

INFLUENCE OF PARAMETERS OF SUBCRITICAL WATER EXTRACTION OVER YIELD OF TARGET COMPONENTS FROM GRAPE POMACE

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Abstract: *The influence of parameters of extraction process of grape pomace (GP) by subcritical water (SCW) has been researched, the antioxidant activity of these extracts has been analyzed, the parameters of the process, ensuring the maximum yield of the desired component - dry and reducing substances, titratable acids, polyphenols have been determined.*

Extraction was performed in the temperature range T 100°C ÷ 1600C, pressure P = 12 MPa, exposure dose τ from 30 to 90 min., hydro ratio 1: 5 and 1:10. It has been found out that under the extraction of SCW dry extract yield is more than two times higher than by washing sweet pomace with hot water. Yield of polyphenolic compounds exceeds the amount of polyphenols obtained in the extraction with organic solvents and water at temperatures up to 60°C. The extracts obtained in the medium of SCW are characterized by high antioxidant activity. Yield of acids under extraction at temperatures (100-120 °C) of SCW is comparable with the number of acids in the original grape pomace.

Key words: *grape pomace, subcritical water, extraction, target component*

1. Introduction

Grapes (*Vitis vinifera* L.) are the largest fruit crop with a world production of more than 70 million tons per year. As a result of the processing of grapes up to 20% waste is produced. Secondary raw materials - SRM, which remain in the press after squeezing juice from fresh grapes or wine from fermented mash consists of ridges, grape skins, seeds and residual liquid (must, wine). [1]

Yield of pomace (with ridges) after using extruding machines is on average 13-15%, hydraulic presses - 17% and screw presses - 20-23%.

The individual components of the grapes are present approximately in unfermented pomace according to the following ratio: grape skins - 50%, ridges - 25% and 25% of the seed [2].

As to their chemical composition GP are a valuable raw material for extracting a variety of products, including tartaric acid [3, 4], tannins [5, 6], ethanol

[7], polyphenols [8,9], furfural [10] and other products [11]. It is necessary to emphasize the high antioxidant activity of GP extracts, suggesting to use them as natural antioxidants [12, 13].

In order to extract different target products (TP), including biologically active substances (BAS) conventional extraction methods are used: maceration, remaceration, percolation, repercolation [14, 15]. These methods are easy to perform, they do not require expensive equipment, however the active substances are not fully taken out (less than 90%), the process time is long, too high content of ballast substances in extracts, high labor intensity of the process, significant losses by diffusion and evaporation of extragent.

For the extraction of the target components (TC) water-ethanol mixture [16, 17], methanol [18, 19] and other organic solvents, sometimes with the use of

additional physical extraction techniques are used in the vast majority of cases. For example, a water-ethanol mixture with pulsed electric fields (PEF) [20, 21], ethanol with waves in a microwave oven [22], ultrasound [23, 24], high voltage electrical discharges (HVED) [25 26] and high hydrostatic pressure [27] are used.

The use of organic solvents is problematic due to their toxicity, high cost and problems with utilization. Thus phospho- and glycolipids, acylglycerols, esters of sterols and other esters which have biological activity almost completely disappear from the content of extracts.

In the last decade it was suggested to use solvents with a low boiling point - liquefied gases: carbon dioxide, propane, ammonia, methane, ethylene and some other compounds with low critical temperatures as extractants [28, 29]. However, carbon dioxide – one of the major greenhouse gases like methane, ozone, nitrogen oxides, as the gases that contain fluorine. Some fluid substances, such as methane, are toxic substances [30], some of them possess narcotic effects [31].

Thus, all of the above methods for extracting BAS from GP have certain drawbacks this fact emphasizes the relevance of the development of environmentally friendly methods of extracting the desired components from raw materials obtained as a result of processing of grapes.

For the extraction of biologically active compounds it is suggested to use subcritical water (SCW) [32-35].

Even small variations in temperature and pressure in SCW change all its physical and chemical properties: dielectric permeability, viscosity, specific heat capacity, diffusion coefficient and density. Water in these conditions behaves like a polar organic solvent.

The main advantages of SCW as a solvent are: a combination of the properties

of gases at high pressures (low viscosity, high diffusion coefficient) and liquids (high resolving ability); combination of negligibly small interfacial tension with low viscosity and high diffusion coefficient, which allows the SCW to penetrate into the porous medium more easily as compared with fluids; high sensitivity of the resolving ability of SCW to a change in pressure or temperature; ease of separation of SCW and dissolved substances at relieving pressure. These properties and the possibility of using the SCR as the solvent (reagent, catalyst) are related to its microstructure and characteristics of the processes occurring at the molecular level. The dependence of the resolving ability of SCW on the state parameters is largely due to the special nature and dynamics of hydrogen bonds (HB) [36, 37].

Hydrogen bonds largely determine the behavior of water and are a major cause of its significant differences from the other liquids. The nature of these highly anisotropic intermolecular interactions contributes to the manifestation of specific thermodynamic and structural properties of water, as well as the dynamic behavior that is unique in comparison with other substances. Properties of liquid water, by which such important processes as the dissolution of various substances and transport of protons are determined, are the result of the movement of molecules in a constantly changing grid structure of HB. [38]

High compressibility, which leads to significant changes in density with little change in pressure and a significant decrease in the dielectric constant from 80 under normal conditions, up to 6 at supercritical (SC) conditions allows non-polar compounds to be dissolved in the SC water [39].

Water is a non-toxic, non-flammable and inexpensive substance; it has easy division with the target products after

the completion of the process. Using SCW instead of organic solvents increases the environmental safety of production, as well as the purity of the products obtained, given their lack of traces of toxic organic solvents and impurities contained therein.

From the list of possible TC (target components) of extracting GP SCW, considering the use of extracted BAS in the food and pharmaceutical industries, this study addressed the following TC: dry and reducing agents, titrable acids, polyphenols.

Grape pomace is valuable because it is rich in lipophilic, polysaccharide and acidic complexes, contains a significant amount of phenolic substances. Polyphenol complex is represented by phenolic acids, flavonoids, tannins, proanthocyanidins, stilbenes.

Grape polyphenols that are concentrated in its skins, seeds and ridges of the bunch of grapes have hygienic and health properties, which are determined mainly by antioxidant, antimutagenic, antibacterial, P-vitaminic activity, i.e., have complex biological activity.

Polyphenols of grapes in native form are mainly flavonoids - poorly water-soluble substances. When this distribution in GP is: 12-20% in the skin of grapes, in a 1% in pulp, 60% in seeds, 19-24 in the ridges of bunch of grapes [7,8].

Numerous studies have found out that while creating biologically active products from grape pomace it is preferable to obtain the total polyphenols dissolved in the liquid phase.

Due to the fact that the flavonoids are poorly soluble in water in its normal condition when conventional extraction processes are used, the use of SCW will significantly increase the efficiency of the process [7, 8], since in subcritical condition water is experiencing larger changes than most other liquids - it turns into almost non-polar medium out of a polar liquid. At 200^oC the density of water drops to 0.8

g/ml, and under the critical temperature, it becomes miscible with both organic solvents and gases. The rate of diffusion increases and its oxidizing ability increases. These circumstances allow positioning of SCW as the most effective solvent, which should be used in designing the process of extracting polyphenols out of GP.

Since 60-70% of polyphenols is gallic acid, known for its antioxidant activity, calculation of analyzed polyphenolic compounds must be carried out according to gallic acid as a substance with a strong polyphenol structure.

GP polysaccharides, composed of the residues of corresponding monosaccharides including glucose, constitute up to 60% by weight of the dry GP, in this regard, to estimate the output of sugars it is necessary to determine yield of a dry extract according to the process parameters and reducing substances in terms of the equivalent amount of glucose.

The most valuable product obtained by complex processing of GP and yeast residuas is, other than ethyl alcohol, tartaric acid and its salts.

The acid indicator is an important indicator which characterizes the process of extraction including from the point of view of the formation of simple sugars from polysaccharides that makes it necessary to determine the total acidity of extracts.

Given the above mentioned, the purpose of the research was to determine the rational parameters of the extraction process of GP SCW which provides maximum yield of the target component (dry and reducing agents, titrable acids, polyphenols) and analysis of the antioxidant activity of extracts obtained.

II. Materials and methods.

2.1. Plant material

Moldova grape variety was purchased in late September in the retail network in

Donetsk (Ukraine) from the manufacturers - the Republic of Moldova. Moldova is table grape variety. The average weight of a bunch is up to 350 grams. The berry is big (2,5 x 1,9 cm), oval, dark purple, with a thick waxy coating. The skin is thick, dense and tough. The flesh is meaty and crispy.

2.2. Preparation of raw materials

Crushing of berries with peduncles was carried out on an industrial juice extractor to a moisture content of grape pomace - 55% [16]. Drying of original pomace at 75°C ± 2°C to constant weight was carried out in porcelain bowls placed in cabinet drier TPIQ02 TII-1 with occasional stirring. Residual moisture of pomace after drying was 4-7 (% abs.). The resulting agglomerates were crushed to fraction passing through a sieve with aperture of 3 mm.

Equipment used for the extraction of SCW is designed and manufactured in a Laboratory of Fluid Technologies of Donetsk National University of Economics and Trade named after M. Tugan-Baranovsky (DonNUET), Ukraine. The used ratio of raw material and extractant (water) was – hydro ratio - 1: 5 and 1:10. The temperature was varied from 100 to 160°C with step 10°C and maintained by pitch controller with an accuracy of ± 10°C. Dwell time - 30 min, 60 min and 90 min. Repetition of the experiments - three times.

The magnitude of the pressure $P=12$ MPa, which provided subcritical conditions and a high yield of extractable substances due to the destruction of cell membranes, was established on the basis of its thermodynamic properties described by differential equations of thermodynamics of International system of equations of 1997 (Formulation IF - 97) [42, 43].

2.3. Methods of assessing the yield of dry extract

The dry extract was determined by evaporation of a precise volume of extract (50 ml) at 105°C under vacuum on a rotary

evaporator ИП-1М with temperature controller ЭРА-М to a constant weight [44].

2.4. Methodology to evaluate the extraction of reducing substances

Determination of reducing substances was carried out by standard methods [45] using the Fehling's reagent.

2.4. Methodology to evaluate the extraction of polyphenols

Total content of polyphenolic compounds was determined at based on gallic acid using a the method of Folin-Ciocalteu (FC- method) [46] that represents the colorimetric determination of products red /ox reactions of phenolic extracts of analyte molecules without differentiation between gallic acid, mono -, di -, oligo- and polymeric compounds. The optical density of the solution was measured at a wavelength of 765 nm against the reference solution.

Total amount of polyphenol compounds in % based on gallic acid was calculated according to the formula:

$$X = \frac{D \cdot m_0 \cdot 25 \cdot 1 \cdot 100 \cdot 100 \cdot 100}{D_0 \cdot m \cdot a \cdot 100 \cdot 100 \cdot (100 - w)}, \quad (1)$$

where D - optical density of test solution;

D_0 - optical density of standard solution of gallic acid;

m - mass of extracted cake, g;

m_0 - mass in grams of gallic acid;

and a - aliquot solution in ml;

w - loss on drying of the extract in percentage.

An aliquot was adjusted so that the optical density was within 0,2-0,6.

2.3.2. Determination of active acidity of extracts

Active acidity was determined in terms of the equivalent amount of tartaric acid. Determination of titratable acidity was

carried out by potentiometric titration performed with phenolphthalein as an indicator [47] and expressed in degrees of acidity.

The content of free organic in terms of the equivalent amount of acids tartaric acid in absolutely dry raw materials in percents (X) was calculated using the formula: [48].

$$X = \frac{V \cdot K \cdot 0,0075 \cdot V_{ext} \cdot 100}{m \cdot V_a} \cdot \frac{100}{(100 - W)} \quad (2)$$

where 0,0075 - the amount of tartaric acid corresponding to 1 ml of a solution of sodium hydroxide (0.1 mol / L), g;

V - volume of sodium hydroxide (0.1 mol / l), which had gone on titration, ml;

K - coefficient of bringing the solution concentration of alkali to exactly 0.1 mol / l;

V_{ext} - extract volume, ml;

V_a - volume of the sample of extract taken for titration, ml;

m - sample weight, g;

W - %. loss on drying of raw materials, %.

$\frac{100}{(100 - W)}$ - scaling factor of absolutely dry raw materials.

Antioxidant activity

Antioxidant activity of extracts and inhibition kinetics of free radicals was examined by using diphenyl picryl hydrazyl (DPPH) [49, 50], which is based on determining the absorbance of DPPH radical, in the presence of antioxidants. To determine the concentration of free radicals calibration curve was constructed within the limits of concentration 0.38-38 g / ml for the free radical DPPH and according to this

standard curve DPPH values at a particular time of the reaction were calculated.

Antioxidant activity of the extract of the tested extract was determined by the formula:

$$AA\% = \frac{[DPPH]_0 - [DPPH]_t}{[DPPH]_0} \cdot 100 \quad (3)$$

where $[DPPH]_0$ - concentration of DPPH radical at time $t = 0$ sec;

$[DPPH]_t$ - DPPH radical concentration measured with a spectrophotometer after 30 minutes.

2.5. Statistical analysis

Variance analysis of the results was carried out by least square method with application of coefficient Student. Differences were considered statistically significant if probability was greater than 95% (p -value < 0.05). Experimental results are expressed as average \pm SD (standard deviation).

Results of regression analysis of the obtained dependences with the use of correlation coefficient, coefficient of determination, the standard deviation and the Fisher criterion (with a confidence interval estimation of the model at the level of error $\alpha = 0,05$ (confidence level 95%) confirmed their adequacy.

III. Results and discussion

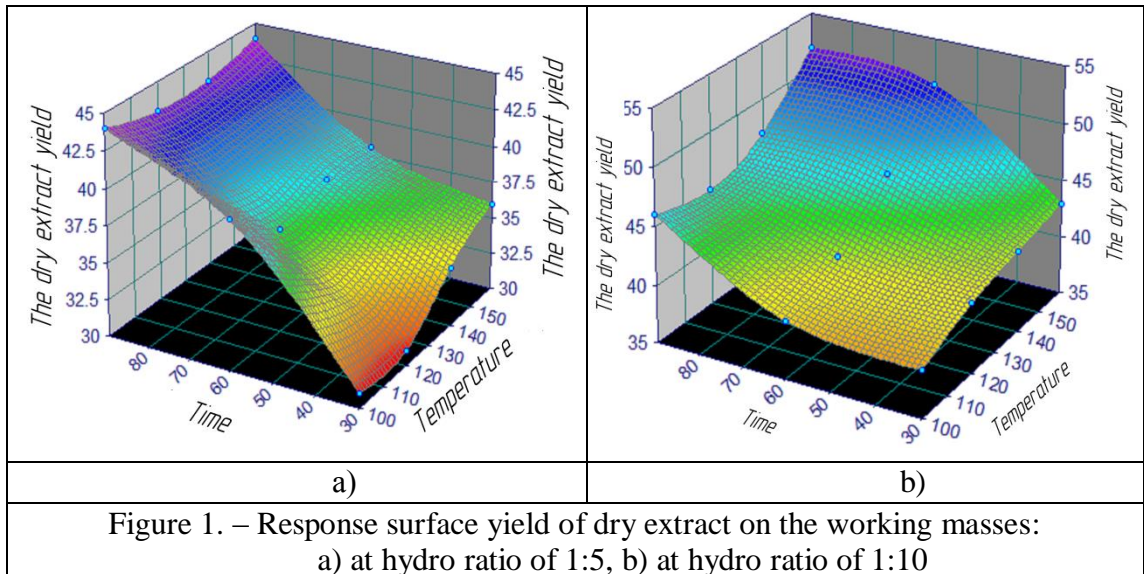
The yield of dry extract (YDE) on the working mass at hydro ratio of 1:5 is described by the regression equation (4) and at 1:10 hydro ratio by equation (5):

$$B\Theta = 14,649 + 0,103 \cdot t + 0,360 \cdot \tau - 0,0014 \cdot t \cdot \tau \quad (4)$$

$$B\Theta = 28,971 + 0,0745 \cdot t + 0,0270 \cdot \tau + 0,000 \quad (5)$$

where t – temperature of extraction, $^{\circ}\text{C}$;
 τ – exposure time, min.

Dependence of the YDE on the working masses on time, temperature and hydro ratio is presented in the form of the response surface in Figure 1.



High total yield of extractives was observed already at 100°C and 0.5 h (31,9% at hydro ratio of 1:5 and 39,4% at hydro ratio 1:10 and can be explained by the following factors:

- residual sugar content of not fermented pomace;
- partial hydrolysis of pectin substances, hexuronic acid acids and mucus.

During extraction at hydro ratio of 1:5, these factors also lead to lower yield of dry extract than with hydro ratio 1:10. This is especially noticeable when the exposure time is 0.5 h. With reduction of hydro ratio extract concentration increases and this leads to acceleration of the thermal destruction at high temperatures.

At 160°C there was considerable swelling of extractable mass. At this temperature, hydro ratio of 1:5 and the exposure time of 1.5 hours in the mass, after extraction, free water was not observed

visually, indicating insufficiency of hydro ratio 1: 5.

At high temperatures, the yield of YDE is defined by two processes: the formation and transition to extract of water-soluble compounds and their decomposition under the influence of temperature and acidity. The main contribution to the increase in the yield of the extract makes the hydrolysis of polysaccharides with their transfer into soluble compounds (oligosaccharides, dextrans, monosaccharides). Pectin hydrolysis is followed by cleavage of acetic acid.

With increasing exposure time and the temperature to 140°C the yield of the extract increases. At 140°C C the rate of hydrolysis of hemicelluloses and decomposition of monosaccharides increases. Thus strong organic acids - formic acid and acetic acid are formed, increase in concentration of which leads to acceleration of hydrolysis of

hemicelluloses and decomposition of monosaccharides. Decomposition of the sugars also leads to the formation of hydroxymethyl furfural, furfural, humin substances etc.

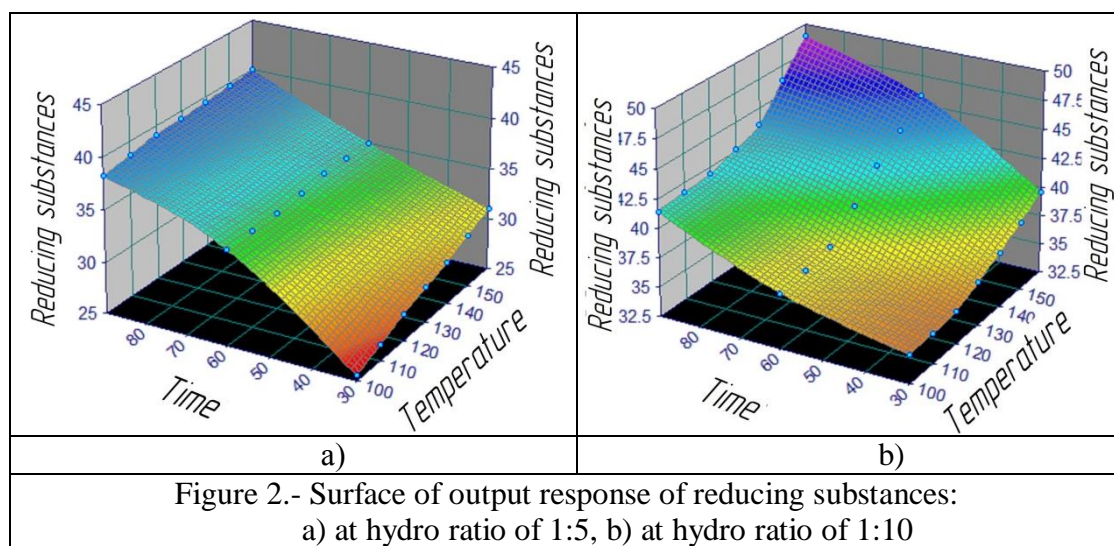
Yield of reducing substances (RS) at hydro ratio of 1:5 was described by the regression equation (6) and hydro ratio 1:10 – by equation (7):

$$PB = 9,189 + 0,1071 \cdot t + 0,3172 \cdot \tau - 0,0010 \quad (6)$$

$$PB = 23,04 + 0,078 \cdot t + 0,034 \cdot \tau + 0,00066 \cdot \dots \quad (7)$$

where t – temperature of extraction, °C;
 τ – exposure time, min.

Dependence of the yield of reducing substances on time, temperature and hydro ratio in the form of a surface of response is shown in Figure 2.



For each hydro ratio with the increase of temperature and exposure time the yield of RS increases. Yield for a hydro ratio 1:10 under appropriate temperatures and exposure time is considerably higher (20-30%) than for a hydro ratio 1:5. This is due to the high concentration of the solution in the second case. High concentration, in accordance with the laws of chemical kinetics, leads to a significant acceleration of decomposition reactions. The final products of decomposition of sugars are humic substances that do not demonstrate the reducing activity.

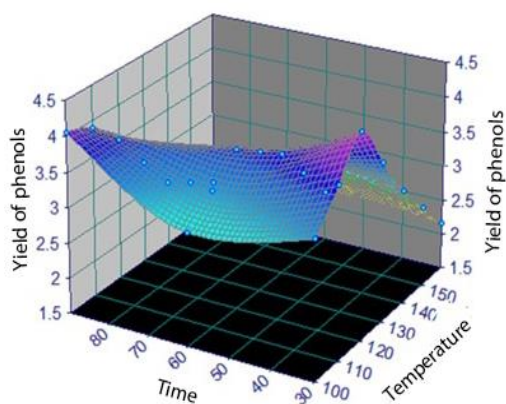
For hydro ratio 1:5 some increase in yield of the RS with increasing

temperature has been noticed. However, it is significantly lower than for the hydro ratio 1:10 and will stabilize at 120-130°C. This is due to the high speed of chemical transformations of forming various sugars in solutions with a relatively high concentration of extractives.

With increasing temperature at hydro ratio 1:10 to 120°C there is a slight increase in the yield of RS. At a temperature 120-150°C there is a significant increase in sugars, which can be explained by hydrolysis of easily hydrolyzable polysaccharides (hemicellulose, pectin, uronic acid, etc.). Above 150°C number of extracted RS stabilizes practically at the same level, so

the work in the conditions of static extraction is not feasible. Analysis of qualitative reactions that describe the yield of reducing substances showed that increase in the concentration of solutions and temperature leads to a greater decomposition of sugars. Rational parameters extracting RS depend on the purpose of further processing of extracts. Fermentation of extracted sugars to alcohol is one of the first schemes, from the viewpoint of the market appeal of the obtained products. Yield of polyphenols (tannin and catechin complex) of GP is represented by phenolic acids, flavonoids, tannins, proanthocyanidins, stilbenes.

Yield of polyphenols (F) at hydro ratio of 1:5 was described by the regression



a)

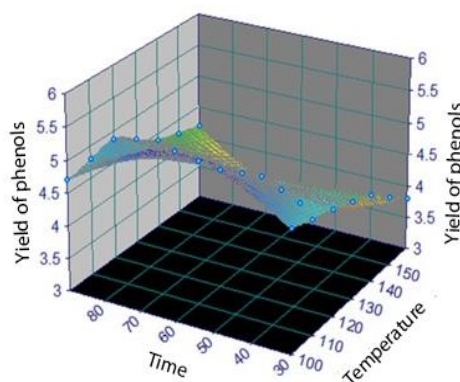
equation (8) and hydro ratio of 1:10 – by equation (9):

$$F = -5,902 + 0,164 \cdot t + 0,019 \cdot \tau - 0,00019 \quad (8)$$

$$F = 7,086 - 0,021 \cdot t + 0,002 \cdot \tau, \quad (9)$$

where t – temperature of extraction, $^{\circ}\text{C}$;
 τ – exposure time, min.

Dependence of the F of GP on time, temperature and hydro ratio is presented in the form of the surface of response in Figure 3.



b)

Figure 3 – Surface of response of yield of F of GP:

a) at hydro ratio of 1:5, b) at hydro ratio 1:10

The obtained data we have considered as a result of the flow of two opposing processes: 1) the transition of polyphenolic compounds into solution; 2) the secondary transformation of polyphenolic compounds, leading to degradation or transition into insoluble state and precipitation.

A significant increase in yield F we can explain by the transition into a solution

of tannins (tannins) and their hydrolysis products under high temperatures and acidic environment.

The amount of tannin (enotannin) in grape pomace may reach 10% (for dry weight). It exceeds its content in oak (5-6,6%), which is traditionally used for obtaining tannins.

The value of titratable acidity (K) at hydro ratio of 1:5 was described by the

regression equation (10) and hydro ratio 1:10 – by equation (11):

$$K = 3,281 + 0,0053 \cdot t - 0,0771 \cdot \tau + 0,000660 \cdot t \cdot \tau \quad (10)$$

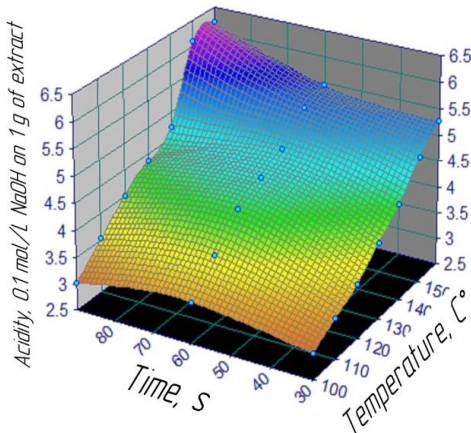
$$K = 0,281 + 0,0271 \cdot t - 0,0262 \cdot \tau + 0,000271 \cdot t \cdot \tau \quad (11)$$

where t – temperature of extraction, °C;
 τ – exposure time, min.

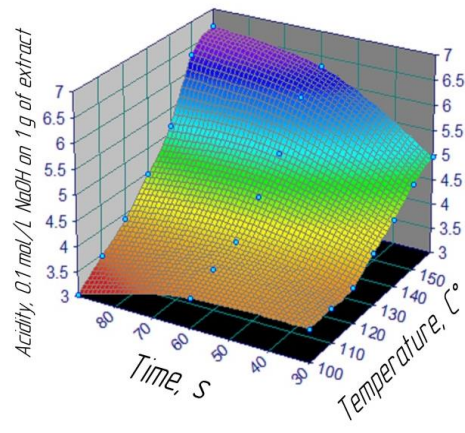
The high K of the obtained extracts has been noted.

Recalculation of K on tartaric acid, which is the main component of grapes acid complex, showed that at 100-120°C the extraction of acidity passes through a maximum in time. This is due to the degree of extraction ratio of tartaric acid from the solid phase and chemical changes at elevated temperature.

The dependence of K (ml 0,1 mol / l NaOH) on time, temperature and hydro ratio is represented in the form of a surface of response in Figure 4.



a)



b)

Figure 4.– Surface of response of titratable acidity:
 a) at hydro ratio of 1:5, b) at hydro ratio 1:10

For some of the experimental points acidity of extracts obtained at hydro ratio of 1:5 is somewhat higher. This is due to the hydrolysis of polysaccharides and sugars decomposition with the formation of strong organic acids - formic and acetic acid, as well as a number of weak – levulinic acid, glucose izosaccharinic acid, xylose izosaccharinic acid, lactic acid [51]. In conditions of the lower hydro ratio concentration of sugars in the solution is greater, and respectively, decomposition speed is higher. The titratable acidity of the extract increases.

According to the formation and transformation of organic acids, dry extract

composition obtained by evaporation of water varies. Tartaric and levulinic acids are nonvolatile. They almost totally remain in dry extract. Formic and acetic acids, on the contrary, are volatile. Therefore, the acidity of the dry extracts obtained by evaporation is lower than the acidity of not evaporated solutions.

Tartrate solutions together with free tartaric acid contain their salts, in particular the acidic potassium tartrate. Therefore, determination of yield of tartaric acid and its derivatives according to titratable acidity gives low results even with the presence of other acids (malic, citric, etc.).

Antioxidant activity

The results of the kinetics of inhibition of free radicals (percent of DPPH which remains in the stable condition) at

hydro ratio of 1:5 are shown in Figure 5, with the hydro ratio 1:10 - in Figure 6.

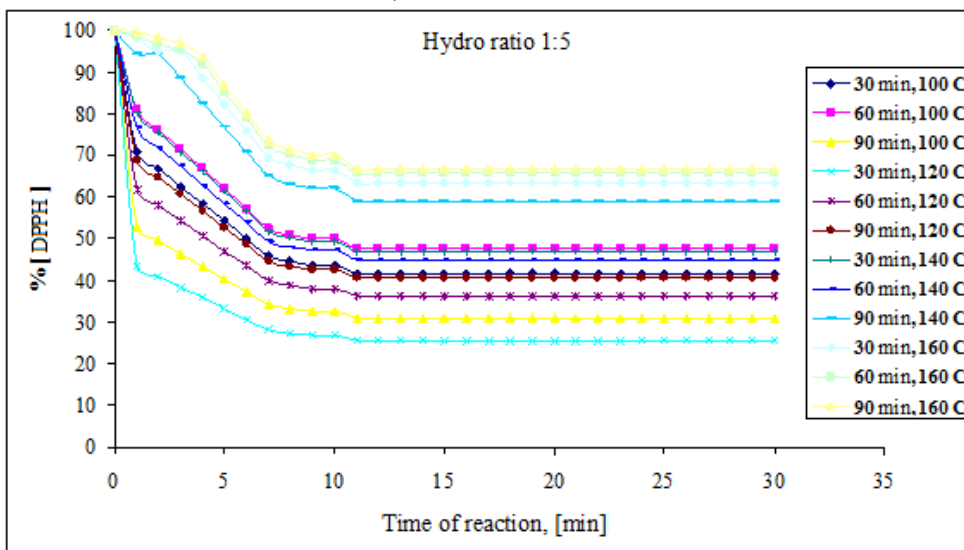


Figure 5 - Kinetic curves of interaction of GP extracts (at hydro ratio of 1:5) with a free radical DPPH

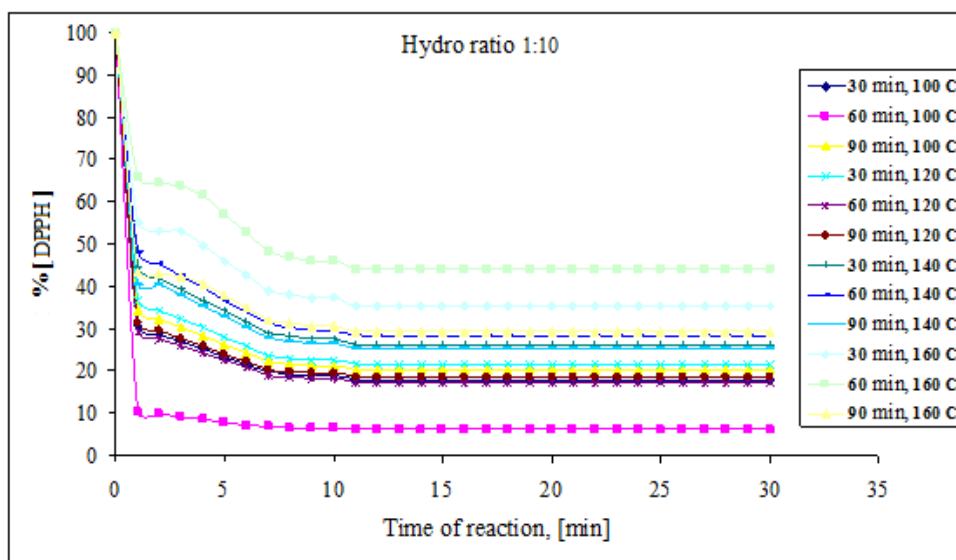


Figure 6 - Kinetic curves of interaction of GP extracts (at hydro ratio 1:10) with a free radical DPPH

Knowledge of the kinetics of atom transfer is important because the free radicals in the body are short-lived species, which means that the influence of the

substance as an antioxidant depends upon its rapid reactivity to the free radicals. More rapid decline in absorption means a more powerful anti-radical ability of the

compounds. The steeper the graph of fall, the better and the faster free radicals bind. When hydro ratio is 1:5 all the free radicals are quickly bound by GP extract obtained in the medium of SCW at the temperature of 120⁰C and exposure time of 30 minutes. At hydro ratio 1:10 high speed of binding of free radicals was observed at the reaction with extracts of GP extracted in SCW at the temperature of 100⁰C and exposure time of 60 min.

As a result of recovery of DPPH by antioxidant (by extracts of GP) purplish blue color of DPPH in methanol decreased to a yellow, the reaction was monitored by change in optical density at a wavelength of 514 nm.

The antioxidant activity of the extracts of GP at hydro ratio of 1:5 was described by regression equation (12) and hydro ratio 1:10 – by equation (13):

$$APA = 117,1 - 0,45 \cdot t + 0,08 \cdot \tau \quad (12)$$

$$APA = 120,64 - 0,36 \cdot t + 0,03 \cdot \tau \quad (13)$$

where t – temperature of extraction, ⁰C;
 τ – exposure time, min.

It was found out that GP extracts obtained in SCW have high APA from 33% to 94% in relation to the stable DPPH free radicals. The most rapidly bind free radicals BB extracts obtained from liquor ratio of 1:10 and a temperature of 100⁰C retention time 60 min. ARA values for these parameters - 94.01%.

The obtained results ARA of GP extracts in the environment of SCW are significantly higher or comparable at least with 24 plant objects, which were extracted by percolation with ethanol.

Thus, extracts obtained in the environment of SCW have properties of ARA comparable not only with extracts

obtained by other methods, but they are superior to them.

IV. Conclusions

The conducted research gives the possibility to make the following conclusions.

When washing sweet pomace by hot water the yield of dry extract is up to 15% of weight of absolutely dry pomace. The bulk of the extract is the carbohydrates (mainly free monosaccharides) and acidic compounds. Under the SCW extraction extract yield is at least two times greater. The increase in yield of the extract can be explained by the formation of water-soluble carbohydrates out of polysaccharides, a significant amount of polyphenolic compounds is also observed.

The maximum number of RS - 48.991% had a yield at $T=160^{\circ}\text{C}$, exposure time $\tau=90$ min, pressure $P = 12$ MPa, hydro ratio of 1:10. These parameters of the process are rational in the fermentation of the extracted sugars into alcohol.

The maximum number of total polyphenols - 5.534% had a yield at $T=100^{\circ}\text{C}$, exposure time $\tau=60$ min, pressure $P = 12$ MPa, hydro ratio of 1:10.

The yield of polyphenolic compounds under the extraction SCW exceeds the amount of polyphenols obtained under the extraction with organic solvents and water at temperatures up to 60⁰C.

It should be noted that during the extraction of polyphenols of SLW low selectivity towards specific groups of flavonoids occurs. In extraction with organic solvents the proportion of phenolic substances in the extract is significantly higher and they are presented primarily by nontanning substances. This fact complicates the selection, separation and purification of polyphenol compounds from the extracts of SCW. Selectivity according to polyphenolic substances for SCW is

lower than for the organic solvents, but there is a significant increase in their yield due to tannins, and hence it makes sense not to extract and utilize separate polyphenol fractions but whole tannin and catechin complex out of GP.

Yield of acids at low temperatures of extraction (100-120⁰C) SCW is comparable to the amount of acids in the source pomace obtained by washing sweet pomace with hot water. When washing with hot water extraction of tartaric acid compounds is 80% and more of their content in the raw materials. Thus, at 100-120⁰C it is possible to extract tartaric acid almost completely.

Extraction of GP SCW (at hydro ratio 1:10, temperature of a process 100⁰C, exposure time 60 min) allows to obtain an extract with high antioxidant activity - 94.01%.

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