Research results of juicing process using the developed design of the working elements of the roll-belt press

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Abstract. The paper presents and describes the developed design of the working elements of the roll-belt press. The theoretical dependences of the energy parameters of the press are found. The optimal operating parameters are substantiated, which allows the most efficient berry juicing. The data of experiments on berry juicing, depending on the juicing pressure and the holding time of the pulp under pressure, are given.

1. Introduction
Nowadays it is more and more difficult to follow a healthy diet with the accelerating pace of life and the problem of a lack of vitamins in the human body is becoming more and more acute [1, 2]. Berries can help to ease this problem. The high content of vitamins and micro and macro elements in products based on berries makes it possible to classify them as therapeutic and prophylactic. The problem is that the main berry products that are widely available to consumers are preserves and jams. However during their production, the raw material is subjected to heat treatment for a rather long time, thereby destroying a significant part of vitamins and nutrients. In order to most fully save the nutrients, it is reasonable to produce directly squeezed berry juices [3-5].

On the open market, the percentage of juices from berries is several times lower than that of juices from fruits. This can be explained by the fact that for large companies it is not profitable to engage in processing due to small volumes of raw materials and small processing enterprises do not have effective equipment of the required productivity capable to provide a high yield of berries juices [6].

The purpose of the study is to develop a design of the working elements of a belt press that makes it possible to effectively obtain juices from berries.

2. Materials and methods
Having identified the shortcomings of the existing presses, the design of the belt press was developed. The main difference of it is the new layout of the working elements (Figure 1). [7]

The working elements of the press are located one above the other, while the originality is in the fact that one of the rolls is pneumatic (filled with air). In contact with the bottom (hard) element, it deforms to fit it. This design, in contrast to the existing designs of belt presses, gives a many times larger contact area at a constant pressure. Produced juice is discharged through the channels of the rigid roller.
At the initial stage, the power characteristics of the developed structure were theoretically determined (expression 1) [7, 8]:

$$M_r = \int h_0 \cdot \frac{p \cdot b}{100} (R_2 - \Delta) \cdot W + 2 \cdot p \cdot R_1 \cdot b \cdot \sin \frac{\alpha}{2} \cdot (R_1 + R_2 - \Delta)$$ (1)

It is found that for the rotation of the working element, a torque is required, which is the sum of the moments: from the force twisting the shell of the deforming roll (it is necessary to determine experimentally) and from the force that squeezes out the pulp from the extraction zone, to determine which it is necessary to experimentally find the dependence of the juice yield on pressing time at the appropriate pressure. Moreover, the searching experiments were carried out on a laboratory press installation in order to determine the optimal parameters of the pressure and the total holding time of the pulp under pressure.

Figure 2. Dependence of the yield of juice from black currant (W) on the squeeze pressure (P) and pressure time (t)
The experiments showed (Figure 2): the optimal parameters of the squeeze pressure - 0.6 MPa and the total holding time of the pulp under pressure - 25 seconds.

3. Results of the study of juicing using proposed press design

The experimental sample was made and experiments were carried out to obtain juices from berries - Figure 3.

![Experimental model of a press without a belt](image)

**Figure 3.** The experimental model of a press without a belt: 1 - frame; 2 - pneumatic roll; 3 - hard rolls; 4 - supporting rollers; 5 - gear motor; 6 - loading hopper; 7 - receiving hopper for pomace; 8 - juice tray;

The experimental studies on squeezing juice from berries were carried out with and without preheating to a temperature of 60 degrees. The graphs of the experimental results are shown in Figure 4.

![Graphs of experimental results](image)

black currant  
chokeberry  
cherry
Figure 4. Dependences of juice yield (W) on squeeze pressure (P) and pressure time (t)

In Figure 4 we can see that the press effectively separated the juice from the raw material. In comparison with other designs of belt presses, the juice yield was 8-12% higher. The maximum obtained indicators of the juice yield are shown in Table 1.

| Berry                | Pressing without preheating, % | Pressing with preheating, % |
|----------------------|--------------------------------|-----------------------------|
| Black currant        | 72,6                           | 76,7                        |
| Chokeberry (Aronia)  | 67,6                           | 72,1                        |
| Cherry               | 74,4                           | 79                          |

Heating is one of the ways to press juice from berries more efficiently. It allows increasing juice production by 10 .. 15% on existing presses. [5] In our case, a high juice yield was achieved even without heating, so the efficiency of the method decreased by 6 .. 10%.

The high yield can be explained by squeezing in a layer up to 1 cm, whereas usually the squeezing with a layer of 2 .. 3 cm is performed on belt presses. Due to the use of a thinner layer, the pressing time has significantly decreased. In the experiments, the time of holding the raw material under pressure was limited to 25 seconds. In this case, the main part of the juice was separated in the first 15 seconds. In the next 10 seconds, the additional output was 3 .. 5%. In existing belt presses, the spin time was more than 2 minutes.

To date, the work to improve this design in order to increase the yield of juice and facilitate its removal from the working bodies is being conducted. For this, it is planned to change the design of the lower (rigid) roll, namely to make it in the form of many small rolls. In this case, it is necessary to make a different angular velocity of the upper and lower rolls, as a result of which the layers of the pulp will shift relative to each other, which will further increase the juice yield. The gaps that will form between the small rolls will make it easier for the juice to extract, preventing it from falling back into the pulp. In addition, the application of the processes of regrinding and mixing the pulp after squeezing with subsequent re-pressing is being studied.

In the course of laboratory tests with innovations introduced into the design of the press and with the use of regrinding and mixing, the juice yield was increased by another 6-8%, depending on the raw material in comparison with the basic design. Biochemical analysis of the juice showed that a significant part of the nutrients passes from the berries into juice, but a sufficient amount of vitamins and micro elements remains in the pomace. Therefore, pomace is also a valuable raw material and its further processing is reasonable. Several options for their processing are currently being considered.

4. Conclusion
According to the results, it can be concluded that the developed design of the roll-belt press allows more efficient extraction of juices from berries than the existing designs of belt presses.
References

[1] Urbański A, Richter M 2021 Stability analysis of heavy machinery moving on weak subsoil. Analytical solution Engineering Structures 241 112152

[2] Wang W-D, Fan J-H, Shi Y-L, Xian W 2021 Research on mechanical behaviour of tapered concrete-filled double skin steel tubular members with large hollow ratio subjected to bending Journal of Constructional Steel Research 182 106689

[3] Pyanikova E A, Kovaleva A E, Ovchinnikova E V, Afanasieva L A 2021 Researching the possibility of using recycled apple raw materials to create functional food products IOP Conference Series: Earth and Environmental Science 677(3) 032030

[4] Vagiri M, Jensen M 2017 Influence of juice processing factors on quality of black chokeberry pomace as a future resource for colour extraction Food Chemistry 217 409-417

[5] Kuzmina N, Krasilnikova A, Terentyev K, Novozhilov E 2018 The application of pectinase in the lingonberry-juice production: The impact on the yield and composition of biological valuable components International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 18(6.4) 275-282

[6] Bakharev A A, Zavrazhnov A I, Pustovalov D V 2010 Roll-belt press for squeezing juice from fruits, berries and vegetables, Patent for invention RU 2396061 C2

[7] Pustovalov D V 2004 Technology and line for pressing apple juice, candidate dissertation (Michurinsk)

[8] Bakharev A A, Zavrazhnov A I, Pustovalov D V 2014 Belt press for squeezing juice from fruits, berries and vegetables with a deforming roll, Utility model patent RU 148630 U1

[9] Bakharev A A, Pustovalov D V 2019 Roll-belt press for squeezing juice from fruits, berries and vegetables with a deforming roll, Utility model patent RU 190884 U1