APPLICATION OF THE METHOD OF DISCRETE INPUT PULSE ENERGY FOR ENERGY-EFFICIENT PRODUCTION OF CHELIDONIUM MAJUS EXTRACT

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Abstract – The paper is devoted to the application of the method of discrete input pulse energy (DIPE), which today is one of the most effective ways to achieve high energy performance in food and chemical technologies. The results of experimental studies of aqueous extraction of chelidonium majus using the method of DIPE are presented. Physico-chemical parameters of the aqueous extract of chelidonium majus depending on the temperature of treatment are given.

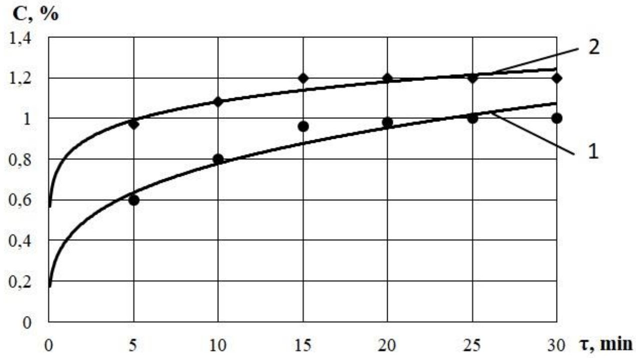
Keywords – the method of discrete input pulse energy, cavitation, extraction, chelidonium majus.

Introduction

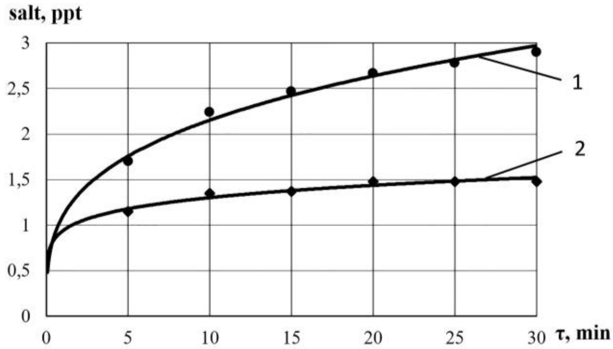
The main task of developing energy efficient technologies is to increase the technical and economic indicators of raw material processing. In particular, increasing the productivity of equipment and reducing energy consumption for technological operations involves the creation and implementation of efficient devices with low specific energy and material consumption, a high degree of impact on the processed substances. Economic, rational, resource-saving and energy-efficient production of biologically active components of natural origin for further use in various industries always remains an urgent problem. The work is devoted to a comprehensive study of technological modes of obtaining biologically active components on the example of chelidonium majus, as its aqueous extract has simultaneous antimicrobial, phagocytic, mitotic and antioxidant activity and is widely used. Experimental studies of the chelidoniun majus extraction process were performed on an apparatus using the method of DIPE developed at the Institute of Engineering Thermophysics of the National Academy of Sciences of Ukraine. This device is one of the modifications of pulsation devices with an active membrane, which has been tested as the energy-efficient cavitation pulsation-type reactor.

Research results

The extraction process using only intensive mixing of the medium provides a condition for increasing the convective diffusion coefficient to infinity, ie convective mass transfer is instantaneous, and the mass transfer coefficient is determined only by the diffusion coefficient in the pores of vegetable raw materials. Initiation of the cavitation mechanism during processing in the reactor leads to a significant acceleration of the process at its slowest stage, ie allows to influence the internal diffusion coefficient. Due to the intense oscillation of the particles of the system "solid – liquid" in places of friction there is a local increase in temperature, a decrease in the viscosity of the extractant, and hence an increase in the internal diffusion coefficient. Since the study was performed using an apparatus in which the processes of dispersion and extraction are implemented simultaneously, to obtain an uncontaminated extract of celandine grass raw material was loaded crushed to the optimal size $l = 3 \div 5$ cm. In the course of research it was found that with less fine grinding the number of ruptured cells increases sharply. This causes the leaching of concomitant substances that contaminate the water system (proteins, mucus, pectin and other macromolecular compounds), which is visually observed during processing. As the result of the conducted experimental researches water systems not turbid which are easily filtered are received. Based on the analysis of economic and technological aspects of testing the process of extraction of celandine grass were carried out at temperatures of 6 °C and 27 °C and hydromodule 1:8. Samples of the water system were taken during treatment with a five-minute interval for further determination of physicochemical properties using the measuring complex EZODO PCT-407. In all selected samples, the value of the hydrogen index was within pH=6,5÷6,78.



a)



b)

Fig. 1. Dependence of the amount of dry matter (a) and salt content (b) in the aqueous extract of chelidonium majus from the duration of processing at temperatures: 1 – 6 ºC; 2 – 27 ºC.

Determination of the amount of dry matter in the obtained samples was performed in accordance with GOST 28561-90. The obtained results are shown in fig 1 a. The presented dependences show that 15 min treatment in a cavitation reactor provides equilibrium of concentrations of target substances in the raw material and extract at a temperature of 6 ºC and 27 ºC. However, the value of salt content in fig. 1 b at an extraction temperature of 27 ºC are more stable than in the samples obtained at 6 ºC. This can be explained by the unsaturation of the solution at a temperature of 6 ºC, because during the extraction process there is a significant local increase in temperature and, accordingly, an increase in the internal diffusion coefficient. At a temperature of 27 ºC of the medium, a moderate local increase in temperature was observed. However, in both cases the medium was heated due to the use of the method of DIPE and the implementation of its most powerful cavitation mechanism.

Note that during the research, the temperature of 27 ºC was maintained throughout the processing period, which is, accordingly, additional energy consumption. Instead, the temperature of 6 ºC did not have to be maintained. It was a constant temperature of the water system at room temperature. However, a relatively maximum yield of dry matter (1,2 %) can be achieved at a constant ambient temperature of 27 ºC.

So, comparing fig. 1 a and fig. 1 b, it is possible to substantiate the obtained indicators of physicochemical parameters against the background of the quantitative composition of the target substances in the system depending on the duration of processing in the cavitation reactor pulsation type. The difference is obtained $\Delta C=(C_2\text{-}C_1)$, % is an inversely proportional value corresponding to the differences in fig. 1 b, which indicates a more intense course of redox reactions in the system using a cavitation mechanism at 6 ºC than when maintaining a temperature of 27 ºC. The measured values of the redox potential (ORP) differ by an order of magnitude depending on the temperature effect on the medium when initiating the cavitation mechanism. However, to describe the quality of the resulting aqueous system, saturated with target substances, it is necessary to have data on biological and chemical parameters in oxidative reactions. It is well known that the oxygen content in water is inverse with respect to temperature, ie with its increase always decreases. Local temperature increase due to the implementation of the cavitation mechanism in the system leads to the release of oxygen. A decrease in ORP indicates an increase in renewable substances in the system, and its growth – oxidative. Accordingly, it is possible to influence the relaxation of the ORP through cavitation treatment. Due to the cavitation effect on the environment, the decrease in the value of ORP is proportional to the decrease in pressure pulses.

Conclusion

The dynamic effects of hydrodynamic cavitation, which are inherent in the pulsation type reactor, have different effects on water systems during the extraction process depending on the duration of processing and temperature regimes. The obtained values of physico-chemical parameters allow to evaluate the efficiency of the extraction process using the cavitation mechanism. The pH value of the aqueous extract of celandine for 30 min meal at temperatures of 6 ºC and 27 ºC were in the range of pH = 6.5 ÷ 6.78. At a temperature of 6 ºC there was an increase of about 1,5 times. Determining the amount of dry matter yield from the duration of treatment showed that 15 min cavitation effect on the medium during the extraction of celandine provides a balance of mass concentrations of the system “solid – liquid”, which reduces the duration of the extraction of target substances without additional heating to boiling point.

The technology of obtaining plant extracts at room temperature is important for the extraction of thermolabile substances, which ensures the optimal use of cavitation mechanisms in mass transfer devices.

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