Мета *дослідження полягає у визначенні характеру впливу високого тиску на зв'язану воду в гарбузовому пюре.* ***Методика дослідження.*** *Використане обладнання – дослідницьке обладнання для обробки високим тиском продуктів харчування та дериватограф Q-1500d.* ***Результати.*** *Експериментально визначено характер впливу високого тиску на зв'язану воду, яка міститься в гарбузовому пюре.* ***Висновки.*** *Обробка високим тиском не сприяє виділенню зв'язаної вологи з гарбузового пюре; властивості й показники продукту після обробки високим тиском залишаються незмінними.*

Ключові слова: *високий тиск, гарбузове пюре, дериватографічний аналіз, зв'язана вода, вільна вода.*

В. А. Сукманов, *доктор технических наук, профессор;* ***Н. В. Герман,*** *доцент (Высшее учебное заведение Укоопсоюза «Полтавский университет экономики и торговли»).* ***Анализ связанной воды в тыквенном пюре, обработанном высоким давлением.***

Аннотация. Цель *исследования заключается в определении характера влияния высокого давления на связанную воду в тыквенном пюре.* ***Методика исследования.*** *Использованное оборудование – исследовательская установка для обработки высоким давлением продуктов питания и дериватограф Q-1500d.* ***Результаты.*** *Экспериментально определен характер влияния высокого давления на связанную воду, которая содержится в тыквенном пюре.* ***Выводы****. Обработка высоким давлением не способствует выделению влаги из тыквенного пюре; свойства и показатели продукта после обработки высоким давлением остаются неизменными.*

Ключевые слова: *высокое давление, тыквенное пюре, дериватографический анализ, связанная вода, свободная вода.*

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