KnE Life Sciences

AgroSMART 2019
International scientific and practical conference
``AgroSMART - Smart solutions for agriculture''
Volume 2019

Conference Paper

Environmental and Technological Problems of Rational Use of Secondary Resources for Processing Grapes

M P Bakhmet[1], E E Ivanova[1], G I Kasianov[1], O V Kosenko[1], N V Magzumova[1], M D Nazarko[1], and Z A Iaralieva[2]

[1]Kuban State Technological University, Krasnodar, Russia
[2]Daghestan State Technical University, Makhachkala, Russia

Abstract

Rational use of grapes processing resources is among environmental problems of AIC of Republics of the North Caucasus and Krasnodar Territory. Currently, waste from grapes processing is not practically used and worsen the ecological state of environment. The research subject is a technology based on the production of cryo-powder from pulp, squeeze, seeds and grapes skin grown in the foothill and mountainous regions. The prerequisites for research were previously performed author works on related topics. The data on vacuum SHF-drying of grape raw materials and subsequent grinding in a cryomiller are given. Modes of preparation of grape raw materials and its subsequent dehydration and cryo-grinding, which provide the possibility of successful use in the dried state in the production technology of wine beverages, are proposed. The principal feature is the use of whole grapes as a raw material, with skin and seeds. Physico-chemical parameters, the content of phenolic substances and organoleptic characteristics of wine beverages made according to the traditional technology and the beverage made from grape cryo-powders are studied. A comparative assessment is made. It is established that vacuum SHF-drying contributes to better preservation of the properties of raw materials and finished products. The organoleptic assessment has shown that wine beverages developed according to the proposed technology had a more intense color and a more pronounced taste of sweetness and acid than traditional wine beverages. The advantage of this technology is the ability to transport grape cryo-powders in unregulated temperature conditions to any point close to the consumer and carry out the production of nutritional food there.

Corresponding Author:
M P Bakhmet
mbahmet@mail.ru

Received: 25 October 2019
Accepted: 15 November 2019
Published: 25 November 2019

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the AgroSMART 2019 Conference Committee.

1. Introduction

Grapes are among the largest and most sought-after products of the population in southern regions of the country. However, climatic conditions of most agricultural areas do not allow grapes to be grown in open ground; therefore, studies that prolong the shelf life of grape processing products are considered relevant. In addition, the industrial processing of grapes produces a significant amount of waste, which is practically not

How to cite this article: M P Bakhmet, E E Ivanova, G I Kasianov, O V Kosenko, N V Magzumova, M D Nazarko, and Z A Iaralieva, (2019), ``Environmental and Technological Problems of Rational Use of Secondary Resources for Processing Grapes'' in *International scientific and practical conference ``AgroSMART - Smart solutions for agriculture''*, KnE Life Sciences, pages 1--10. DOI 10.18502/kls.v4i14.5571

used. At the same time, these so-called ``wastes'' belong to the secondary resources of viticulture and winemaking and can be processed into high-quality products and food additives.

As it is known, grape processing is usually concentrated in the places where it is grown. Delivering grapes either processed into drinks in glass bottles, or in other containers over long distances is associated with significant financial costs, and climatic conditions limit the transportation time of both fresh and processed raw materials in unheated vehicles. In this regard, the problem has arisen to process the grapes and its secondary resources in such a way that the product would withstand long periods of storage and transportation, be of high quality and have a small mass. If necessary, it is possible to prepare wine beverages based on this product according to the classic yeast fermentation technology.

When performing an analytical review of the scientific and technical literature on the problem under study, the authors have noted the increased interest of researchers in the problem of processing secondary resources for processing grapes grown in the regions of the North Caucasus and Southern Federal Districts for powdery food additives [1, 5]. Chemical composition of grapes grown in Daghestan, North Ossetia and Krasnodar Territory is analyzed in the works of various authors [2, 4, 7, 9].

The development of methods of organic farming in grapes cultivation contributed to the improvement of the soil ecological condition [3]. In this regard, a method for improving the soil developed by KubSTU by means of adding sorbent from grape seed meal is particularly effective [6].

Among the existing methods for complex processing of grape raw materials, a method of extracting is particularly distinguished to obtain a variety of beverages [8].

During the drying period of secondary resources of grape processing, the composition influence and thermal conditions on the change of physico-chemical and antimicrobial properties of dry powders was taken into account [10]. Optimizing the process of removing moisture from plant materials became possible using mathematical planning methods of the experiment [13]. Intensify the drying process of plant materials for the production of powdered beverage became possible through the use of foaming additives [14].

The part of the research is devoted to the assessment of physico-chemical parameters of secondary resources for processing grapes and other fruits [11, 12]. The implementation of this direction allows increasing production efficiency and reducing the cost of finished products.

2. Materials and Methods

The qualitative composition of raw materials and semi-finished products on the devices of collective use centers of the Institute of Food and Processing Industry of Kuban State Technological University was determined during the research.

Part of the research was carried out with the participation of the authors in laboratories of the Institute of Physics and Mountain Botanical Garden of Dagestan Scientific Center of the Russian Academy of Sciences.

Physico-chemical and microbiological studies of the quality and properties of raw materials and finished products were analyzed on modern devices in accordance with the requirements of Technical Regulations of the Customs Union, the current GOST and TS. The used devices included: infrared, ultraviolet, atomic adsorption spectroscopy devices, an infrared thermometer, a capillary electrophoresis device, a Coulter counter.

The raw materials for research were Daghestanian grapes and grape squeezes of ordinary and raisin varieties: Bor kara, Baiat kapy, Gyulyabi Daghestanian, Boriu raisins, Budai shuli, Boru koz raisins grown in the mountain-valley zone of Daghestan (Russia) in September 2016.

3. Cryo-powder Technology

Cryopowders from berries, squeezes, seeds and grapes skins were obtained according to the technology developed by the authors. The berries were separated from the ridges, crushed together with skin and seeds. The resulting mass of raw material was metered into radio transparent dripping pans with a layer thickness of 10--12 mm. The freezing of raw materials in dripping pans was carried out by applying liquid nitrogen to the raw material surface at minus 160 °C for 10--15 minutes and vacuum SHF-drying of berries for 0.5 h to a moisture content of 4.0--5.0 %.

The main feature of the heat treatment of grape raw materials in the electromagnetic field of ultra-high frequency is fast volumetric heating. In this case, thermal energy is generated in the product itself due to its interaction with SHF-field. Heat generated in the product when it interacts with the electric field is distributed throughout the product due to convection or thermal conductivity.

Grape pulp cryodrying was carried out with the following parameters: -- temperature at the stage of moisture removal phase transition ``ice-steam'' (--180...--190)$\pm$5 °C. At the same time, the ``ice-steam'' phase transition removes 70--90 % of moisture.

- material temperature at the final drying stage is (+30...+32) ± 5 °C;
- final moisture content of the dried material -- 4--5 %;
- drying cycle duration -- 0,5 h.

The dried material is a porous mass, easily destructible and turns into a powder product. The resulting raw materials, in the form of cryo-powder, are much less hygroscopic, and the size of this powder particle is two orders of magnitude smaller compared to fruit pulp.

The technology of obtaining sublimated powder from the pulp ensures the safety of substances that form color formation: anthocyanins, chlorophylls, carotenoids, tannins and other polyphenols. The concentration of phenolic compounds is not changed and, in the future, the beverage aroma is enhanced.

Figure 1 shows the apparatus-technological scheme of the industrial line for cryo-powders production.

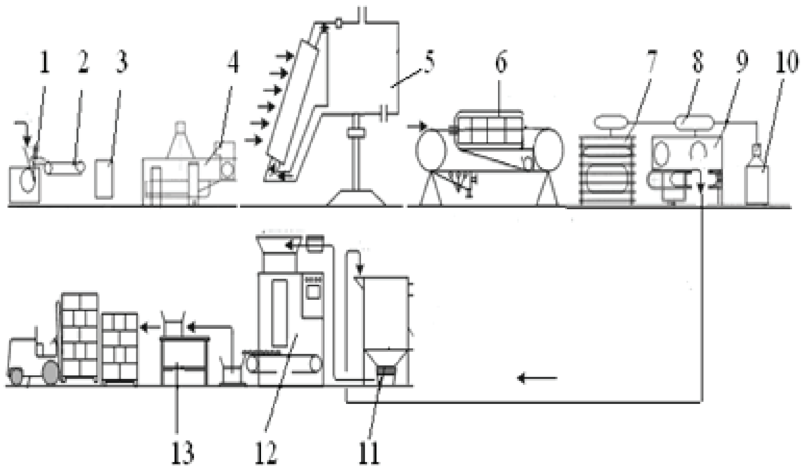

Figure 1: Apparatus-technological scheme of cryo-powders production 1 -- cleaning machine, 2 -- inspection conveyor, 3 -- machine for removing inedible parts, 4 -- blanching machine, 5 -- solar dry kiln, 6 -- SHF-drying, 7 -- cryogenic apparatus, 8 -- liquid nitrogen dispensers, 9 -- cryomiller, 10 -- Dewar's flask, 11 -- dispenser, 12 -- prepacking machine, 13 -- packing machine.

Table 1 shows chemical composition of cryo-powders obtained from grapes grown in the mountain-valley zone of Daghestan.

4. Cryo-powder Enrichment Technology

The manufacture of food products based on cryo-powders from grape products processing includes the dissolution of cryo-powders in light water. The processes of sulfitation, enzyme, and yeast-laying are necessary in the manufacture of wine beverages. This

Table 1: Chemical composition of cryo-powders obtained from grapes grown in the mountain-valley zone of Daghestan.

Component name	Content of components in 100 g of grape variety:					
	Bor kara	Baiat kapy	Gyulyabi Daghestanian	Boriu raisins	Budai shuli	Boru koz raisins
Caloric value, kcal	327.4	333.5	331.5	326.6	331.3	286
Proteins, g	5.5	5.7	5.6	5.5	5.7	5.2
Fat, g	2.6	3.5	2.7	2.6	2.9	2.5
Carbohydrates, g	70.5	69.8	71.2	70.3	70.6	71.5
Dietary fiber, g	9.8	9.6	9.8	9.7	9.8	9.7
Water, g	11.6	11.4	10.7	11.9	11.0	11.1
Unsaturated fatty acids, g	1.4	1.4	1.4	1.4	1.4	1.4
Ash, g	2.5	2.5	2.5	2.5	2.5	2.5
Saturated fatty acids, g	1.2	1.2	1.2	1.2	1.2	1.2
Mono -- and disaccharides, g	39.6	39.6	39.6	39.6	39.6	39.6
Vitamin PP, mg	0.5	0.5	0.5	0.5	0.5	0.5
β -- carotene, mg	36	36	36	36	36	36
Vitamin C, mg	2.4	2.4	2.4	2.4	2.4	2.4
Vitamin E (TE), mg	0,6	0.6	0.6	0.6	0.6	0.6

is followed by the processes of preliminary fermentation with maceration, pressing, sulfitation, secondary fermentation, the formation of taste, beverage stabilization.

Rehydration can be accomplished by infusing 1:(3--5) cryo-powder in water with low deuterium content and active mixing of the obtained mixture.

The process of sulfitation and enzyme is carried out as follows. The resulting mixture of powder and light water is saturated with sulfur oxide in a ratio of 75 mg/l of water and enzymes are put into operation. When laying the French yeast (25 g/100 l), fermentation and maceration takes 5 days (with the need for slow mixing). During this period, the phenolic and coloring agents pass from the solid to the liquid phase.

It is necessary to separate the pulp from the solution by pressing after the fermentation process. In total, the whole process of wine beverage formation takes about a month, after which the drink is stabilized and bottled.

Wine beverage with high physico-chemical parameters is obtained using cryo-powders.

Table 2 shows determination results of the numerical values of physico-chemical characteristics of the wine beverage, manufactured according to the developed technology: active acidity, alcohol content, mass concentration of sugars, titratable acids, volatile acids, extractivity, relative density, acid content in the finished wine.

Table 2: Physico-chemical indicators of wine beverage from grapes cryo-powder.

Indicator	Norm	Result
Active beverage acidity (pH)	3.0--4.2	3.5+0.1
Alcohol, % vol.	>9	10.97±0.06
Mass concentration:		
-- sugar, g/dm^3	<4.0	5.4±0.2
-- titratable acid, g/dm^3	>4.0	6.4±0.1
-- volatile acids, g/dm^3	<1.2	0.52±0.08
-- extractivity, g/dm^3 (total / unreduced)	>18.0	27.9±0.3/24.5±0.9
Relative density, d		0.9993±0.0002
content in finished wine:	1.5--5.0	2.29+0.14
Tartaric acid, g/l	< 5.0	1.61+0.32
Malic acid, g/l	0.5--2.5	0.51+0.06
Lactic acid, g/l	0.25--1.0	1.33
Organic acid ratio:		
-- amount (lactic acid + malic acid)		2.12
-- tartaric acid/amount (lactic acid + malic acid)		1.08
-- tartaric acid/malic acid		1.4

Table 3 shows the content of phenolic components in wine beverages made according to the existing and new technology -- anthocyanins, catechins, leucoanthocyanins, tannins (polyphenols), flavonols and flavones. This group of biologically active substances primarily forms the color intensity of the finished wine and its taste.

Table 3: Content of phenolic components in wine beverages made according to the existing and new technology.

Phenolic compounds, mg/l	existing technology	new technology
Anthocyanins	350--450	410
Catechins	380--450	450
Leucoanthocyanins	90--80	140
Tannins (polyphenols)	600--4800	2840
Flavonols	30--40	37
Flavones	2--8	7

DOI 10.18502/kls.v4i14.5571

Table 4 shows the content of organic acids, and Table 5 -- quality indicators of wine beverages.

TABLE 4: Content of organic acids in wine beverages.

Indicator name	Normal content	Research results
Tartaric acid, g/dm^3	1.5 -- 5.0	2.29 ± 0.14
Malic acid, g/dm^3	<5.0	1.61 ± 0.32
Lactic acid, g/dm^3	0.5--2.5	0.51 ± 0.06
Succinic acid, g/dm^3	0.25--1.0	1.33
Organic acid ratio:		
-- amount (lactic acid + malic acid)		2.12
-- tartaric acid / amount (lactic acid + malic acid)		1.08

TABLE 5: Quality indicators of wine beverages.

Indicator name	Normal content	Research results
Alcohol,% vol.	>9	8.97±0.06
Mass concentration:		
-- sugar, g/dm^3	<4.0	5.4±0.2
-- titratable acid, g/dm^3	>4.0	6.4±0.1
-- volatile acids, g/dm^3	<1.2	0.72±0.08
-- extractivity, g/dm^3 (total / unreduced)	>18.0	29.9±0.3/24.5±0.9
Relative density, d		0.9993±0.0002

Organoleptic characteristics of the produced wine beverages confirmed their high quality.

Obtaining grape oil from grape seeds using gas-liquid technologies is of considerable interest. Unlike grape oil obtained by the pressing method, the extraction oil obtained using liquid carbon dioxide has high dietary properties.

Figure 2 shows a chromatograph sample of grape seed oil.

The oil obtained by pressing from grapes seeds is light yellow, almost odorless, edible. Oil pressed from grape squeezes and extraction -- dark, brown-green color, needs refining.

Grapeseed oil belongs to the linoleic group of oils. Fatty acid composition of grape oil is presented, %: saturated (3.8--7.2), monounsaturated (27.0--30.0) and polyunsaturated (58.0) fatty acids. At the same time, oleic acid is 30.0 %; linoleic -- 57.0 % and linoleic acid -- 57.0 %.

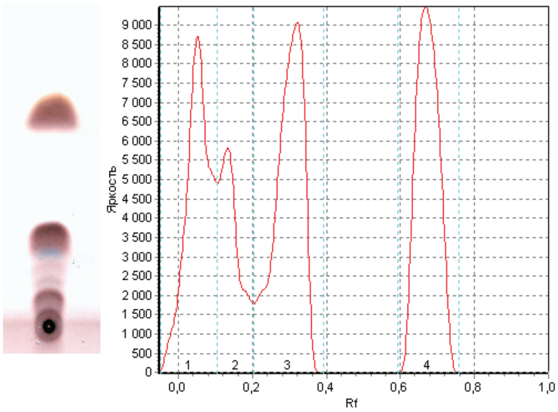

Figure 2: Thin-layer chromatograph of the lipid composition of grape oil.

Grape oil obtained from the secondary resources of grape seed processing contains a set of valuable polyunsaturated fatty acids.

5. Conclusions

The research is devoted to the development of high-tech processing of pulp with the seeds of grapes berries, grape squeezes, grape seeds and skins. Ordinary grapes and raisin varieties was used for processing: Bor kara, Baiat kapy, Gyulyabi Daghestanian, Boriu raisins, Budai shuli, Boru koz raisins, possessing a set of technological characteristics, allowing them to be used for the production of wine beverages not only by the classical technology, but also subjected to vacuum SHF-drying and cryo-grinding for subsequent use as part of products throughout the year.

Regime parameters of preparation, freezing and vacuum SHF-drying raw materials, allowing the preservation of native properties of raw materials in the production of wine beverages, comparable in quality to the beverages produced by traditional technology, are theoretically justified and experimentally tested in the work.

Fundamentally important point is that pulp with grape skins and seeds was used as a raw material for cryo-powders, and their rehydration was carried out by adding light water in a ratio of 1:(3--6) to a sugar content of 20±2 g/l.

Vacuum SHF-drying using recommended by the authors regime parameters does not cause significant changes in physico-chemical parameters, as well as loss of phenolic substances of fruits and berries (anthocyanins, catechins, tannins, leucoanthocyanins, flavonols and flavones), maintaining the organoleptic characteristics of resulting wine beverages.

The complex of organic acids (tartaric, malic, lactic, succinic) does not also undergo quantitative changes in dried raw materials. This factor also ensures the achievement of taste, typical of high-quality red wine beverages from the grape varieties used in the work.

The proposed technology for wine beverages production can be implemented in regions where grapes cannot be grown based on the production of wines from sublimated grape raw materials. This will reduce transportation costs for product delivery to consumers. Another undoubted advantage is the possibility of producing wine beverages without reference to harvest time.

6. Conclusion

Thus, the authors have carried out a study on the solution of environmental and technological problems of rational use of secondary resources for processing grapes.

The possibility of obtaining food from cryo-powder grape squeeze has been confirmed. Further research is needed to achieve optimal parameters both in the field of obtaining sustainable indicators of food quality and expanding their range, and in the direction of searching rational regime parameters for the preliminary preparation of secondary resources of viticulture. In particular, the freezing regimes (process speed and final temperature), sublimation temperature and the amount of moisture associated with it, which is removed by the ``ice-steam'' phase transition, are interrelated with the quality of dried materials and technical parameters of drying devices.

The problem solution of the integrated use of secondary resources for grapes processing will significantly improve the ecological condition of traditional winemaking and viticulture regions.

References

[1] Abdullabekov, R.A. (2016). Use of grape raw materials as BADS source in the conditions of RD. *Mining agriculture*, no. 1, pp. 153--158.

[2] Vlasova, O.K., Bakhmulaeva, Z.K., Magadova, S.A. (2017). Formation of the chemical composition of grapes in the north-western zone of Daghestan. *Winemaking and viticulture*, no. 1. pp. 27--30.

[3] Voronkova, O.Iu. (2018). Application of the ecological block of criteria limits in economic and mathematical modeling of the development of organic agricultural

production. *Problems of development of AIC region*, no. 1, pp. 168--173.

[4] Kustova, I.A., Makarova, N.V. (2015). Comparative analysis of the chemical composition and antioxidant activity of grapes of several varieties: world level and own research. *Winemaking and viticulture*, no. 3, pp. 76--77.

[5] Nadykta, V.D., Shcherbakova, E.V., Olkhovatov, E.A. (2017). Technology of powdered food additives. *Polythematic network electronic scientific journal of Kuban State Agrarian University*, no. 131, pp. 659--671.

[6] Патент РФ на изобретение № 2651172 ``Способ получения сорбента из шрота семян Винограда''. АВторы Назарько, М.Д., КасьяноВ, Г.И., БарбашоВ, А.В., ЦВеткоВ, М.С. ЗаяВка № 2017124273 от 07.07.2017. ОпубликоВано 18.04.2018. Бюл. № 11.

[7] Ramazanov, O.M., Ramazanov, Sh.R., Magomedov, M.G. (2015). Chemical composition of table grapes in the mountain -- valley zone of Daghestan. *Bulletin of Michurinsk State Agrarian University*, no. 3, pp. 35--40.

[8] Sosiura, E.A. et al. (2016). Technology of extracting plant raw materials for the production of functional beverages. In the collection of scientific papers of the *International Scientific and Practical Conference ``Innovative development of agrarian science and education'', dedicated to the 90th anniversary of corr.-memb. RAAS, Honored Worker of RSFSR and DR, Professor M.M. Dzhambulatov*, pp. 283--290.

[9] Khanikaev, D.N. (2017). Chemical composition of grapes of different varieties of grapes in the conditions of North Ossetia-Alania. *News of Gorsk State Agrarian University*, vol. 54, no. 3, pp. 165--169.

[10] Chandrasekar, V., Gabriela, J., Kannan, K., Sangamithra, A. (2015). Effect of foaming agent concentration and drying temperature on physico-chemical and antimicrobial properties of foam mat dried powder. *Asian J. Dairy Food Res.*, vol. 34, pp. 39--43.

[11] Hasanah, H., Chong, G., Suzana, S. (2014). Comparison of physico-chemical analysis and antioxidant activities of Nigella sativa seeds and oils from Yemen, Iran and Malaysia. *J. Sci.*, vol. 43, pp. 535--542.

[12] Kasyanov, G., Davydenko, T. (2017). High-tech processing of secondary resources of winemaking. *Food science and technology*, vol. 1, pp. 75--80.

[13] Patil, V., Chauhan, A.K., Singh, R.P. (2014). Optimization of the spray—drying process for developing guava powder using response surface methodology. *Powder Technol.*, vol. 253, pp. 230--236.

[14] Production of Nigella sativa Beverage Powder under Foam Mat Drying Using Egg Albumen as a Foaming Agent. (2017). *Beverages*, no. 3, pp. 9. DOI:10.3390/beverages3010009.