OPTIMIZATION OF EXTRACTION PROCESS OF BIOLOGICAL ACTIVE SUBSTANCES FROM PRE–TREATED GRAPE SEEDS IN PULSED ELECTRIC FIELD

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Abstract: the results of the extraction of biologically active substances from grape seeds pre–treated in pulsed electric field. To establish mathematical models has been used Matlab program. Analysis of the experimental data showed the existence of Nonlinear dependencies from and from considerations of modeling accuracy appealed to the spline functions. Nominal mathematical models have been established of the total mass extracted in the functions of number of impulses and the intensity of field for extraction temperatures 25 to 65°C. The components and modeling coefficients were determined with spline functions of extracted total mass of biologically active substances.
Keywords: grape seed oil, extraction, biologically active substances, mathematical model.

Introduction

Nowadays**,** the countries with a developed winemaking as France, Spain, Italy, Argentina used extensively in practice complex, thorough processing of secondary wine products. Presently, in the Republic of Moldova there is no basically, enterprises which would apply a complex technology to exploit the secondary wine products. It is therefore important to implement new effective technologies for recovery and treatment of secondary wine products with low consumption of energy and materials [1].

It was proved that seed polyphenols possess health–keeping properties that have been associated with their antioxidant activities in vivo and in vitro [2, 3]. A study on vivo regarding the effects of antioxidants showed that proanthocyanidins from grape seeds have a protective influence better than vitamin E and vitamin C against lipid peroxidation thus interrupting and fragmentation of DNA in mice [4].

Experimental research evolved for studying the extracting process of biologically active substances from the seeds of grapes may be arbitrarily large numbers for various reasons, including economic. For this reason, in all areas, for theoretical study of a certain process the mathematical model is established [5]. In determining of the mathematical model the simplifying assumptions are adopted and the approximations are made on the analyzed process parameters. They lead to the mathematical incomplete descriptions and departs from the reality. For these reasons, frequently, at the present time establishing the mathematical model and looming theoretical and then finalized based on experimental data [6].

Materials and methods

For the experiments were used red grape seeds from the Republic of Moldova that have been pre–treated to electrical voltage of 90, 165 and 260V, which generates the electric field strength of 300, 500 and 866,6V/cm and produces 900 electrical impulses with the duration of 900μs in 15 minutes. Then pre–treated seeds in the amount of 3g were subjected to extraction with aqueous ethanol solution with 50% concentration in solid–liquid ratio 1:8, at temperatures of 25 and 65°C for 60 min. The extracts obtained were subjected to filtration and transferred to the the packaging dark colour. Samples of grape seed extracts were kept in the dark place at a temperature of 4±1°C [7]. In the grape seed extracts was determined the total mass extracted ($P9_{tn}$) and mass tannins.

Determination of tannins is that all the phenolic compounds are oxidized by the Folin–Ciocalteu reagent. The color intensity is proportional to the content of phenolic compounds. The color intensity is determined in spectrophotometer at λ = 750 nm and the content of phenolic substances is determined calibration curve [8].

For establishing the mathematical model has been used Matlab program. For the sake of modeling accuracy, for the establishment of mathematical models appealed to the spline functions, i.e. cubic spline; because the processes are nonlinear [9].

Results and discussions

In the table 1 are presented the values of eno tannins mass extracted from grape seeds pre–treated in the functions of the number of units (N) and (I) field intensity at temperatures of 25 to 65°C.

Table 1. The values of eno tannins mass extracted from grape seeds pre–treated in the functions of the number of units (N) and (I) field intensity at temperatures of 25 to 65°C

N sample	Duration pretreatment, min	The number of pulses, s^{-1}	The intensity of the electric field, V/cm	Pulse duration, μs	Voltage, V	Total mass extracted, mg/3 g	The eno tannins extracted, mg/3 g
25.0±1.0 °C							
1	15	0	0	0	0	111.6±0.22	2.20±0.03
2	15	900	866.66	900	260	185.8±0.20	3.60±0.07
3	15	100	866.66	900	260	160.8±0.25	4.60±0.05
4	15	900	500	900	165	143.3±0.18	5.10±0.05
5	15	100	500	900	165	140.8±0.15	5.90±0.10
6	15	900	300	900	90	170.1±0.16	4.80±0.05
7	15	100	300	900	90	121.8±0.15	2.70±0.05
65.0±1.0 °C							
1	15	0	0	0	0	189.3±0.18	13.00±0.10
2	15	900	866.66	900	260	263.4±0.21	29.40±0.05
3	15	100	866.66	900	260	205.3±0.15	29.10±0.07
4	15	900	500	900	165	212.6±0.15	31.80±0.15
5	15	100	500	900	165	347.3±0.22	29.60±0.15
6	15	900	300	900	90	204.1±0.15	28.00±0.15
7	15	100	300	900	90	176.7±0.12	23.00±0.10

On the basis of the results obtained were established mathematical models. Thus, in fig. 1 and 2 are presented the graphs of nominal mathematical model (with average values) for total mass extracted ($P9_{tn}$) depending on the number of pulses (N) and field intencity (I), for temperatures 25 to 65°C, and in the fig. 3 and 4 are played mathematical model derived components.

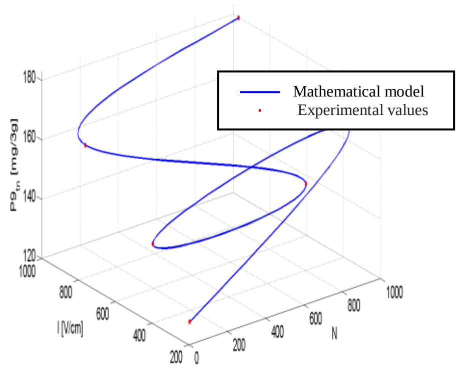

Fig.1. Nominal mathematical model of the total mass extracted $P9_{tn}$=f (N, I), for t = 25 °C

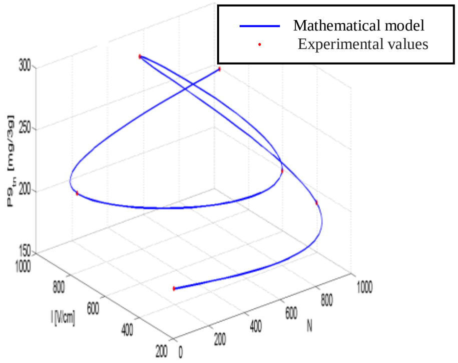

Fig.2. Nominal mathematical model of the total mass extracted $P9_{tn}$=f (N, I), for t = 65 °C

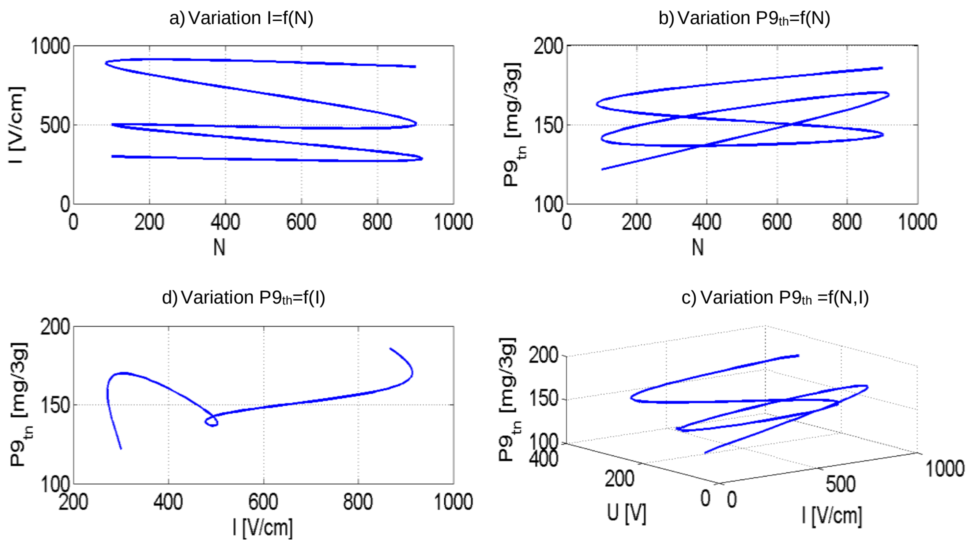

Fig. 3. Spline function model for components of total mass extracted, for t = 25°C, the nominal model $P9_{tn}$ = f (N, I)

As noted in fig. 3 and 4, there are 5 parts of the curve of mathematical model. It is also said to have derived a mathematical model space in three dimensions (k=3). Accordingly, the mathematical model has 4 groups (k+1) as 15 each (5·3 =15) as inferred from fig. 5 and 6.

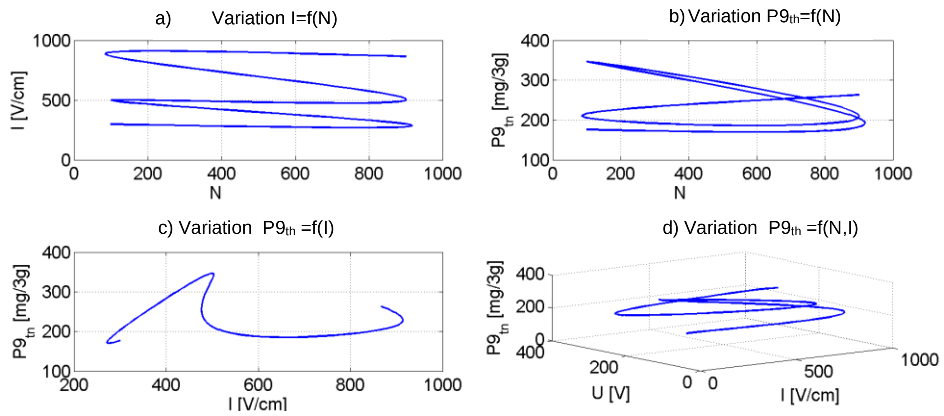

Fig. 4. Spline function model for components of total mass extracted, for t = 65°C, the nominal model $P9_{tn}$ = f (N, I)

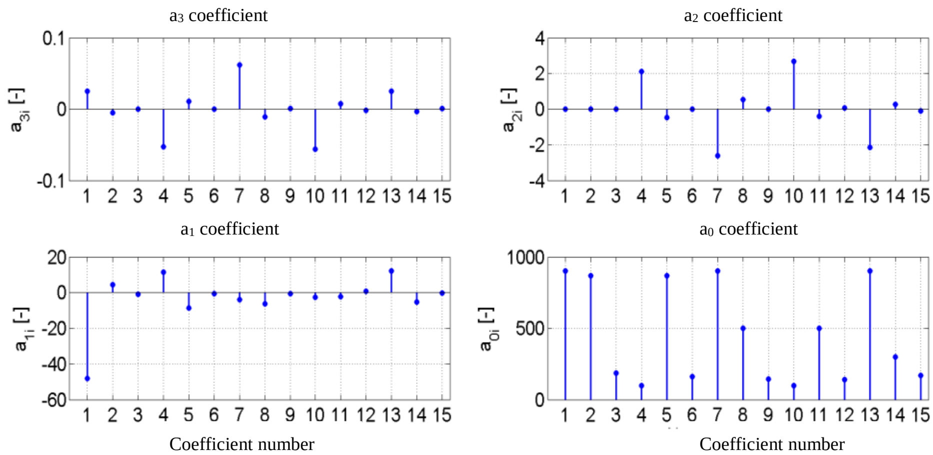

Fig. 5. Coefficients of the spline functions modeling of total mass extracted, for t = 25 °C, the nominal model $P9_{tn}$ = f (N, I).

In a similar manner to establish and the two mathematical models uncertain, superior and inferior. On the basis of the three mathematical models deduced values were obtained, the number of pulses, the electric field intensity, the voltage U, as well as total mass values extracted tannins ($P9_{tn}$–nominal values, $P9_{ts}$–uncertain values higher, $P9_{ti}$–uncertain values lower) at temperatures of 25 and 65°C. In table 3 and 4 are presented some values obtained on the basis of all three mathematical models.

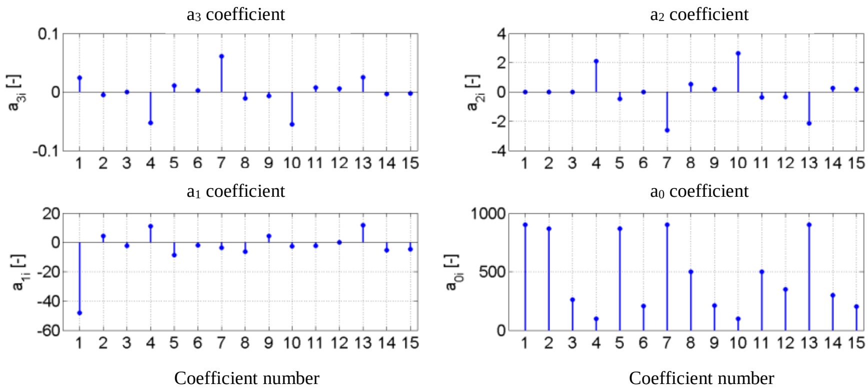

Fig. 6. Coefficients of the spline functions modeling of total mass extracted, for t = 65 °C, the nominal model $P9_{tn} = f(N, I)$.

Table 3. Some values obtained on the basis of all three mathematical models with spline functions to the extracted total mass, for t = 25°C

N	**I**	**U**	**$P9_{ts}$**	**$P9_{tn}$**	**$P9_{ti}$**
84	885.39	273.92	162.93	162.68	162.43
90	875.33	270.81	161.84	161.59	161.34
100	866.66	260.00	161.05	160.80	160.55
156	477.43	147.71	146.88	146.73	146.58
385	740.55	229.11	154.16	153.92	153.69
501	279.37	86.43	142.84	142.69	142.53
606	656.07	202.97	150.83	150.61	150.39
710	352.24	108.97	167.00	166.84	166.68
802	329.82	102.04	169.11	168.95	168.79
900	**300.00**	**90.00**	**170.26**	**170.10**	**169.94**
918	288.40	89.23	169.46	169.30	169.14

Table 4. Some values obtained on the basis of all three mathematical models with spline functions to the extracted total mass, for t = 65°C

N	**I**	**U**	**$P9_{ts}$**	**$P9_{tn}$**	**$P9_{ti}$**
85	885.09	273.83	210.15	210.00	209.85
96	900.33	278.54	215.77	215.61	215.46
100	**500.00**	**165.00**	**347.52**	**347.30**	**347.08**
230	459.07	142.03	326.26	326.05	325.83
498	697.23	215.71	186.78	186.64	186.50
695	884.74	273.72	254.41	254.22	254.03
799	575.56	178.07	190.68	190.54	190.40
870	310.80	96.15	213.58	213.42	213.27
898	514.40	159.14	205.17	205.02	204.87
900	866.66	260.00	263.60	263.40	263.20
917	288.87	89.37	194.16	194.01	193.87

Obviously, the last two tables appear both experimental values and other values as a result of mathematical modelling; among the latter are values that exceed the maximum quantities of experimental *N*, *I* and *U*, because the model aims at maximum $P9_{tn}$ parameter to all 6 samples with pre–treatment, which is 170,1 mg/3g at a temperature of 25 °C and 347,3 mg/3g at a temperature of 65 °C (nominal value found in tables 3 and 4).

In the latter case, which refers to the influence of the pre–treatment of grape seeds in pulsed electric field (tables 1–2), it should be noted that due to the three factors of influence taken into consideration (*N, I,* and *U*) and because of the limited space to three–dimensional modeling considerations (e.g. fig.1 and 2), the voltage *U* was adopted taking into account the experimental data, i.e. the ratio of the intensity of the field *I.*

Conclusions

In case of use of polynomial models on parts (between number of pulses, intensity of field and voltage) were obtained analytical expressions that do not have the complicated form and can be used in practice.

The highest accuracy of mathematical models has been obtained in the case of calling the spline functions, that are the analytical expressions of the type parts.

Using predictive mathematical models based on spline functions allow a good interpolation of data and ensures the greatest reliability of the results obtained, including the tabular values of factors of influence (pulse number, field intensity, voltage) which are not found experimentally.

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