Вісник Тернопільського національного технічного університетуhttps://doi.org/10.33108/visnyk_tntu
Scientific Journal of the Ternopil National Technical University
2021, № 1 (101) https://doi.org/10.33108/visnyk_tntu2021.01
ISSN 2522-4433. Web: ***visnyk.tntu.edu.ua***

UDC 637

FEATURES OF PRESSING THE JUICE FROM VIBURNUM BERRIES

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Summary: *The article is devoted to the investigation of the process of pressing the juice from viburnum berries. The yield of juice from berries according to the data is approximately 60–65%. However, due to the small amount of processing, as well as specific properties, the investigation of individual technological processes is not given enough attention. The peculiarity of viburnum is the presence of heart-shaped grains, which in the juice bring bitterness. In the process of pressing it is important to create the pressure optimal for it. In order to establish the process modes, the investigations of the compression and filtration characteristics of viburnum berries are carried out. According to the investigation results, rational technological parameters and modes of equipment operation are proposed. Rational values of the height of the product layer in the process of juice removal and the pressure of the pressing process are established.*
Key words: *viburnum, berries, pressing, juice, filtration, pressure, porosity*.

https://doi.org/10.33108/visnyk_tntu2021.01.094 *Received 18.12.2020*

Statement of the problem. The main innovative areas of the food industry development are the expansion of raw material base, the development of technological processes using new physical and chemical methods of processing raw materials and related equipment [1]. At present, there is a tendency to use in the food structure non-traditional raw materials, including various types of wild raw materials, wastes from the production of juices and wines – pomace (skins and seeds), which are accumulated annually in large amounts during processing. Due to biologically active substances contained in non-traditional raw materials, it is possible to regulate the technological process and create products with targeted health properties [2]. The use of viburnum berries is promising in this direction. Viburnum contains 70% more vitamin C than lemon, and it also contains vitamins A, E, P and K. [3]. Berries contain manganese, zinc, iron, phosphorus, copper, chromium, iodine, and selenium [4]. The latter, being present in the cell nucleus, is a substance that takes part in the metabolism of substances and fats in the human body. It is a component of more than 30 important biologically active compounds. Without selenium, vitamin E and iodine are not absorbed by the body. It is an integral part of the immune system and is involved in the mechanism of disease protection. Of all the berries and fruits grown in Ukraine, celery is found only in viburnum. It should be noted that the heat treatment of products containing celery of animal origin is followed by the loss of this element up to 90%, at the same time, during the processing of the plant origin products the loss is less than 50%.

According to recent investigations [5–7], natural carotenoids and ascorbic acid (vitamin C), which are the part of viburnum seed oil, protect the body from cancer, have significant antioxidant effect and prevent premature aging. Thus, the addition of powders or extracts of viburnum berries to food makes it improve their nutritional value and, due to the presence of antioxidants in the powders, increase the shelf life and expand the raw material base of the food industry. Another important fact is that viburnum is distributed throughout Ukraine, it grows in shrubs and plantations, and new varieties of viburnum that can be grown on an industrial scale. Therefore, the study of effective ways of processing viburnum fruits, optimization of technological processes and the operation of appropriate equipment are relevant.

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Analysis of the available investigations and publications. Viburnum is a highly efficient raw material for processing and has a wide range of use in food [6]. Viburnum juice can be used in the selection of alcoholic and soft drinks, juice blends and sauces production [5]. The yield of juice from berries according to data is approximately 60–65% [7].

After processing of viburnum fruits to the pulp mass the rest 30…35% are pomace (peel, stone). The high content of catechins in the powder obtained from viburnum pomace, makes it possible to use it as a stabilizer of the main pigment of beet while obtaining red food dye. The dye is stable when used in the confectionery manufacturing at any pH value [4]. The author [8] notes that bread enriched with viburnum extract powder is characterized by larger volume and better porosity, the smell and taste do not deteriorate and a pleasant taste of viburnum berries is felt. The use of powder reduces the maturation of the dough by 25% compared to the steamless method without the additives. At present there are many developments of biscuit recipes using vegetable powders [8]. Despite the significant number of recipes using the viburnum berries components, the technological process of its processing and ways of intensification of individual operations are not sufficiently studied. In general, the initial operations of the technological process of processing viburnum berries are not determined by the final product or semi-finished product (juice, powder, oil), they include washing and inspection, which are similar for other berries, which enables the use of traditional equipment. However, its division into juice, grains and peel is special for the viburnum processing. The feature of the viburnum berries division is the presence of large hard stone. The process of juice pressing is carried out without prior grinding, as the number of stones in the berry gives unpleasant taste to the final product. Therefore, the use of screw presses, which are often used for berries is not reasonable. On basket and packet presses the juice is squeezed out at insignificant increase of pressure not to clog pores in the filter-pulp. The process is long, taking into account the high viscosity of viburnum juice, at the same time the stones are compacted, forming a compressed layer, which complicates further juice separation. It is possible to intensify the process by pressing the viburnum in a thin layer and at a small pressure value.

The objective of the paper is to investigate the process of separating the juice from the viburnum berries and to determine the optimal technological parameters and modes of equipment operation.

The object of the investigation are fresh and frozen viburnum berries are; fresh and frozen viburnum berries bunches.

The subject of the investigation is the process of squeezing the juice from viburnum berries and the compression-filtration properties of berries.

Statement of the problem. Processing of wild raw materials and, particularly, viburnum has a low level of mechanization. Due to the small volume of processing, as well as specific properties, the investigation of certain technological processes is not paid enough attention, especially it concerns to the juice extraction. As it has been already noted, the characteristic feature of viburnum is the presence of heart-shaped grains, which gives the juice bitter taste. Therefore, in the pressing process it is important to create the optimal pressure for the process [9]. When the juice is squeezed, there are two interrelated processes – the compaction of the berries during the destruction of the shells under the action of pressure and the filtration of the juice through the lower layer. According to researchers, in such processes [10] the presence of optimal pressure and inversely proportional dependence of the filtration duration on the layer thickness is observed. The authors proposed to carry out the process of pressing in the thin layer of the product on a belt press. In order to establish the process modes, the investigations of compression-filtration characteristics of viburnum fruits are carried out using the theory of filtration consolidation [10] with respect to compressible sediments.

Under the pressure action, the shell of the berries is destroyed, the juice fills the inter-grain gaps and the system becomes completely saturated with moisture, and the particles that are not deformed (stones and skin) form the skeleton of this sediment. When the juice is removed, the moisture content of the clot or porosity changes, characterizing the volume of juice that is still in the berries and between the solid particles (stones and skin).

The change in the ratio between moisture and solid particles characterizes the porosity:

$$e = \frac{\varepsilon_1}{\varepsilon_2}; \quad (1)$$

where ε_1 is the fraction of pores (juice) per unit volume of mass;
ε_2 is the fraction of solid particles (stone, skin) per unit volume of mass.

Under the action of pressure, two interrelated processes take place - grain compression and juice filtration. Deformation of grains under the action of pressure is characterized by the compressibility coefficient:

$$a = \frac{\Delta e}{\Delta p}, \quad (2)$$

Where a is the compressibility coefficient, 1/Pa;
Δe is the change of porosity coefficient;
Δp –is pressure change, Pa
or, the modulus of compressibility G, Pa:

$$G = \frac{1 + e}{a}, \quad (3)$$

Filtration of juice through the layer of compressed berries is characterized by specific resistance to filtration, which is determined by the expression:

$$r_0 = \frac{\Delta H \cdot \tau}{\mu \cdot v \cdot h} - \frac{R}{h}, \quad (4)$$

where r_0 is the specific resistance to filtration, $1/m^2$;
ΔH is hydrodynamic pressure, Pa;
τ is the time during which the volume $v_п$, s passes through the berries layer
μ is dynamic viscosity of the juice, Pa·s;
v is specific volume of liquid passing through the layer of berries (m^3/m^2);
h is the height of the berry layer, m;
R is the resistance of filter barrier, $R = 2{,}3 \cdot 10^5$ 1/m.

The comprehensive assessment of compression-filtration properties is the consolidation coefficient b, m^2/s:

$$b = \frac{G}{\mu \cdot r_0}, \quad (5)$$

The determination of compression and filtration properties of viburnum berries is carried out according to the developed method [10]. The deformation of the viburnum layer is measured by the clock-type indicator, the amount of filtered liquid by luiquid measuring cylinder. The thickness of the viburnum layer at each load stage is defined as:

$$h_i = h_f + \Sigma \Delta h_i, \quad (6)$$

where h_i is the layer thickness at n-y load, mm;
h_f is the final height of the pressed layer, mm;
Σh_i is the sum of layer defornations at $f - i$ load stages, mm.

The initial height of the layer is 30–50 mm. The pressure is applied stepwise in the range from 0 to 40 kPa in steps 5.0 kPa. Stabilization of the layer occurred 10–15 min after the load application. The specific resistance to filtration is determined at completely stabilized layer. The experiments are carried out with fresh viburnum berries, frozen berries, and berries bunches. Frozen berries are melted and kept under normal conditions until the temperature reaches 20℃.

Results of the investigations and their analysis. Under the action of the load on lviburnum layer its deformation is taken place due to the release of moisture (juice) and reorientation of the stones. The volume of the released deformation corresponds to the volume of deformation of the curd. That is, in this case, there are two interrelated and interdependent processes – the release of juice as a result of grain compression and its filtration through the layer corresponding to the porosity coefficient change.

The presence of bunches increases the elastic properties of viburnum berries almost 2 times, especially at the beginning of the load (Fig. 1).

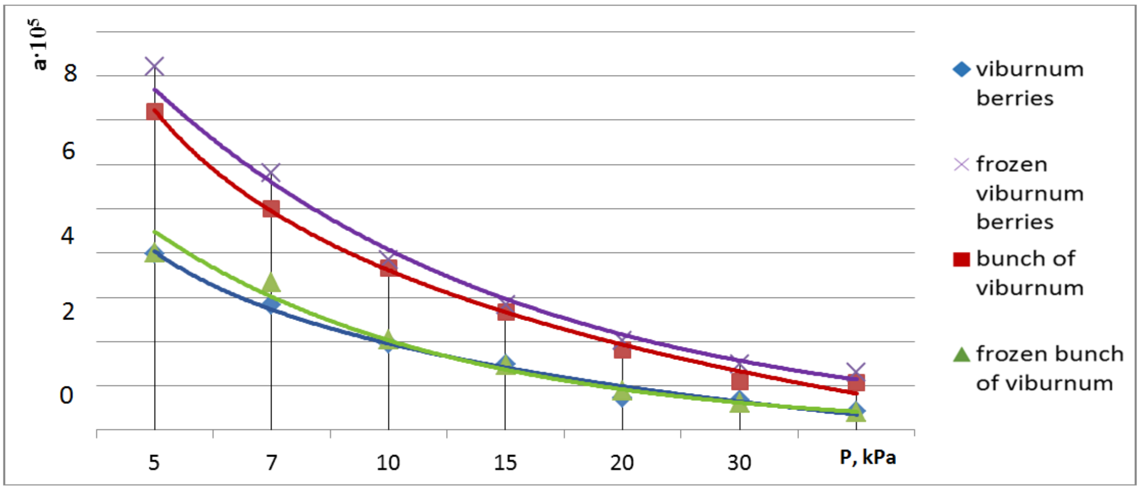

Figure 1. Dependence of compressibility coefficient on pressure

As the pressure and the release of juice increase, the elastic properties decrease both for the mass of individual berries and for frozen and unfrozen berries bunches. That is, in the case of berries storage in the frozen state, their compression properties remain unchanged. At pressure 40 kPa, the compressibility of the sediment is close to zero and is almost the same for all viburnum masses. This condition corresponds to the complete separation of juice from berries and, in practice, there are only stones and skin, which have no elastic properties.

The results of the investigations of the of compressibility modulus dependence on pressure are presented in the form of the graph in Figure 2.

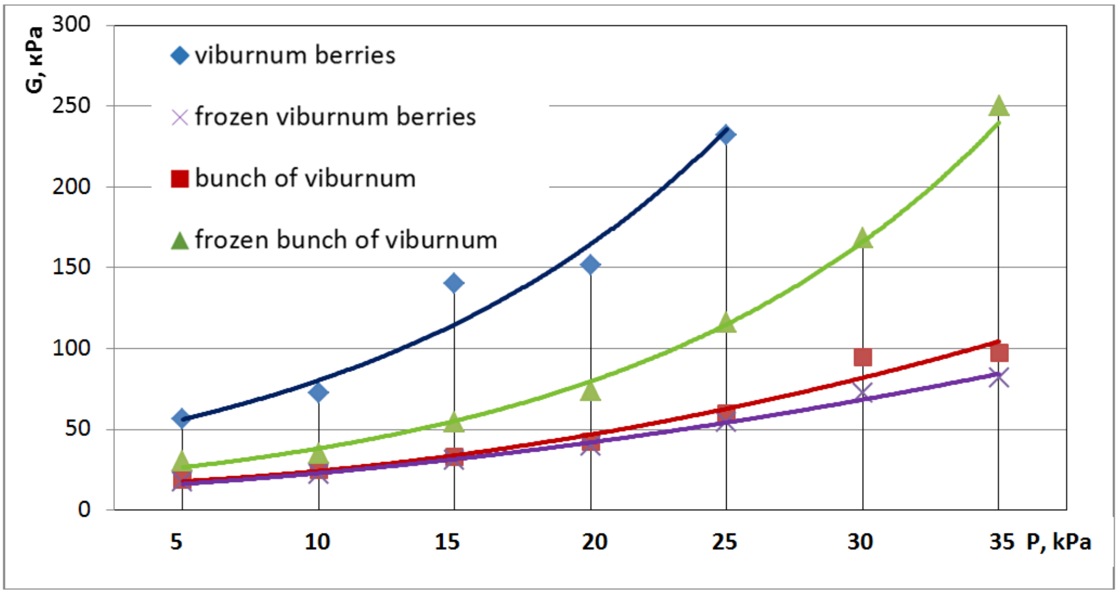

Figure 2. Dependence of the compressibility modulus on pressure

The amount of pressure also affects the filtration characteristics of viburnum. Under the action of pressing pressure, the maximum load at the initial time is received by the upper layers, as the moisture separates, the pressure will be distributed between the layers and when the compressed layer of viburnum stabilizes, all berries will be under pressure. Therefore, to establish the dependence of the specific filtration resistance on the pressure the investigations are carried out under stabilized layer. It is determined that with the pressure increase on the viburnum layer within the range from 5 kPa to 40 kPa, the specific filtration resistance increases significantly (Fig. 3).

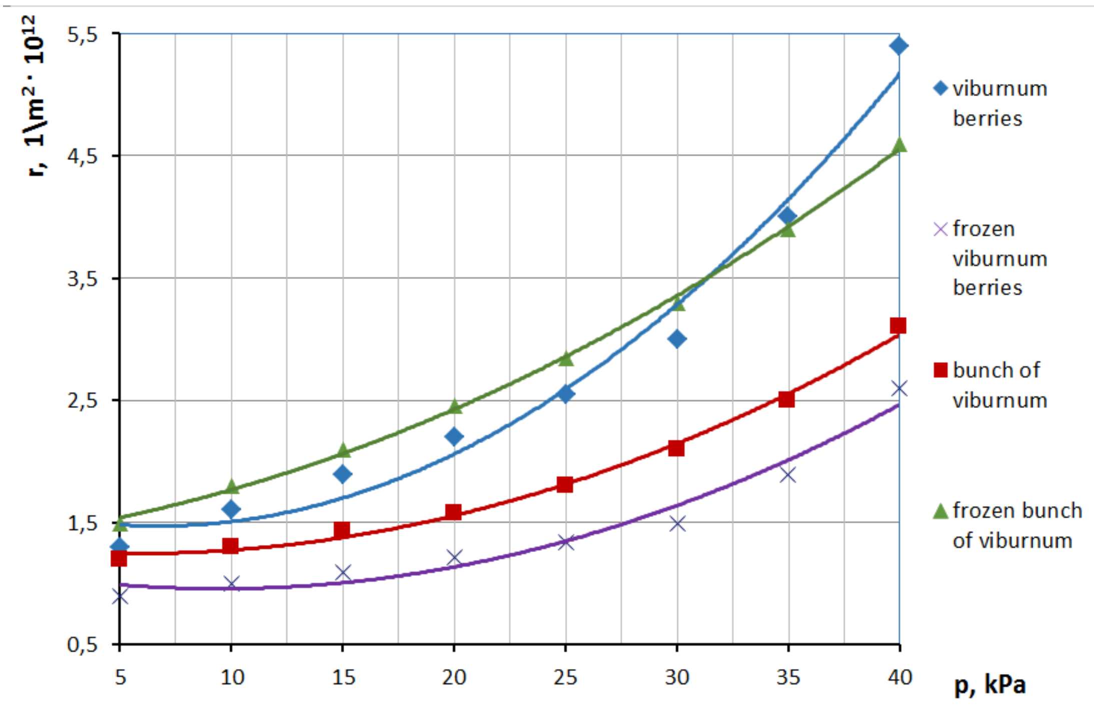

Figure 3. Dependence of specific filtration resistance on pressure

As it is evident from the graphs, viburnum berries, which have been subjected to preliminary heat treatment (freezing), under the action of small load are very quickly compressed and poorly pass the filtrate through the compressed layer. At the same time, viburnum berries subjected to heat treatment under small load are compressed and well passed through the filtrate layer (up to 25 kPa), and when the load on the piston is increased over 25 kPa, the layer is compressed and the amount of liquid passing through it is decreased.

In this case, pressing is reasonable only to a certain height of the compressed layer (50 mm), further pressing will not give positive results, as the amount of filtrate passing through the compressed layer is constantly decreasing. For viburnum berries with bunches, the results are similar, but the amount of filtrate passing through the compressed layer will be higher.

Viburnum berries with bunches being previously subjected to heat treatment (first frozen and then melted), show better results, because under low load (5–10 kPa) they pass larger volume of filtrate compared to viburnum berries not subjected to heat treatment. With increasing load, the layer is compressed, but the amount of passed filtrate is not significantly reduced compared to conventional berries after freezing.

Thus, from the obtained graphical dependence it is noticeable that heat treatment significantly improves the filtration properties of pre-frozen viburnum berries without bunches. However, for viburnum berries with bunches, heat treatment by freezing is undesirable because it significantly increases the specific resistance of berries filtration.

For all the investigated samples at pressure of 40 kPa, the viburnum layer is almost impermeable to moisture, i.e. we can come to the conclusion that large pressing force will not result in the intensification of the pressing process.

The comprehensive assessment of the compression-filtration properties is the consolidation coefficient b. It is determined that for all investigated materials, the consolidation coefficient increases with the pressure increase (Fig. 4).

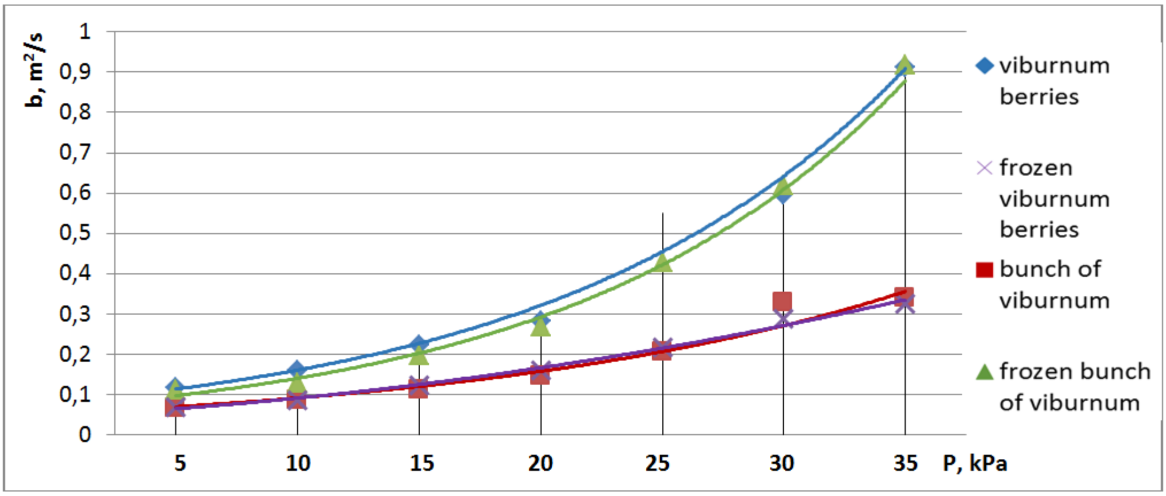

Figure 4. Dependence of consolidation coefficient on pressure

Conclusions. It is reasonable to squeeze the juice from the viburnum berries at relatively small height of the product layer – up to 50 mm.

The presence of bunches increases the elastic properties of viburnum berries almost 2 times, especially at the beginning of the load.

Heat treatment significantly improves the filtration properties of pre-frozen viburnum berries without bunches. However, for viburnum berries with bunches, heat treatment by freezing is undesirable because it significantly increases the specific resistance to berries filtration.

Excessive pressing effort does not intensify the pressing process. It is reasonable to squeeze the juice from the viburnum berries at pressure value up to 25 kPa. When the pressure value 40 kPa is reached, the viburnum layer is almost impermeable to moisture.

References

1. Rybak T, Tson O, Stashkiv M, Boyko A, Tson A. Analytical and applied model of absorption in the seed grain dresser and pelletizer system. Scientific Journal of TNTU. 2017. Vol. 87. No. 3. P. 111–116. DOI: https://doi.org/10.33108/visnyk_tntu2017.03.111
2. Kajszczak D., Zakłos-Szyda M., Podsędek A. Viburnum opulus L. A Review of Phytochemistry and Biological Effects. Nutrients. 2020. No. 12. P. 3398. DOI: https://doi.org/10.3390/nu12113398
3. Polka D, Podsędek A, Koziołkiewicz M. Comparison of Chemical Composition and Antioxidant Capacity of Fruit, Flower and Bark of Viburnum opulus. Plant Foods Hum Nutr. 2019. Vol 74. No. 3. P. 436–442. DOI: https://doi.org/10.1007/s11130-019-00759-1
4. Perova I. B., Zhogova A. A., Cherkashin A. V. Biologically Active Substances from European Guelder Berry Fruits. Pharmaceutical Chemistry Journal. 2014. No. 48. P. 332–339. DOI: https://doi.org/10.1007/s11094-014-1105-8
5. Kraujalyte V., Venskutonis P. R., Pukalskas A., Cesonien L., Daubaras R. Antioxidant properties and ˙polyphenolic compositions of fruits from different European cranberrybush (Viburnum opulus L.) genotypes. Food Chem. 2013. No. 141. P. 3695–3702. DOI: https://doi.org/10.1016/j.foodchem.2013.06.054
6. Konarska A, Domaciuk M. Differences in the fruit structure and the location and content of bioactive substances in Viburnum opulus and Viburnum lantana fruits. Protoplasma. 2018. Vol. 255. No. 1. P. 25–41. DOI: https://doi.org/10.1007/s00709-017-1130-z
7. Erdogan-Orhan I., Altun M. L., Sever-Yilmaz B., Saltan G. Anti-acetylcholinesterase and antioxidant assets of the major components (salicin, amentoflavone, and chlorogenic acid) and the extracts of Viburnum opulus and Viburnum lantana and their total phenol and flavonoid contents. Med Food. 2011. Vol. 14. No. 4. P. 434–440. DOI: https://doi.org/10.1089/jmf.2010.0053
8. Makovskaya I. S., Novoselov S. V. Analiz i perspektivyi ispolzuvaniya kalini v proizvodstve plodoyagodnih siropov funktsionalnogo naznacheniya. Polzunovskiy almanah. 2011. Vol. 4. No. 2. P. 137–145. [In Russian].
9. Vodyanitsky G., Slyusarenko I., Tymkiv V., Mamchur V., Dovbysh A. Mathematical modeling of mixing-grinding of feed by vertical conical screw. Scientific Journal of TNTU. 2019. Vol. 95. No. 3. P. 67–74. DOI: https://doi.org/10.33108/visnyk_tntu2019.03.067
10. Shynkaryk M., Kravets O. Mathematical modelling of the separation of suspension process on the filter with selt-purifier filter element. Food Journal. 2016. No. 1. P. 135–143.

Список використаної літератури

1. Rybak T., Tson O., Stashkiv M., Boyko A., Tson A. Analytical and applied model of absorption in the seed grain dresser and pelletizer system. Вісник ТНТУ. 2017. Том 87. № 3. С. 111–116. DOI: https://doi.org/10.33108/visnyk_tntu2017.03.111
2. Kajszczak D., Zakłos-Szyda M., Podsędek A. Viburnum opulus L. A Review of Phytochemistry and Biological Effects. Nutrients. 2020. № 12. С. 3398. DOI: https://doi.org/10.3390/nu12113398
3. Polka D., Podsędek A., Koziołkiewicz M. Comparison of Chemical Composition and Antioxidant Capacity of Fruit, Flower and Bark of Viburnum opulus. Plant Foods Hum Nutr. 2019. Vol. 74. No. 3. P. 436–442. DOI: https://doi.org/10.1007/s11130-019-00759-1
4. Perova I. B., Zhogova A. A., Cherkashin A. V. Biologically Active Substances from European Guelder Berry Fruits. Pharmaceutical Chemistry Journal. 2014. No. 48. P. 332–339. DOI: https://doi.org/10.1007/s11094-014-1105-8
5. Kraujalyte V., Venskutonis P. R., Pukalskas A., Cesonien L., Daubaras R. Antioxidant properties and polyphenolic compositions of fruits from different European cranberrybush (Viburnum opulus L.) genotypes. Food Chem. 2013. No. 141. P. 3695–3702. DOI: https://doi.org/10.1016/j.foodchem.2013.06.054
6. Konarska A, Domaciuk M. Differences in the fruit structure and the location and content of bioactive substances in Viburnum opulus and Viburnum lantana fruits. Protoplasma. 2018. Vol. 255. No. 1. P. 25–41. DOI: https://doi.org/10.1007/s00709-017-1130-z
7. Erdogan-Orhan I., Altun M. L., Sever-Yilmaz B., Saltan G. Anti-acetylcholinesterase and antioxidant assets of the major components (salicin, amentoflavone, and chlorogenic acid) and the extracts of Viburnum

opulus and Viburnum lantana and their total phenol and flavonoid contents. Med Food. 2011. Vol. 14. No. 4. P. 434–440. DOI: https://doi.org/10.1089/jmf.2010.0053

8. Маковская И. С., Новоселов С. В. Анализ и перспективы использувания калини в производстве плодоягодних сиропов функционального назначения. Ползуновский альманах. 2011. № 4/2. С. 137–145.
9. Vodyanitsky G., Slyusarenko I., Tymkiv V., Mamchur V., Dovbysh A. Mathematical modeling of mixing-grinding of feed by vertical conical screw. Scientific Journal of TNTU. 2019. Vol. 95. No. 3. P. 67–74. DOI: https://doi.org/10.33108/visnyk_tntu2019.03.067
10. Shynkaryk M., Kravets O. Mathematical modelling of the separation of suspension process on the filter with selt-purifier filter element. Food Journal. 2016. No. 1. P. 135–143.

УДК 637

ОСОБЛИВОСТІ ВІДТИСКУ СОКУ З ЯГІД КАЛИНИ

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Резюме. *Присвячено дослідженню процесу відділення соку із ягід калини. Калина є високоефективною сировиною для перероблення і має широкий спектр використання у харчуванні. У калині на 70% більше вітаміну С, ніж в лимоні, вона також містить вітаміни А, Е, Р і К. Із мінеральних речовин ягоди містять марганець, цинк, залізо, фосфор, мідь, хром, йод, селен. Натуральні каротиноїди та аскорбінова кислота (вітамін С), що входять до складу олії з калинових кісточок, захищають організм від онкологічних захворювань, надають значну антиоксидантну дію і перешкоджають передчасному старінню. Вихід соку з ягід за даними становить приблизно 60–65%. Проте у зв'язку з невеликими об'ємами переробки, а також специфічними властивостями вивченню окремих технологічних процесів не приділяли достатньої уваги, зокрема це стосується відтиску соку. Особливістю калини є наявність зерен серцеподібної форми, які при попаданні у сік приносять гіркоту. Тому в процесі відтиску важливим є створення оптимального тиску для проведення процесу. Для встановлення режимів процесу проводилися дослідження компресійно-фільтраційних характеристик ягід калини з використанням теорії фільтраційної консолідації стосовно стисливих осадів. Під дією тиску відбувається руйнування оболонки ягід, сік заповнює міжзернові проміжки й система стає повністю вологонасиченою, а ті частинки, що не деформуються (кісточки і шкірка, корінці) утворюють скелет цього осаду. При відведенні соку змінюється вологість згустка або пористість, яка характеризує об'єм соку, що знаходиться в ягодах та між твердими частинками. За результатами досліджень запропоновано раціональні технологічні параметри та режими роботи обладнання. Встановлено раціональні значення висоти шару продукту в процесі відведення соку та тиску процесу відтискування.*

Ключові слова: *калина, ягоди, відтиск, сік, фільтрація, тиск, пористість.*

https://doi.org/10.33108/visnyk_tntu2021.01.094 *Отримано 18.12.2020*