

Research on the ways of the pectin extraction from the potatoes

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Keywords:

Pectin
Hydrolysis
Potato
Infrared
Spectra

Article history:

Received 12.09.2012
Received in revised form
21.10.2013
Accepted 23.12.2013

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ABSTRACT

Introduction. As addition to traditional raw plant materials for pectin production - apple and citric mush, there is a possibility to use potato pulp, that is a by-product of starch production and contains approximately 2-5,5 % of pectin in dry weight (DW).

Materials and methods. Material research - potato pulp. Through the statistical processing of the experimental data of previous optimum parameters of hydrolysis-extraction of potato pectin. The structure of the resulting potato pectin studied by means of infrared spectroscopy.

Results. The precise planning of the experiment and statistical analysis of experimental data helped to determine optimal conditions for the process of potato pectin hydrolysis-extraction. The peculiarities of the output pectin structure were investigated by means of infrared spectroscopy. It was discovered that potato pectin contains a considerable quantity of ballast substances and has a low jelly-forming capacity. Micro photographing showed that outlet samples of pectin contained a considerable amount of starch that is extracted along with pectin substances and precipitates in the reaction with ethanol. In case of enzyme usage in hydrolysis pectin becomes freer from impurity.

Conclusions. The potato was investigated as a potential raw material for pectin extraction. Infrared spectra of potato pectin confirm that it contains functional (carboxyl, hydroxyl and ester-bounded) groups in the molecule of this polysaccharide. The samples of pectin (got after processing the raw material with enzymatic agent) have a higher number of carboxyl and carbonyl groups, manifesting a partial hydrolysis of starch polysaccharides.

Introduction

A natural polysaccharide called pectin is a unique biopolymer, being the main constructing material of the plant cell wall. It is acknowledged that natural diet supplements containing pectin make a complex influence on the human body: prevent radioactive metals from absorption in the digestion tract and provoke their disposition; they have antioxidant characteristics, help the human body to dispose of xenobiotics (particularly pesticides), normalize the cholesterol level, increase resistance to allergies, improve metabolism [3,4]. The curing properties of pectin substances can be explained by their content and structure. Pectin is widely used today in food industry and medicine.

Nevertheless, the pectin production is not organized in Ukraine and the need in the substance is satisfied by import, making the price high. The problem of the pectin lack in Ukraine can be solved by means of introducing its production from cheap home raw materials.

Main part of plant raw materials processed by food industry becomes waste: beet pulp, apple and citric mush. However, these secondary raw materials can be used for the production of pectin substances. Citric mush is the main source of pectin abroad. In Ukraine there is a lot of raw potato pulp left from the production of starch. This by-product can be recycled to get pectin or dietary fibers and because of this the investigation of the ways of potato pectin extraction is of high importance.

The references analysis shows that technological regulations of the potato pulp hydrolysis process can lead to producing three end products: starch with pectin, pectin and potato fiber.

The objective of the work was the investigation of the technological conditions of the potato pectin extraction, calculating mathematical formula that help to optimize the process of the raw material hydrolysis, the investigation of the potato pectin structure.

Materials and methods

Modern industrial technology of pectin is based on the acid-thermal hydrolysis of the raw materials. The mineral and organic acids, alkali and enzymatic agent are used as hydrolyzing reagent. The catalytic effect of the Hydrogen ions on the molecules of pectin substances depends on the temperature and pH of the environment [1].

The existing technologies of pectin imply the combination of the processes of hydrolysis and extraction in one technological operation. Most technologies employ ethanol for pectin extraction [1].

In our project we used potato pulp, rinsed by water in order to wash the starch out. In the series of investigation we used potato pulp processed by bacterial α -amylase (for bound starch hydrolysis) and bacterial protease (for reducing the level of proteins that are the components of ballast compounds). The potato pulp water content was measured by applying the weight method [1]. The dry weight (DW) concentration in the pectin extract was measured by the refractometric method and pH was calculated by potentiometric measurements.

Infrared spectra (IR-spectra) were implied in the investigation process of pectin that was extracted from the potato pulp. The IR-spectra were measured in the band of 700—3600 cm^{-1} by FT-IR Nikolet spectrophotometer of Nexus production.

There were determined the technological parameters for the process of raw potato materials, i. e. pH, temperature and hydromodulus of the process. The hydrolysis was conducted with periodic stirring in the thermal bath, equipped by the glass thermometer.

The potato pulp was mixed with heated acid solution at a proper for hydrolysis temperature. The acid concentration as hydrolytic factor was calculated depending on the indicated hydrolysis mixture pH and the hydromodulus level [1]. The hydrolysis hydromodulus (q) is calculated from the correlation between the weight of the acid solution and the weight of potato raw material. In our experiment we made it equal to 2. 100 grams of the raw material with known water content were hydrolyzed with the acid of determined concentration. The duration of the hydrolysis process was calculated from the moment when the hydrolyzed mixture reached required temperature. After the hydrolysis the liquid phase was separated, the extract was neutralized to the 4-5 level of pH by the ammonium hydroxide solution, cooled to the temperature of 20°C and there was conducted a coagulation of pectin substances in the extract by the ethanol. Then we observed the stable hydrocolloid precipitation that floated on the surface of the liquid. The received pectin was dried by the air and grinded after additional ethanol rinse. The amount of end product (%) was calculated in relation to the dry weight.

Results and discussion

The experiment was based on the rotatable design of the second order for a three-factor experiment. The changeable factors of the experiment were the temperature, the duration of the hydrolysis and the concentration of the hydrolyzing reagent (% HCl).

Factors for levels	- α	-1	0	+1	+ α
Acidity, % HCl	0,3	0,7	1,3	1,9	2,3
Temperature, °C	40	48	60	72	80
Duration, min	33	50	75	100	117

Resulting from the statistical calculations of the experimental data there have been determined optimal conditions for the process of pectin-hydrolysis-extraction from the potato pulp: 1,45% concentration acid to the hydrolysis weight, 70,5 minutes of hydrolysis at the temperature of 72 °C. As a result of the experiment planning there was made a mathematical model of the raw potato materials hydrolysis. The resulting equation has a practical meaning and enables to predict the result and quality of the pectin using the information about temperature, acidity and duration of the process.

The photograph of the potato pulp (Fig. 1) was taken by means of electron microscope. The picture shows a considerable quantity of starch granules which under these particular conditions of hydrolysis are partially hydrolyzed (becoming dextrans) and are precipitated by ethanol.

Most small starch granules come into the extract and are precipitated by ethanol along with pectin substances. This statement is manifested by micro photographs of ready potato pectin powder, made by means of investigative microscope MBD-15 (fig. 2)

Infrared (IR) spectra can provide us will the detailed information about the structure of pectin substances. [2]. IR- spectra contain important information about the content and structure of substances, give an opportunity to determine the purity of the substance, relative and absolute quantity of free and bound carboxyl groups, presence of the ash component [2, 5]. IR spectra on investigation were taken of pectin substances extracted from the potato pulp in different conditions: with the preceding employment of amylolytic or proteolytic enzymatic agents and further by means of hydrolysis with employment of the chloride acid but without any enzymes. Spectrum of the pectin substances has a complicated structure (Fig. 3).

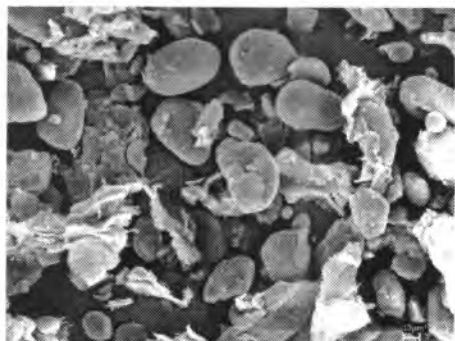


Fig. 1. Potato pulp (scanning electron microscopy)

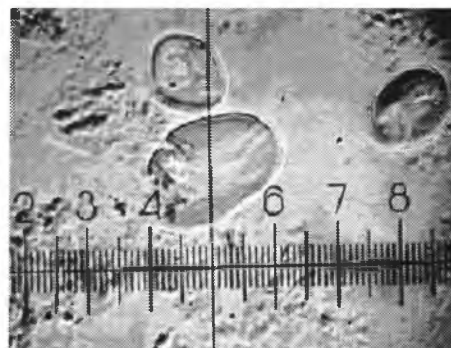


Fig. 2. Microphotograph of potato pectin (magnified 660 times)

Valence vibration of the hydroxyl group $\nu(\text{OH})$ belongs to the characteristic $3400 \dots 3200 \text{ cm}^{-1}$ band. This band manifests the presence of intermolecular hydrogen bond in the polymer structures. The stripes in the band of $2900 \dots 2700 \text{ cm}^{-1}$ correspond to the valence vibrations of the group $\nu(\text{CH})$. Deformation area of the water molecule $\delta(\text{H}_2\text{O})$ vibration is situated in the band of 1639 cm^{-1} . Inner deformational asymmetric vibration of $\delta_{\text{as}}(\text{CH}_3)$ take place in the band of 1460 cm^{-1} , symmetric – 1377 cm^{-1} [5].

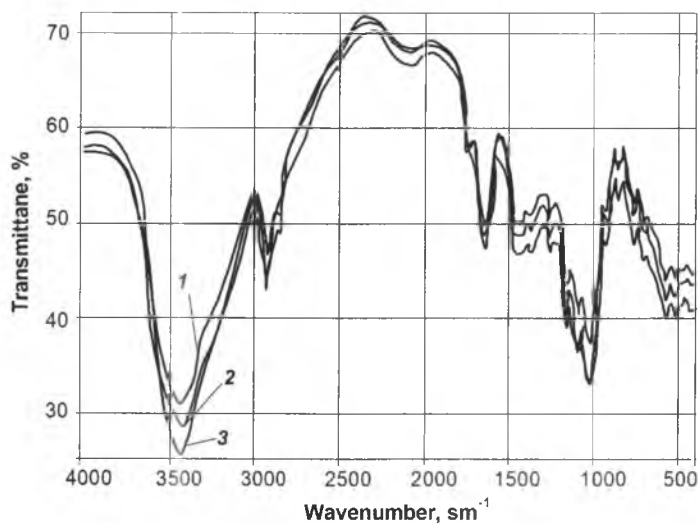


Fig. 3. IR-spectra of pectin samples from raw potato materials: 1 – without employing enzymatic agent; 2 – employing protease ; 3 – employing α -amylase

The band of $2000\text{-}1500 \text{ cm}^{-1}$ belong to the vibrations of the group $\text{C}=\text{O}$. Absorption is possible in this case, it is related to valence vibrations $\nu(\text{C}=\text{O})$ of carboxyl and carbonyl groups: ($1748\text{-}1739 \text{ cm}^{-1}$), ($1700\text{-}1680 \text{ cm}^{-1}$) [2].

Interrelation between the absorption intensity rates (corresponding these groups) can change depending on the bond type that prevails (ester, acid or ionic) [2].

The stripes of absorption are seen more clearly in the samples with enzymatic agents in the band of 1740 cm^{-1} , manifesting the presence of free carboxyl groups.

Conclusions

The potato pulp was investigated as a potential raw material for pectin extraction. The extracted potato pectin contains a considerable quantity of starch granules which are extracted and precipitated along with pectin substances.

There have been determined optimal conditions for the process of pectin extraction from the potato pulp: 1,45 % concentration acid to the hydrolysis weight, 70 minutes of hydrolysis at the temperature of 72 °C. Calculated parameters coincide with the data of former experimental investigations.

Infrared spectra of potato pectin confirm that it contains functional (carboxyl, hydroxyl and ester-bounded) groups in the molecule of this polysaccharide. The samples of pectin (got after processing the raw material with enzymatic agent) have a higher number of carboxyl and carbonyl groups, manifesting a partial hydrolysis of starch and protein and possibility of extracting pure pectin.

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