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INDUSTRIAL BIRCH-BARK ALCOHOL-BASED EXTRACTION

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ABSTRACT

In this work algorithms of calculation of intra diffusive kinetics of process of extraction of the birch bark differing in difficult capillary and porous anisotropic structure are considered. Possibility of calculation of process of extraction of the extractive substances (ES) and betulin from birch bark at constant values of coefficient of internal diffusion is experimentally confirmed, dependencies of coefficients of internal diffusion on the birch bark sizes are established. The effective new way of allocation of betulin from birch bark with the use of microwave field allowing reducing at 10-15 times process duration in comparison with traditional methods of extraction is developed. Influence of key parameters on microwave extraction process is studied: type of solvent, concentration of ethyl alcohol, power consumption, the intensity of hashing and liquid module of the process. The empirical equation for the mathematical description of process is received and optimum values of parameters of allocation of betulin are defined: concentration of ethyl alcohol of 86%, duration of process is 6-7 min., liquid the module 1:20, power consumption of 16 kW· h/kg birch bark or 67 kW · h/kg betulin.

Keywords: birch bark, betulin, mass exchange, extractive substances, microwave extraction.

1. INTRODUCTION

At the large pulp and paper and wood-processing enterprises because of birch, wood debarking annually collects up to 300 thousand. M3 cortex (VE 1 the Resurrection, 1998). It is burned or taken out to dumps while birch bark – the strongest natural antiseptics and biostimulator. Birch bark contains to 50% of EV (2 Kislitsyn A.N., 1994) that represents considerable potential interest for chemical processing for the purpose of receiving new products and the biologically active agents (BAA). Use of waste of processing of birch wood allows to increase the profitability of production and to gain a big effect on the national economy.

The external layer of bark - birch bark - contains valuable ES and BAA, first of all, betulin, therefore, it is processing with receiving BAA is the most rational utilization direction.

The domestic pharmaceutical industry has an acute shortage in psychogenesis preparations. Betulin and the derivatives synthesized on its basis possess various biological activity (3-8), in particular antiseptic (9, 10), gastro and hepatoprotective properties (11,12), antineoplastic, anti-HIV activity (13,14) and represent great interest for chemical and pharmaceutical and food industries.

2. REVIEW OF THE REFERENCES

The problem of extracting betulin from birch bark held some scientists in Russia and abroad - Kislitsyn AN, BN Kuznetsov, Levdanskii VA, VI Roshchin and, etc. There are numerous scientific publications (15-21, 28) concerning receiving betulin from birch bark under various conditions of extraction, and also to the directions of its use.

The most widespread methods of allocation of betulin are based on birch bark extraction by various solvents by insisting method, by reflux method (22-25), and on alkaline hydrolysis of birch bark with the subsequent extraction of betulin (15). The main shortcomings of these methods are the duration of the stage of allocation of betulin caused by its low availability to estrogen and low solubility in the majority of solvents.

For the purpose of intensification of process of receiving betulin it is offered to activate birch bark in the conditions of non-isobaric steam cracking (15,16,18), to use shock and acoustic influence (26) and supercritical extraction by carbon dioxide (27). However, these ways demand high pressure or high temperatures, use of the hardly separated alkali that complicates technology and increases the power consumption of the process.

The published data on industrial production of betulin from birch bark in Russia and abroad not.

3. METHODS AND MATERIALS

3.1 Material (raw materials)

As raw materials used samples of industrial birch bark from the Arkhangelsk plywood plant (further – technical birch bark). The material was ground in laboratory crusher of the using-up action. For carrying out skilled extraction prepared model samples of technical birch bark with the fixed sizes (in the tangential, longitudinal and radial directions), defining their geometrical characteristics.

3.2 Methods

3.2.1 Extraction of ES and betulin by insisting method

In flask, the hinge plate of birch bark was filled in with ethyl alcohol (86% about.) at certain liquid module, and then the flask was connected to the return refrigerator and placed in water bath at temperature of 90 °C. Extraction was conducted at solvent boiling temperature. Duration of the process is 5 h.

3.2.2 Extraction of ES and betulin by microwave extraction method

We have developed an experimental installation for research of process of the microwave oven - extractions based on the household microwave oven (29-31). Birch bark was loaded into the flask, filled in with the corresponding quantity of estrogen. Then the flask was placed in the microwave oven - the camera, connected it to the return refrigerator, included mixer and extracted within 10 min. at certain power consumption. After a time, the received weight was filtered. Extract of birch bark was merged in the prepared flask.Allocation of ES from extracts was carried out by the full distillation method of solvent and betulin-raw by the method of physical condensation (solvent replacement).

At research of kinetics of extraction of ES and betulin from birch bark periodically (in one minute) made selection of extracts. Watched increase of the concentration of EV using weight method (evaporation and drying of the selected solution volume). The quantitative maintenance of betulinol in the extract was defined by the HELC method (highly effective liquid chromatography).

3.3 Tools

3.3.1 Highly effective liquid chromatography

The analysis was made on the LC-20 chromatograph of Shimadzu firm. Column Zorbax Eclipse Plus C-18, 3×100 mm, size of particles 3, 5 μm. Temperature of the column is 40 °C. Chromatography was spent in the gradient mode of supply of eluents. The volume of the entered test is 2 mkl. The speed of a stream is 0, 4 ml/min. Detecting was carried out on the diode and matrix detector at the wavelength of 205 nanometers. As standards used samples of the SIGMA-ALDRICH firm (the maintenance of betulin ≥ 98%, lupeol ≥ 94%).

3.3.2 Gas chromatography-mass spectrometry

The analysis was carried out on gas chromatography-mass spectrometer - GCMS mass spectrometer – QP of 2010 Plus of Shimadzu* firm. The capillary column 60 m long, with an internal diameter of 0,32 mm of HP-5MS is used. *Chromatography* conditions following: as a gas of the carrier used helium, the speed of stream made 37 cm/min.; temperature of input of sample 300 ºC; reference temperature 110 ºC, the program of the rise in temperature to 220 ºC with the speed of 10 ºC/min. and to 300 ºC with speed of 40 ºC / the min., isothermal mode - 35 min.; temperature of the transfer line 280 ºC, source of ions - 250 ºC, the mode of electronic blow at 70 eV, detection of masses from 50 to 500 m/z.

3.3.3 Infrared spectroscopy (IK - spectroscopy)

The analysis of samples was carried out on the Vertex 70 IK-spectrophotometer (Bruker firm). The range of record of the range of 4000-600 cm^{-1}, resolution, is 2 cm^{-1}. ATR prefix (the repeated broken full internal reflection) of Pike firm with prism from the diamond was used.

4. RESULTS AND DISCUSSIONS

4.1 Characteristics and chemical composition of ES and birch bark

The main groups of substances in birch bark are ES and suberin. The maintenance of EV allocated with ethyl alcohol makes 34% of dry birch bark (a. s. b.), including 24% of betulin, 2, 9% of lupeol and 7, 1% of other components. Identification of the main components is carried out using IK-spectroscopy, tomato - mass spectrometry. HELC (Table-1) defines the quantitative maintenance of betulin and lupeol.

Table-1. The maintenance of betulin and lupeol from extract, % on weight.

Ekstraktiv	Betulin	Lupeol
Betulin raw	66,6 ± 5,4	8,2 ± 0,7
Extractive substances	70,0 ± 5,6	9,3 ± 0,7
Cleared betulin	90,5 ± 6,8	9,4 ± 0,8

Apparently, from Table-1, the quantitative maintenance of betulin (~ 70%) and lupeol (~ 9%) in extractive substances is close to the content of these substances in betulin-raw (~ 67% and ~ 8% respectively). The lowered maintenance of the main components in betulin-raw is connected with partial dissolution when filtering aqueous-alcoholic suspension. The residual maintenance of betulin in aqueous-alcoholic solutions makes 1, 5-2%.

4.2 Testing of solubility of the cleared betulin, Betulin raw and ES

At extraction of betulin from birch bark, its dissolution in extractant comes by the method of extraction. Determination of solubility is important at choice of estrogen and calculation of kinetics of extraction

for the purpose of finding of concentration of saturated spirit ES solution and betulin in birch bark and definitions of the minimum liquid module at birch bark extraction. Investigated solubility of betulin raw, the cleared betulin and ES birch bark. Influence of temperature and concentration of ethyl alcohol (86 and 95%) for solubility is given in Table-2. The increase of the concentration of ethyl alcohol with 86 to 95% slightly increases the solubility of the analyzed substances. Cleared betulin has smaller solubility.

Table-2. Solubility of products, %.

Temperature, °C	Cleared betulin		Betulin raw		The extractive substances	
	Concentration of alcohol, %					
	95	86	95	86	95	86
25	0,86	0,54	2,30	2,07	2,52	1,48
40	1,15	0,74	3,48	2,68	3,53	2,17
60	1,77	0,85	5,99	3,87	3,23	2,64
Speed. boilings	2,03	1,51	6,30	5,04	6,41	6,03

4.3 The mathematical description of extraction of ES from birch bark

4.3.1 Hydrodynamic conditions

For the definition of the limiting stage of mass exchange investigated the influence of hydrodynamic conditions on the birch bark extraction process.

Speed of extraction of birch bark is defined by rate of diffusion from the internal volume of birch bark to its surface and the branch of the dissolved substances in environment determined by the hydrodynamic mode of the movement (hashing) of extractant. The hydrodynamic mode in the extractor is characterized by the size of the criterion of Reynolds (Re).

In series of experiences with the model spill intensity of hashing was changed from 100 to 800 revolutions per minute. Kinetic extraction curves at various values of the criterion of Re are shown in Figure-1.

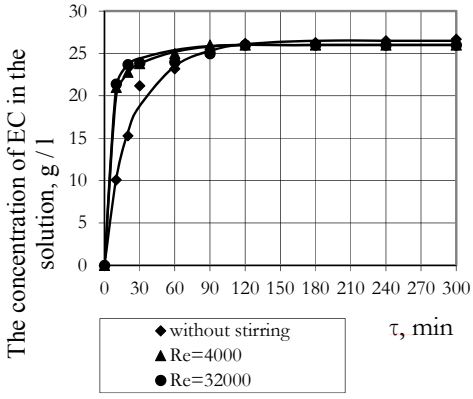


Figure-1. Kinetic extraction curves at various values of criterion of Re.

The results showed that the model bark at different mixing intensity observed the same pattern. In the initial period (10 min) and high speed of the process depends on the hydrodynamic conditions in the machine. As EW extraction increases the working length long, and the process of mass transfer is fully transferred into interdiffusion area. With an increase of more than 4000 criteria Re mass transfer is limited only by the internal diffusion, since experimental curves in Figure-1 for values Re = 4000 and Re = 32000 are virtually identical.

4.3.2 Theoretical regularities of extraction of birch bark

Extraction of birch bark for the purpose of allocation of extractive substances and betulinol is the mass-exchanged process complicated by anisotropic capillary and porous structure of birch bark. The kinetics of transfer of substance from solid body in liquid phase can be described the generalized dependence

$$(X_n - X)/(X_n - y_o) = f(\mathrm{Fo_d}, \mathrm{Bi}, \mathrm{G}, b) \quad (1)$$

where *Xn*, *X*, *yo* - concentration of the distributed substance initial and current in solid body and liquid phase; Fod = *Dτ/l2* - diffusive criterion of Fourier; Bi = βl/D - Biot's criterion; - the simplex of geometrical similarity characterizing form and the sizes of particles; *b* - relation of total volume of firm particles to the volume of liquid phase; β - mass transfer coefficient in liquid phase; *l* - the defining linear size (for plate - half of thickness, for sphere and the cylinder - *R* radius); *D* - coefficient of internal diffusion (mass conductivity); τ - extraction process duration.

The most available way of pilot study of kinetics of process of mass exchange in system "solid body - liquid" is carrying out periodic process in which certain amounts of strong substance and liquid are loaded into the

device with mixer and change of concentration of solution in time is traced. The equation (1) has appearance

$$\frac{X_н - X}{X_н - y_0} = \frac{1}{1+b} - \sum_{n=1}^{\infty} \frac{4(\nu+1)\exp(-\mu_n^2 \mathrm{Fo}_д)}{\left(1+\frac{2}{\mathrm{Bi}}\right)\mu_n^2 - 2(\nu+1)\left[\frac{\mu_n^2}{\mathrm{Bi}} - 2(\nu+1)b\right] + \left[\frac{\mu_n^2}{\mathrm{Bi}} - 2(\nu+1)b\right]^2} \quad (2)$$

where ν = ½ (G – 1), for plate ν = –½, for the cylinder ν = 0 and for the sphere ν = ½; n – numbers of natural row; μ_n - roots of the characteristic equation.

Extraction of plant materials is usually limited by internal diffusion (Bi → ∞). Then the equation of kinetics (2) can be written down in the simplified look

$$\frac{X_н - X}{X_н - y_0} = \frac{1}{1+b} - \sum_{n=1}^{\infty} A_n \exp(-\mu_n^2 \mathrm{Fo}_д) \quad (3)$$

Values A_n and roots of the characteristic equations μ_n depend on the form of particles.

At τ → ∞ and respectively $\mathrm{Fo_d} \rightarrow \infty$ from the equation (3) for periodic process ($y_0 = y_n$) follows:

$$\frac{X_n - y_r}{X_n - y_n} = \frac{1}{1+b} \quad (4)$$

From equation

$b = (y_r - y_n)(X_n - y_r)$.

Substitution of value 1 / (1 + b) from (4) in (3) if to be limited to one member of row, gives expression

$$\frac{X - y_r}{X_n - y_n} = B_1 \exp(-\mu_1^2 \mathrm{Fo_d}) \quad (5)$$

Here X – average concentration of the drawn substance in the solution that is in a time of solid body in any timepoint. To it there corresponds average concentration of the solution *at*. According to condition of material balance,

$$y_r - y = b(X - y_r) \quad (6)$$

The right part of this equality defines relative amount of substance, which has passed into extract from solid body in time from the considered time point until the end of experience, and the left part - increment of concentration of solution for the same period. From the equation (5) using ratio (6), we will express:

$$\frac{y_r - y}{X_n - y_n} = B_1 \exp(-\mu_1^2 \mathrm{Fo_d})$$

or

$$\ln \frac{y_r - y}{X_n - y_n} = \ln B_1 - \mu_1^2 \frac{D\tau}{l^2} \quad (7)$$

where $B_1 = bA_1$.

According to the equation, (7) graphic dependence is under construction $\ln[(y_r - y)/(X_n - y_n)]$ from τ extraction duration. As conditions under which this equation is removed were observed, at not small values τ on graphics the straight line turns out. It is an area of the regular mode of extraction. Extrapolation of straight line $\ln[(y_r - y) / (X_n - y_n)] = f(\tau)$ до τ = 0 defined value B_1 in the equation (7), and on straight line inclination tangent of angle tg α founded the size of coefficient of internal diffusion $D = -\frac{l^2 \mathrm{tg}\,\alpha}{\mu_1^2}$.

As the linear size l in anisotropic bodies, it is possible to apply the equivalent size to the accounting of tridimensionally of the process of mass conductivity. Thus, real three-dimensional bodies are conditionally given to the equivalent one-dimensional. Anisotropism of birch bark demands the accounting of unevenness of the directions in which there is extraction. Resistance to mass transfer to radial and longitudinal surfaces is replaced with an equivalent increase in the way of diffusion of the distributed substance.

The values calculated according to skilled data μ_1 = 2,7–3,1 and A_1 = 0,590…0,645 are close to theoretical for sphere that validates choice of representation of sample of birch bark in the form of sphere. Further accepted values $\mu_1 = \pi$ and $A_1 = 6/\pi^2 = 0{,}608$.

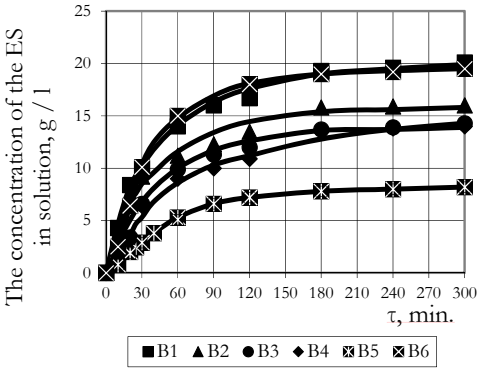
4.3.3 Research of kinetics of extraction of model samples of birch bark

When studying the kinetics of process of mass transfer experiments were made in the conditions excluding the influence of external diffusion (Re> 4000) on the process of extraction of EV and betulinol. Influence of size of the way of diffusion was investigated in series of experiments on the extraction of model samples of birch bark. Geometrical characteristics of samples of birch bark are provided in the Table-3.

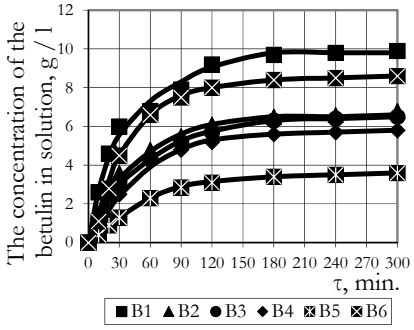
Table 3. Geometrical characteristics of samples of birch bark and experimental values of coefficients of internal diffusion

Sample	The average sizes of particles of birch bark in the tangential, longitudinal and radial directions (from 100 measurements), mm	Equivalent radius of particles of birch bark, *R*, м	Coefficient of internal diffusion of ES $D \cdot 10^{11}$, m^2/s	Coefficient of internal diffusion betulina $D \cdot 10^{11}$, $м^2/с$
B1	2,5×2,6×1,6	0,00087	1,76	1,44
B2	5,3×2,7×1,6	0,00174	7,28	5,50
B3	5,2×5,3×1,6	0,00177	6,40	5,76
B4	7,5×5,0×1,7	0,00246	12,40	14,10
B5	2,6×7,7×1,5	0,00091	1,97	1,36
B6	7,4×2,6×1,6	0,00227	12,40	9,03

Kinetic curve (Figure-2) show that with an increase in the sizes of birch bark in width and length the speed of process decreases and extent of extraction of ES and betulinol decreases.



a)



b)

Figure-2. Kinetic curve extractions of ES (a) and betulin from birch bark.

The characteristic type of logarithmic dependence of simplex of the concentration of ES from τ at extraction of a sample of B1 birch bark ethyl alcohol is shown in Figure-3.

Comparison of experimental data and settlement curve of extraction for sample of B1 birch bark (Figure-4) shows that in working interval of time the divergence of results does not exceed 10% and confirms possibility of application of the offered algorithm for research of kinetics of extraction of birch bark.

Results of experiments with other samples of birch bark have shown similar regularities. In Figure-5 correlation schedules for ES and betulin (B1-B6 samples) are submitted. The Average Square Deviations (ASD) make 0, 17 and 0, 11 g/l.

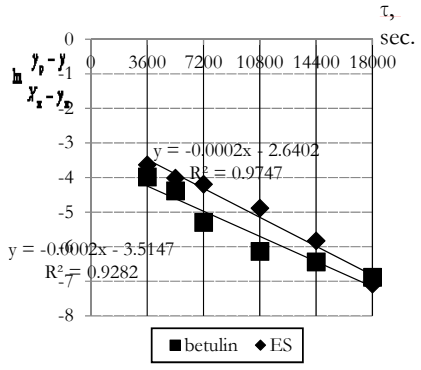


Figure-3. Dependence ln[$(y_р - y) / (X_н - y_н) = f(\tau)$ at extraction of ES and betulin for B1 sample.

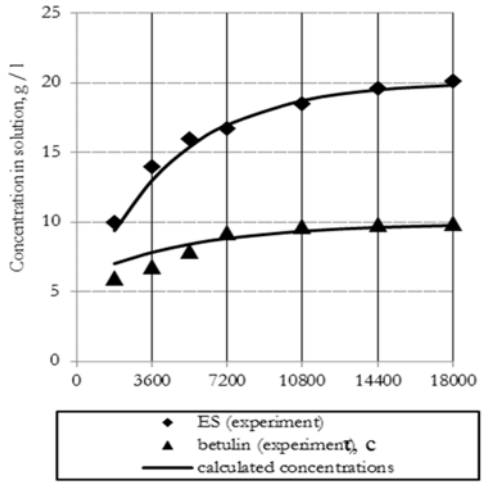


Figure-4. Comparison of settlement curves of extraction of ES and betulin with experimental data for B1 sample.

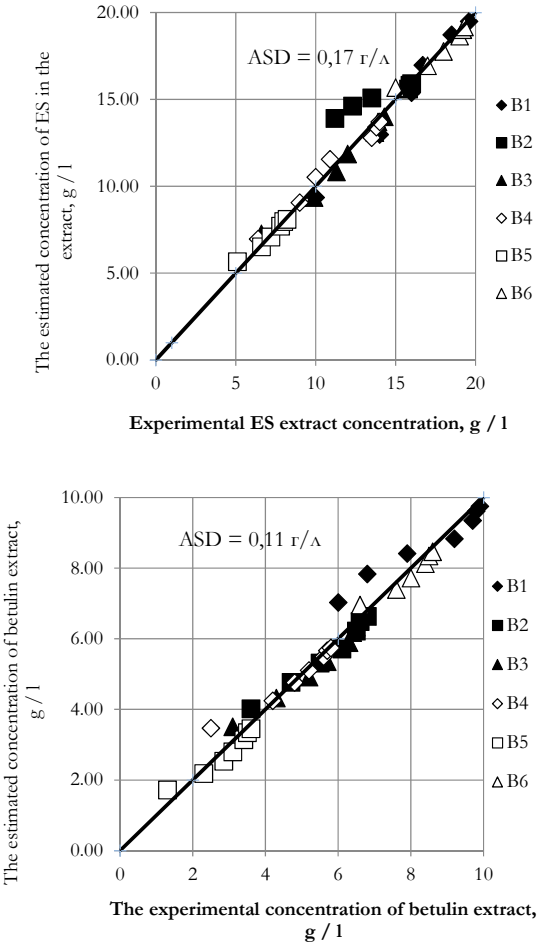


Figure-5. Correlation schedules for ES and betulin (B1-B6 samples).

The coefficient of internal diffusion is in sedate dependence on the given birch bark sample radius:

for ES

$D = 1,49 \cdot 10^{-5} R^{1,94}$ (correlation coefficient0,992),

for betulin

$D = 4,62 \cdot 10^{-5} R^{2,14}$ (correlation coefficient0,989).

Extent of extraction at extraction of birch bark pays off on the equation

$E = E^* (1 - E_1)$,

where $E^* = 1 - X^*/X_n$ – the equilibrium (maximum) extent of extraction for birch bark of given size defined by practical consideration; E_1 – concentration simplex.

Value of coefficient of internal diffusion *of D* can be used for calculation of duration of process of extraction of birch bark ethyl alcohol in industrial conditions at the set extent of extraction of EV and betulin on the equation

$$\tau = \frac{R^2}{D\pi^2} \ln \frac{0,608}{E_1}.$$

4.4 Extraction of birch bark at influence of microwave field

In Figure-6 the kinetics of extraction of EV and betulin with microwave processing and without it is shown. 90% extent of extraction of EV are observed in 90 min. without microwave processing and in 10 min. - in the microwave chamber. Achievement of the extent of extraction, equal 50%, at usual extraction makes 16-20 min., and in the field of the microwave oven - less than one minute.

Advantage of microwave extraction is the high speed of internal warming up of birch bark in polar solvent; it's boiling up in cells of birch bark and intensive emission of the formed extract in surrounding solvent (barodiffusion).

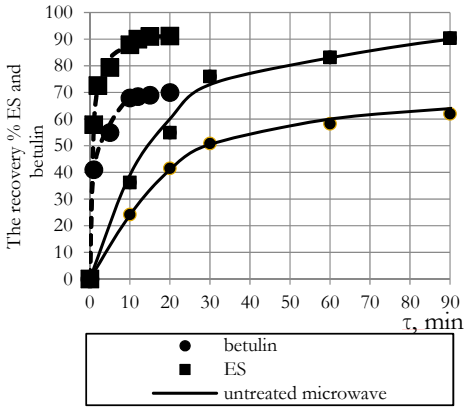
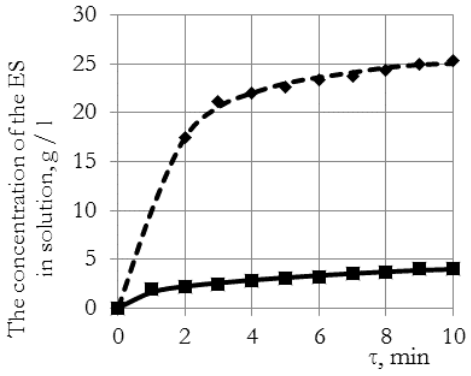


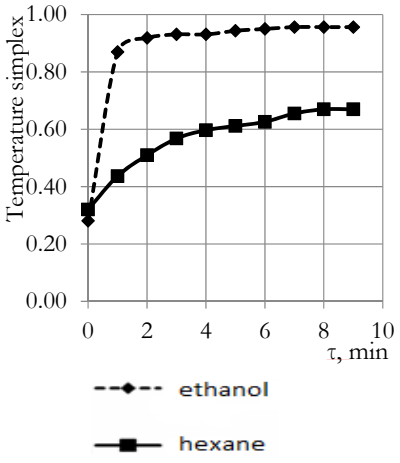
Figure-6. Influence of microwave processing on kinetics of extraction of ES and betulin.

4.4.1 Influence of type of solvent for microwave extraction

In Figure-7 (b) it is visible that at the influence of microwave field with ethyl alcohol process goes practically at solvent boiling temperature and with geksan - boiling temperatures are lower. The temperature simplex is the relation of the temperature of boiling of extract to a temperature of boiling of the pure solvent.



a)



b)

Figure-7. Change of concentration of ES in solution and temperatures in microwave chamber depending on the chosen solvent.

Influence of the concentration of ethyl alcohol on the extent of extraction of ES (Figure-8) is investigated. With the reduction of the concentration of alcohol extent of extraction of ES since betulin, it is insoluble in water decreases. Ethyl alcohol with a concentration of 95% and 86% draws approximately the identical quantity of ES. Application of 86% - the foot of alcohol simplifies regeneration of solvent by rectification and does not demand more difficult and expensive equipment.

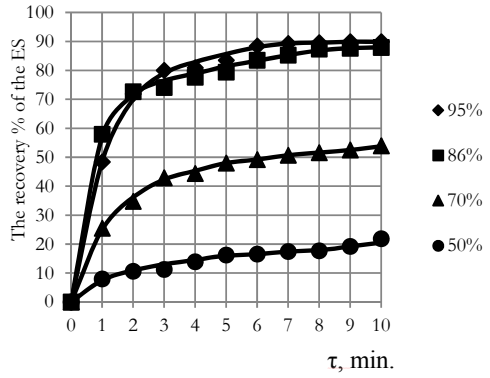


Figure-8. Influence of concentration of ethyl alcohol on extent of extraction of ES.

4.4.2 Influence of the liquid module

The ratio of phases (liquid the module) − one of the key parameters defining the process of extraction of ES of birch bark. At the choice of the liquid module, it is necessary to consider the solubility of substances in the extractant. When carrying out microwave extraction with module variation from 1:10 till 1:20 (on volume) in the range of process duration till 10 min. it is established that the maximum extraction of EV from birch bark is observed in 5-6 min., irrespective of the module of extraction (Figure-9). And the variation of the module has shown that at module 1:20 7-8% more EV is taken, than at the module 1:10.

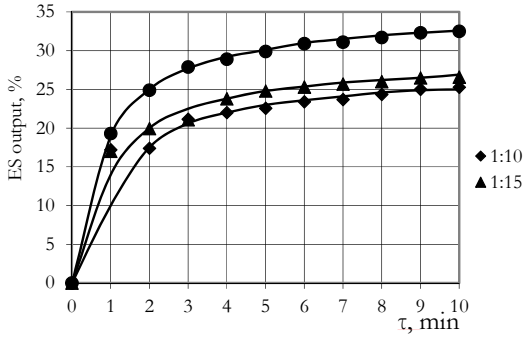


Figure-9. Kinetics of extraction of ES from birch bark depending on the liquid module.

4.4.3 Research of kinetic regularities of process of microwave extraction of birch bark

Earlier given algorithm of calculation of intra diffusive kinetics of process of extraction of birch bark is applicable and for microwave extraction. In Figure-10 correlation schedules for ES and betulin (B7-B15 samples) are submitted. ASD do not exceed 0, 15 g/l.

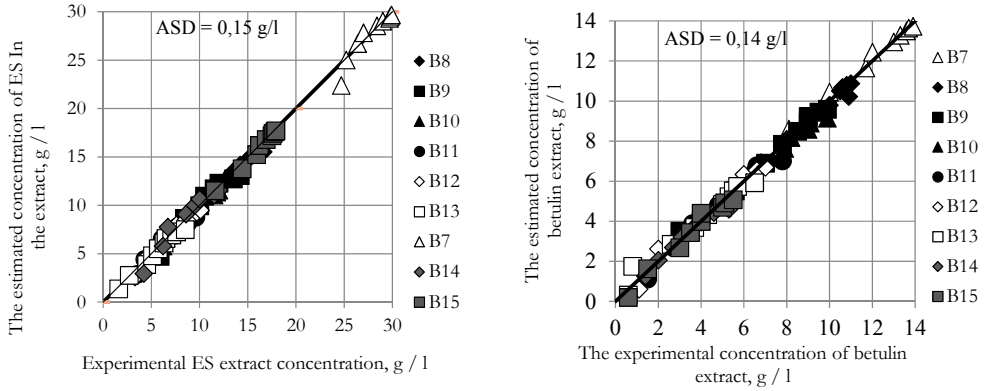


Figure-10. Correlation schedules for ES and betulin.

4.4.4 Mathematical description of influence of key parameters

Microwave extractions

For obtaining the mathematical description of process of extraction of betulin depending on the chosen variables and determination of optimum parameters of its allocation have used method of scheduled experiment in the form of rotatable composite uniforms - the plan of the second order. In total in the course of realization of experiment 31 experiments, seven of them in the center of the plan are made. As independent variables have been chosen liquid the module (x_1), power consumption, kWh (x_2), mass of hinge plate, g (x_3), the intensity of hashing determined by number of turns of mixer (x_4). Output parameter is the betulina-raw exit (y_1), %, carried to the mass of birch bark (Table-4).

Table-4. Conditions of planned experiment.

Factor	The coded value	Δx_i	$-\alpha$	–	0	+	$+\alpha$
The liquid module	x_1	**2,5**	**1:7,5**	**1:10**	**1:12,5**	**1:15**	**1:17,5**
Power consumption, kW · h	x_2	0,014	0,012	0,026	0,040	0,054	0,068
Mass of hinge plate,	x_3	2,5	5,0	7,5	10,0	12,5	15,0
Intensity hashing, rpm	x_4	150	100	250	400	550	700

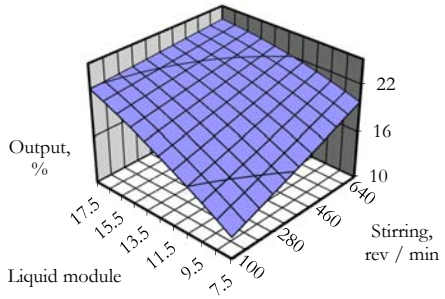
After exception of the full equation of effects with insignificant coefficients, the final equation used by us for assessment of adequacy of model looks as follows:

$$\overline{Y} = 21{,}00 + 0{,}49\,x_1 + 0{,}56\,x_2 + 0{,}19\,x_4 + 0{,}19\,x_1x_2 - 0{,}36\,x_1x_3 - 0{,}35\,x_1x_4 - - 0{,}43x_3x_4 - 0{,}15\,x_1^2 - 0{,}23\,x_2^2 - 0{,}30\,x_3^2 .$$

The received empirical equation is adequate (value of criterion of Fischer F = 1, 12 < F_{table} = 3, 87). Interpretation of the received model is presented in the form of schedules of surfaces of response to Figure-10.

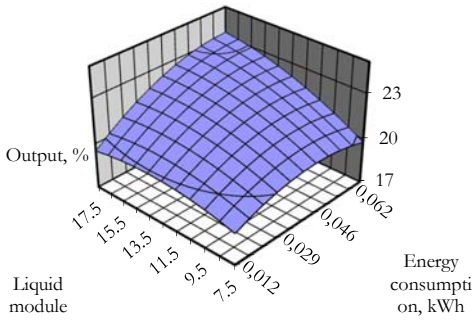
Three parameters positively influence betulina-raw exit, in particular, liquid the module and power consumption. However, the big module will be economically inexpedient. Hashing slightly affects raw betulin exit. With the increase in the intensity of hashing external diffusion sharply increases, (mass transfer from birch bark particle surface in surrounding ekstragent), and also there is the prevention of emission of the extract from the reactionary flask.

For the definition of the optimum expense of electric energy have used "method of abrupt ascension". For this purpose, three parameters have been recorded at one level. Step by step changed the only power consumption. Based on the received results optimum power consumption has made 16 kW·h/kg birch barks or 67 kW · h/kg betulin.



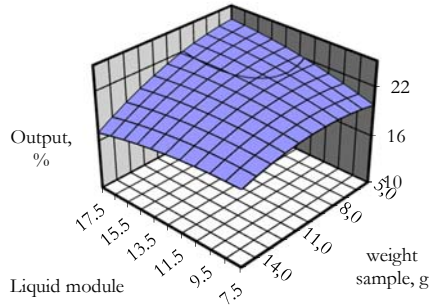
a)

*The mass of hinge plate is 5 g; power consumption of 0,068 kW



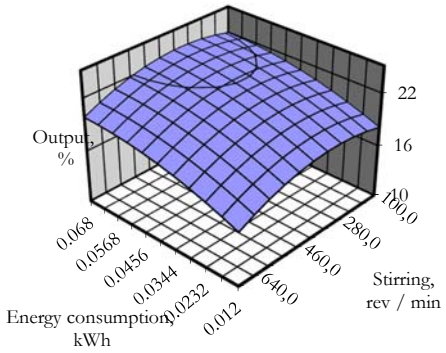
b)

* the Mass of hinge plate is h 5 g; intensity hashing of 700 rpm



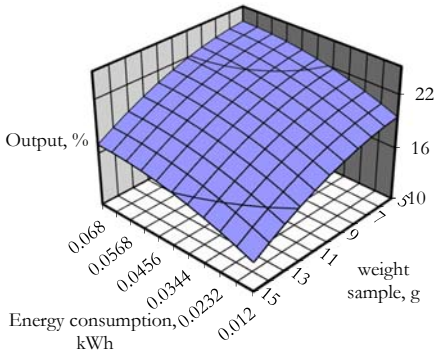
c)

* Power consumption of 0,068 kWh; intensity hashing of 700 rpm



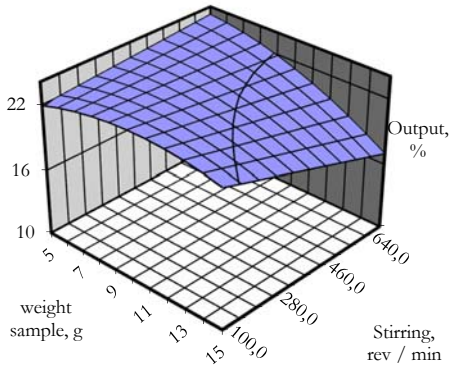
d)

* the Mass of hinge plate is 5 g; liquid module 1:17,5



e)

*Liquid module 1:17, 5 intensity of hashing of 700 rpm



f)

* Liquid module 1:17,5raskhod of energy of 0,068 kW · h

Figure-10. Surface output response of raw betulin depending on the natural values of factors: a - liquid and mixing module; b - the fluid module and the power consumption; c - liquid mass and hinge module; d - energy consumption and mixing; e - energy consumption and the mass of sample; f - modulus liquid and energy consumption; * - Factors are fixed at the same level.

5. CONFIRMATIONS

On the basis of trial tests the technological scheme of receiving betulin including stages of preparation of raw materials, extraction, partial distillation of alcohol and sedimentation of betulinovy concentrate from uparenny extract by method of physical condensation, filtration and drying of product is offered. Strengthening of spirit solutions is carried out by rectification method.

The specifications on a new product of "Betulin" approved by the Arkhangelsk skilled vodoroslevy combine are developed. Depending on branches of application three brands of betulinovy, concentrate (Table-5) are established:

P (food) - recommended for use as dietary food supplement;

M (medical) - recommended for use in medical and chemical and pharmaceutical branches;

X (chemical) - recommended for use in chemical synthesis.

Table-5. Physical and chemical indicators of betulin.

Crystal powder of white color	Norm for brand			Method tests
	P	M	X	
Appearance	Powder from the light-beige till white color	Powder from dairy till white color	Crystal powder of white color	The visual
Maintenance of betulinol, %, not less than	60	70	95	HELC
Humidity, %, no more than	5	4	1	Drying
Ash-content, %, no more than	0,05	0,04	0,01	Combustion
Solubility in ethyl alcohol at temperature of 78 ° C, %, no more	7	5	2	The gravimetric
Melting temperature, °C, not less	It is not regulated		258	The capillary

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