Intensification of pectin obtaining from apple pomace

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Abstract. This study is devoted to the problem of improving the methods of pectin obtaining from apple pomace. The relevance of the study is dictated by the fact of formation of a large amount of waste when receiving apple juice. The output of apple juice at the enterprises of the processing industry is from 50 to 75%, therefore, 25-50% is waste. In our studies we used 42 KHz frequency of ultrasonic vibrations. The powers of ultrasound waves were 30 and 50W. The output of pectin depends on the sample exposure time, and with time passing this growth decreases and eventually stops, which may indicate that a certain amount of destruction has been reached at a given power. The maximum increase in the output of pectic substances is observed when the ultrasonic treatment time is 15 minutes and it is 26%. Capacity also affects pectin output. With power increasing from 30 to 50 W, the amount of pectin released increases by an average of 10%. It is shown that the use of separation at the stage of solution partitioning from pectin allows one to increase the speed of the process by a factor of two.

1. Introduction

The main raw materials for pectins are waste of a large number of food productions. The citrus pectin is obtained from orange peels, which is most popular in the world due to its low cost. The peel of oranges contains a large amount of pectinesterase enzyme, which promotes the deetherification of pectin [1]. In addition, pectin is obtained from mandarin peels, lime, lemons, sunflower baskets, sugar beets [2], black currants [3]. In South America pectin is obtained from some species of cacti [4].

Pectins are among the polysaccharides that can be used in various sectors of food industry as thickeners, gelling agents, emulsifiers, stabilizers and therapeutic and prophylactic additives [5]. The most important property of pectin, from a medical point of view, is its ability to bind with cholesterol, radionuclides, heavy metal ions [6].

The degree of etherification plays a significant role when using pectins. High-methoxyl pectin (HM-pectin, HE-pectin) possesses a weak charge and is less sensitive to charged molecules, such as proteins. HM-pectin increases the colloidal stability of protein molecules, thereby stabilizing acidic beverages. In this case, the interaction mechanism, apparently, is the electrostatic interaction between the protein and pectin, and not the adsorption of pectin on the surface of the protein molecule [7].

In dairy industry and in production of juices from fruits, citrus pectins are used, and the pectin from lime has the best quality in the technology of these products. Pectin from oranges and grapefruit has satisfactory characteristics, and pectin from mandarins does not suit at all [8].
Usage of pectic substances in baking has several reasons. In bakery production, pectin is used to increase volume and water retention during storage, which allows one to obtain softer and more porous products, as well as improve structural and mechanical properties of crumb and to increase its humidity. These valuable properties of pectins are due to its high water-holding capacity, which allows one to improve the quality indicators of bread. High hydrocolonic properties are related with the fact that pectins during the process of water absorption compete with flour starch and reduce its hydration, and pectins in baking processes are able to release moisture, causing starch gelatinization [2].

Due to the ability to form jelly, pectin is widely used for jelly production: marmalade, jelly fillings for sweets [9].

Pectin from sugar beet pulp is used in dietetic and pharmaceutical product technologies, since this pectin has the property of binding heavy metals. Apple and tomato beverages based on beet pectin have been created, which can be recommended to megacities residents, as well as to people working in hazardous industries, such as metallurgy, chemical industry. Pectin from sunflower baskets is used in cosmetics production [10].

To obtain pectin, it is very expedient to use pomace obtained from apples as a result of their processing into juice [11]. The output of apple juice is from 50 to 75%, therefore, the remaining part is pomace. For companies that produce juices, this is waste and its competent disposal is an absolute part of costs, which ultimately affects the cost of production. In this regard, usage of waste from one production as a raw material for another enterprise is already a strong resource-saving factor.

Apple pomace has its drawbacks. Since this is a plant product and, moreover, it is very juicy (its humidity is 70–90%), it is susceptible to microbiological damage, which limits its applicability in its native form. On the other hand, if pectin production is carried out near enterprises of apples primary processing, this problem is partially removed. In addition, it is possible to store and transport the pomace in dried form. However, in this case, significant energy costs are inevitable. It is important to understand that in order to obtain pectin, using one way or another, dried pomace still needs to be moistened and the evaporated moisture (plus associated costs) inevitably will increase the cost of the product and complicate the process chain. An interesting option is the pomace preservation with the help of chemical reagents. The cost of this technique is less than for drying the product, but there still remains the question about the separation of the preservative from the semi-finished product during pectin production.

2. Experimental part

Technology for pectin production from apple pomace exists and is implemented in the world with varying degrees of success [12-14].

A typical technological scheme for pectin producing includes several steps:
1. Obtaining the pomace.
2. Drying and subsequent grinding.
3. Extraction of soluble substances with cold water and its separation.
4. Extraction of pectin components of pomace using hot water (temperature up to 92 °C) at pH from 3.5 to 4.5
5. Treatment by amylolytic and proteolytic enzymes followed by inactivation.
6. Clarification using activated carbon followed by separation of coal particles.
7. Precipitation of pectin fractions by ethyl alcohol and separation of the residue.
8. Drying the residue.

Industrial production of pectin is a very time consuming and resource-intensive process. It requires serious thermal power and a large excess of ethanol to precipitate. This alcohol is regenerated after use, which also obliges to high energy costs.

Scientific and engineering studies aimed at improving the efficiency of pectin production have been carried out continuously in recent decades and affect various areas of the technological process [15, 16]. This is an increase in the output of the finished product, as well as chemical [17], and design solutions.
Structurally, pectin in plant tissues is part of complexes containing protein and hemicellulose, which, in turn, are associated with cellulose, forming a fairly strong and plastic frame. To obtain pectin from this complex system, various techniques are used: chemical, biochemical, and physical.

The present studies are aimed at usage of ultrasonic waves for partial disintegration of this system and separation of pectin fractions from other components. The effectiveness of ultrasound for such purposes was confirmed by scientific studies [18, 19].

High-frequency elastic oscillations in medium cause appearance of areas with high and low pressure. In areas with low pressure, microscopic vacuum cavities are systematically formed, which collapse/breaks plant tissue. It is difficult to predict specific break points of the cell cages, but the fact of mechanical destruction can be observed instrumentally, for example, by accumulation of substance in the medium (in our case, pectin).

An ultrasonic wave generator constructed on the basis of piezoelectric elements was used in our work. The electric field generated by the device causes oscillations of the source of ultrasonic waves, which is transmitted through the walls of the device to the material under study. The frequency of ultrasonic vibrations was 42 KHz, and the power of ultrasonic waves was 30 and 50W. As a smoothly varying variable we selected the sample exposure time. The research results are presented in Figure 1.

![Figure 1. Pectin output depending on the ultrasound treatment mode](image)

As is seen from Fig.1, the output of pectin depends on the time of sample treatment and while time is passing, this growth decreases and eventually stops, which may indicate that a certain amount of destruction has been reached at a given power. The maximum increase in the pectic substances output is 26%. Power also affects the output of pectic substances, with a 60% increase in power, the amount of pectin released increases, on average, by 10%.

Further we conducted studies aimed at identifying the temperature optimum for extraction of pectic substances with water from apple pomace. For this purpose, extraction was performed at various temperatures, and then the pectin precipitated with alcohol was isolated from medium in two ways: by filtration and separation. The obtained data are shown in Figure 2. From the data obtained, it is seen that the maximum output of pectic substances is in the range between 60 and 70 °C.
Figure 2. Influence of temperature on pectin substances output

The optimum range of temperature extraction can be explained by the plant nature of the raw materials used. Apparently, apples grades and conditions for pomace obtaining can affect the structure of cell walls and, consequently, the pectin output at various temperatures.

Usage of mixture separation is very promising. As our research shown, in comparison with traditional filtration, separation makes it possible to extract soluble fractions of pectin more fully, on average, by 10%. In addition, the process of separation itself is significantly accelerated. Filtering under vacuum takes 120 minutes or more, and using separation the whole process, including loading and unloading the apparatus, takes no more than 50 minutes. Thus, the operation of pectin separation can be accelerated more than twice, with a noticeable increase in its output.

3. Conclusions
Summarizing the obtained results we can draw the following conclusions:

1. Ultrasonic processing of apple pomace allows one to increase the efficiency of pectin extraction by more than 20%, and the power of acoustic treatment also has a positive impact on the process efficiency.

2. The use of separation at the stage of solution partitioning from pectin allows one to speed up the process more than twice, which, as applied to production scales, will result in significant time savings, which today is a decisive economic factor.

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