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PECTIN FROM GREEN KENAF BAST

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A technology is proposed for obtaining from kenaf bast and flax bast a food pectin the physicochemical indices of which correspond to proposed requirements.

In order to improve the nutrition of the people, particular attention must be devoted to expanding the variety of food products for prophylactic and healing purposes, which is achievable by the wide use of plant polysaccharides and pectin substances.

In view of the deterioration in the ecological situation on the territory of the CIS, the demand for pectin is increasing continually and considerably exceeds the volume of its production. In the states of the CIS about 300-350 tons of pectin is produced per year, which is explained by the low level of the technique and technology of existing factories. The bulk of the demand for pectin is covered by importation.

At the present time, an increase in the production of pectin is being hindered further by the inadequate supply of raw material to the factories. The traditional forms of raw material for the production of pectin are the peel of citrus fruits, sugarbeet pulp, and pomaces. The quality of the pectins from pulps and pomaces is somewhat inferior to that of citrus pectin. Furthermore, the conditions for collecting and storing pomaces and sugarbeet pulp are associated with certain difficulties and require the consumption of large amounts of energy [1].

Many scientific laboratories and centers are engaged in the search for other raw material resources for the production of pectin. Technologies for the production of pectin from sunflower heads, from the bark of coniferous trees, from tobacco leaves, and from other types of raw material have found no industrial application. Further improvement in these technologies is required.

One of the available nontraditional types of raw material consists of the wastes of cotton production – cotton bolls. At the present time a technology has been developed for obtaining food pectin from the valves of cotton bolls and design documentation has been drawn up for the construction of a pectin factory with a capacity of 100 tons of pectin per year [2]. In the Pakhta pilot plant (Tashkent Province, Chinaz region) about 2 tons of pectin has been produced, and more than 70 tons of fruit jelly has been made from it.

A number of wastes from the preserving industry, wastes from the production of plant drugs, from essential oil crops, and from forest and seed-producing enterprises form raw material for the production of pectin – for example, the agricultural wastes from white cabbage, onion skins, and carrot residues [3], cotton bolls [4], fig leaves [5], pomegranate rind [5], and wastes from food production [6] and from the processing of pulse, and other, crops. In the majority of cases, these wastes are destroyed or are fed to animals and poultry.

A new source of pectin-containing raw material has proved to be green kenaf bast. This raw material is a technical crop widely cultivated in regions of Central Asia. According to information from Uzlubprom [~ Uzbekistan Bast Industry], more than 16,000 tons of kenaf bast is manufactured for the need of the republic's textile sector, and this is processed by seven bast factories, each with a capacity of about 2-2.4 thousand tons per year.

A study of domestic, foreign, and patent publications has shown the absence of information on the isolation of pectin substances from kenaf bast. Preliminary laboratory work to establish extraction regimes and the physicochemical indices of kenaf pectin have served as a starting point for deeper investigations on the quantitative content of pectin substances and on the development of a technology for extracting pectin for food purposes.

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We have investigated the bast of kenaf, flax, and hemp for the presence of pectin substances. Kenaf bast was supplied by local bast factories, while flax bast was obtained from Kostroma, and hemp bast from Krasnodar. Kenaf and flax bast are produced in large quantities and, in the dry form, are stored in bales, which ensures a continuous supply of raw material to the bast factories.

The qualitative composition of kenaf bast is complex: cellulose, 55-60%; hemicelluloses, 6-8%; pectin subsances, 7-12%; lignin, 8-13%; phenolic compounds and melanin, 0.5-1.9%; protein, 1-1.5%; lipids, 2-3%; pigments, 2%; starch, 5%; and ash substances, 5-7% [7, 8]. Representatives of the Malvaceae family – the cotton plant, hollyhock, and kenaf -, which are the technical raw materials for the production of fiber, vegetable oil, and dyes, may simultaneously be a source of food pectin. In the leaves of the cotton plant up to 8.46% of pectin substances accumulates, in the stems 2.75-4.2%, and in the bolls up to 15% [9]. The hollyhock contains a glutinous polysaccharide in its roots and up to 20% of pectin in its petals after the extraction of a dyestuff, while kenaf bast contains 7-12% of pectin.

Kenaf bast is subjected to primary treatment that includes [10]: spreading (wetting with dew); water retting (cold and hot water); physicochemical treatment (steaming, boiling). After boiling, the kenaf bast corresponds to textile demands, and the fiber obtained remains strong. However, with this treatment, many valuable components, including the pectin, are leached out and are discarded with the waste waters. The discharge of these products adversely affects the ecological state of the local environment.

In the water retting of the raw material, the pectin substances undergo biological degradation, and on boiling with alkaline reagents they are converted into a water-insoluble form and cover the floor of reservoirs with a thick layer of gel. The composition of the gel includes hemicelluloses, starch, proteins, and other substances that have a deleterious influence on the vital activity of aquatic plants and animal organisms.

In the alkaline boiling of the bast with soda or other reagents having alkaline properties, pectins undergo degradation – demethoxylation and deacetylation – and are cleaved to form pectic acid. The pectic acid, on coming into contact with the mineral components of the aqueous medium, is converted into pectates, which can be present in an insoluble state for a long time. A similar transformation of other water-soluble substances is not excluded. Scientists at the Bast Institute have carried out a physicochemical digestion of kenaf bast with disodium phosphate [8], as a result of which they obtained pectin substances not satisfying consumer and food requirements.

We have extracted pectin from kenaf bast with various organic and inorganic acids and solutions of their salts, together with disodium phosphate [7]. The mean yield of pectin in all cases was 4-5%, its jelling power being 400-608 mm Hg and its ash content 1.5-5%. The use of an organic acid and a small amount of disodium phosphate made it possible to obtain pectin of consumer quality. A patent application has been based on the results of our work.

The physicochemical indices of kenaf pectin are close to those of citrus pectin and are better than those of pectins isolated from other nontraditional types of raw material: cabbage leaves, cotton bolls, onion skins, etc. The ash content of the pectin is 0.1-0.3%, the gel strength according to Sosnovskii 600-610 mm Hg, and the degree of esterification 46-48%.

Prepared confectionery articles (fruit jelly, candied peel, fruit and vegetable preserves) satisfied the demands set.

We have investigated kenaf pods, which contained 10-12% of pectin. The quality and indices of this petin were comparable with those of the pectin from the bast part of kenaf.

We have also investigated the pectin content of flax bast. The acid boiling of flax bast gave a 4% yield of pectin with a degree of esterification of 30-35%, a gel strength 550-600 mm Hg, an ash content of 0.8-1.0%, and an acetyl group content of 0.65%.

The technological scheme that we have developed provides for two-stage extraction with solutions of oxalic acid and disodium phosphate. Hydrolysis–extraction is carried out at 75°C with a raw material–extractant ratio of 1:10-15 for 60-120 min. Under these conditions the strengths of the kenaf and flax fibers remained at the required level.

The advantage of this technology over water retting is enormous: water consumption is sharply reduced, the necessity of water tanks for the retting of the raw material disappears; the ecology of the environment and of the working zone does not suffer; and the process is carried out in closed rooms, which improves the working conditions of the operatives. The technological water is recycled. The slimey wastes after the mechanical treatment of the bast and precipitation of the extract can be used for the gluing and fixing of laminated wood sheets obtained from kenaf tow.

With, as an example, the Dzhumabazar bast factory, which has a bast-processing capacity of 4031 tons, it has been shown that at an average yield of pectin of 3% it is possible to obtain 123 tons of pectin a year, which can satisfy the demands of the republic's food industry. A pectin factory or unit can be organically combined with the basic production of technical kenaf bast without great capital expenditure. The funds laid out in the reconstruction of an existing factory will be repaid in 1.2-1.5 years.

Thus, by the technology that we have developed, it is possible to obtain from nontraditional types of pectin-containing raw material — kenaf and flax basts — a low-methoxyl food pectin the physicochemical and consumer properties of which are comparable with those of citrus pectin.

EXPERIMENTAL

Initial raw material — green kenaf bast of the 1992 crop, GOST [State Standard] 18382-73, and flax bast of the 1993 crop from the Kostroma flax-processing factory.

Isolation of the Pectin Substances. The pectin substances were isolated from kenaf bast by hydrolysis—extraction using a two-stage scheme. Air-dry whole kenaf (1000 g) was washed with hot water for 30-45 min to eliminate mechanical impurities and dust. Then the swollen raw material was pressed out, transferred to an enameled vessel, and covered with a 0.3% solution of oxalic acid. Hydrolysis—extraction was conducted at 75°C for 60 min with periodic stirring.

After the end of extraction, the raw material was pressed out manually to separate the liquid phase and was covered with a 0.3% solution of disodium phosphate to execute the second stage of extraction at the same temperature for 60 min. Then the liquid phase was separated off, combined with the the first extract, filtered through coarse calico, and centrifuged at 6000 rpm.

The purified extract was concentrated in a rotary evaporator at 40-45°C to a dry-matter content of 4-5%. Coagulation of the pectin substances was achieved with acidified 96% alcohol at an extract—alcohol ratio (v/v) of 1:2. The coagulated pectin was separated by filtration through coarse calico on a Büchner funnel. The separated moist pectin was again treated with 96% alcohol at a ratio (w/v) of 1:1 and was again filtered on a Büchner funnel. The washing of the pectin with alcohol was carried out on the funnel until the reaction for chloride ions was negative. The pressed-out pectin was disintegrated and dried in a vacuum desiccator over P_2O_5. After the air-dry mass had been ground, 50 g of pectin was obtained.

The moisture, ash, and acetyl group contents and the gel strength of the pectin were determined by published procedures [11]. The moisture content of the pectin was 8%, the ash content 0.3%, the gel strength according to Sosnovskii 600-610 mm Hg, and the degree of esterification 46%.

Pectin substances were also isolated from flax bast by twofold extraction with a 0.4% solution of oxalic acid at a raw material—extractant ratio of 1:10-15. The yield of pectin was 4% (40 g), moisture content 8%, ash content 0.8%, acetyl group content 0.65%, degree of esterification 35%, gel strength 570 mm Hg.

Fruit jelly prepared in accordance with a standard recipe [13] using kenaf and flax pectins readily separated from the mold and gave a vitreous fracture. The consumption of pectin for preparing fruit and vegetable confectionery was 2 g per 1000 g of finished mass.

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