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ULTRASONIC EXTRACTION OF BIOLOGICALLY ACTIVE COMPOUNDS FROM THE VEGETABLE RAW MATERIAL

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A possibility of biologically active compounds extraction from different herbs has been studied using ultrasonic treatment. Optimal parameters of acoustic influence have been determined experimentally. Ultrasonic treatment of vegetable raw material has been shown to intensify the extraction process up to 5-7 min and to increase the extracted compounds content by a factor of 1.5-2. Calculations have been carried out to estimate the ways of introduced energy consumption. The method of ultrasonic extraction is recommended to be used in pharmaceutical industry to prepare extracts of high quality at small energy expenses.

The extraction of biologically active compounds (BAC) is the most important stage in production of medicines from herbs. Usually, this process is carried out via methods of percolation and maceration, characterized by small efficiency and long drawing (up to 21 days) [1,2]. That is why the problems of intensification and product quality increasing are of great importance at pharmaceutical plants. As is shown [3-6], the use of different electro-physical methods (ultrasound, electroflotation, etc) allows to increase the extraction rate and BAC yield and to decrease metal- and power-consuming of industrial setups.

The aim of the work presented is to study a possibility of ultrasonic intensification of BAC extraction from the vegetable raw material and to determine the ways of the introduced acoustic energy consumption as well.

Panax ginseng (leaves and roots), *Flores Crataegi, Fructus Crataegi* (flowers and foetus), *Herba Hyperici*, *Herba Leonuri*, *Pinus silvestris L.* (needle) have been used as raw materisl. Plants have been cut beforehand up to 70 - 2000 microns. Granulometric control has been conducted on vibrating analyzer KhimLABO (Russia). The raw material hasn't changed its color during the cutting. The ultrasonic treatment has been carried out using ultrasonic setup UZDN-A (Russia) with a conic nozzle of piezoelectric radiator. A sample of dispersed raw material has been placed into a beaker with ethanol solution (20-70%). Ultrasonic treatment has been carried out at the intensity of 1 - 70 w./cm^2 and oscillation frequency of 20-22 kHz for 60-420 s. The use of ethanol is explained by its application in pharmaceutical industry.

Ultrasonic dispergator has been tuned to necessary intensity and duration; 0.5 g of dispersed raw material and 25 ml of ethanol solution has been ultrasonically treated in the beaker. After ultrasonic treatment the suspension has been centrifuged and filtered. Then the extract obtained has been dried and the dry residue content has been evaluated (gravimetric analysis). To determine energy quota spent to heating, suspension temperature before and after ultrasonic treatment has been measured.

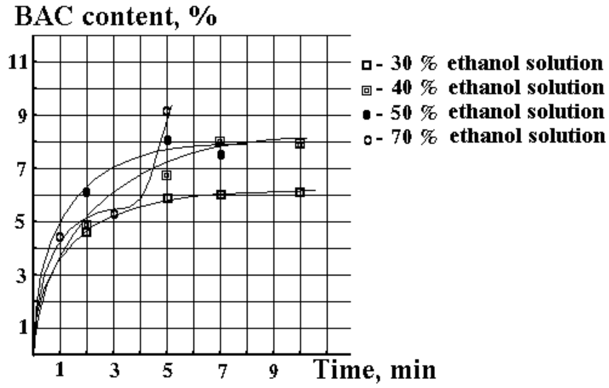
The choice of optimal parameters of ultrasonic treatment (intensity, frequency and duration) has been carried out individually for each kind of raw material. The evaluation of right approach to this choice has been conducted on the base of qualitative analysis of the extracts by IR-spectroscopy. A comparison of the oscillation frequencies of spectra of the extracted BAC with literature data has allowed to confirm the presence of these compounds or to show their destruction at wrong parameters of ultrasonic treatment.

The results of BAC ultrasonic extraction are presented in Table 1 and Figs. 1 and 2. According to these data the use of ultrasound has allowed to intensify the extraction process and increase BAC content in the extracts. The character of the curves "dry residue content - ultrasonic treatment duration" changes from exponential to tangential one, that is likely explained by redistribution of BAC between alcohol and water at the definite moment of the process conducting. By comparing Figs. 1a and 1b, one can see that ultrasonic treatment permits to use leaves of Panax ginseng like roots in preparing of medicines in pharmaceutical industry.

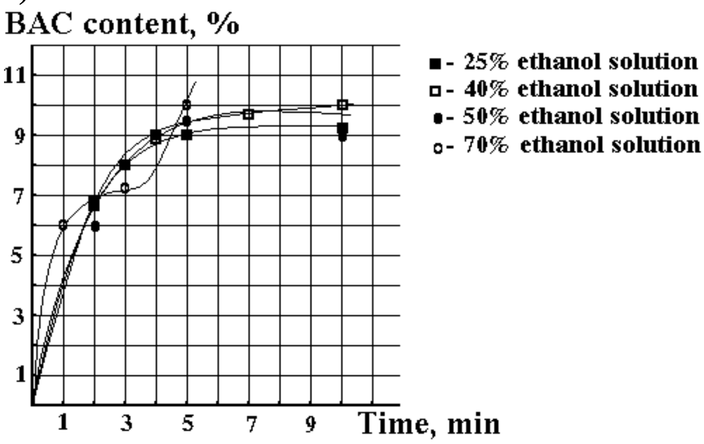
Table 1. - The results of ultrasonic extraction

Raw material	Ultrasound intensity, w./cm^2	Ultrasonic treatment duration, s	Ethanol solution, %	Dry residue content, %	
				without ultrasound	after ultrasound
Panax ginseng (leaves)	70	300 – 420	20-70	6,4	9,7
Panax ginseng (roots)	70	300 – 420	25-70	6,1	9,5
Flores Crataegi	12	300	70	<1	2,5
Fructus Crataegi	12	420	70	<1	1,6
Herba Hyperici	12	180	40	2,8	4,2
Herba Leonuri	70	300 – 420	70	1,4	3,6
Pinus Silvestris L.	70	300 - 420	25 - 40	1,6	2,6

The results of IR-spectroscopy have confirmed the increase of BAC yield after ultrasonic treatment (UST) on the one hand, and on the other - the destruction of some BAC at definite regime of UST. A comparison of the absorption bands in IR-spectra of polysaccharides of Panax ginseng after UST (Table 2) with literature data [7] confirms the right approach to the choice of UST parameters (intensity, frequency and duration). The least intensity of the absorption bands has been observed in the field of frequencies of 1020 cm^{-1} and 1030 cm^{-1}.



a)



b)

Fig.1. BAC content versus US-treatment duration at the intensity of 70 w./ñm^2:
à) *Panax ginseng (leaves);* b) *Panax ginseng (roots).*

Table 2. - A comparison of the oscillation frequencies in IR-spectra of polysaccharides of *Panax ginseng (leaves)* with literature data [7]

Group	Literature data on wavenumbers, $ñm^{-1}$	Experimental wavenumber, $ñm^{-1}$
α- è β- glycosyl bonds, γ(ÎÍ)$_{Ñ}$	840±5 880±10	800 850 860

To estimate the efficiency of acoustic energy in surface erosion and solids dispersion, a term of erosion-acoustic efficiency has been proposed [8], which is well described by equation (1):

$$\eta_{EA} = E_M / E, \qquad (1)$$

Å – introduced acoustic energy; Å$_{ì}$ – energy spent to mechanistic erosion. Calculations have been carried out for ultrasonic treatment of *Flores Crataegi*. Erosion-acoustic efficiency has been equal to:

$$\eta_{EA} = 8\%.$$

Besides erosion, introduced acoustic energy is spent to suspension heating. Suspension temperature before and after UST has been found to be 26°Ñ and 70°Ñ, resp. As the content of the vegetable raw material is rather small in suspension (0.5 g in 25 ml of 70% ethanol solution), we can suppose that the energy is mostly spent to ethanol solution heating. A quota of acoustic energy η_H spent to suspension heating is calculated as erosion-acoustic efficiency and has been found to be:

$$\eta_H = 53\%.$$

The investigation results let us to conclude: the use of ultrasonic treatment leads to a considerable intensification of the extraction process and to the increase of BAC content in the extracts; UST regime is individual for each kind of raw material; when UST intensity is more than 70 w./cm^2 and its duration is 20-30 min., the ultrasonic influence results in destruction of some types of BAC; investigations of the extracts by IR-spectroscopy and a comparison of the experimental results with literature data confirm the presence (or destruction) of some BAC.

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