

Role of Citrus Pectin in Biological Activity: A Review

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Abstract

Pectin is a naturally occurring biopolymer. It has been used successfully for many years in the food and beverage industry as a thickening agent, a gelling agent and a colloidal stabilizer. In this review, study of the role of pectin polysaccharides, including its various pharmacological activity, such as its immuno-regulatory, anti-inflammatory, hypoglycemic, antibacterial, antioxidant and antitumor activities, have been summarized. The review provides natural sources, chemical structures, biological activities, and practical applications in the food industry as well as pharmacology and different branches of medicine. Pectin has become an essential part of the research and development of natural herbs and health products due to their wide availability.

Keywords: - *Citrus Pectin, Source, extraction, Biological activity, glycogen regulation.*

INTRODUCTION

French chemist Louis Nicolas Vauquelin in 1790 in tamarind fruit, discovered pectin in citrus fruits (Vauquelin, 1790). Henri Braconnot introduced the term “pectin” because of the gelling properties of these substances (Braconnot, 1825). Pectin is usually obtained from the

residues of plant material after extracting the juice (apple or citrus peel) or sugar (sugar beet). This review will first describe the source and production, chemical structure and general properties of pectin. Pectin is the methylated ester of polygalacturonic acid, contains 1, 4-linked -D-galacturonic acid residues.

STRUCTURE OF PECTIN

Pectin is a polysaccharide with a core consisting of α -1,4-linked D-galacturonic acid and α -1, 2-L-rhamnose, large number of neutral sugars, including arabinose, galactose, and lesser amounts of other sugars. The structural classification of pectin includes: homogalacturonan (HG), rhamnogalacturonan I (RG-I), and substituted galacturonans such as rhamnogalacturonan II (RG-II) (Figure 1). It composed of as many as 17 different monosaccharides and more than 20 different linkages. (Minzanova, Salima T et al. 2018)

GENERAL PROPERTIES OF PECTIN

Pectins are soluble in warm water.

Monovalent cation salts of pectinic and pectic acids are usually soluble in water; di- and trivalent cations salts are weakly soluble or insoluble. Dry powdered pectin, when added to water, has a tendency to hydrate very rapidly, forming clumps.

Most important use of pectin is based on its ability to form gels. HM-pectin forms gels with sugar and acid. HM-pectin, unlike LM-pectin, does not contain sufficient acid groups to gel or precipitate with calcium ions, although other ions such as aluminium or copper cause precipitation under certain conditions. (Rolin C 1993), (Hercules Incorporated 1999). (Raj et al. 2012)

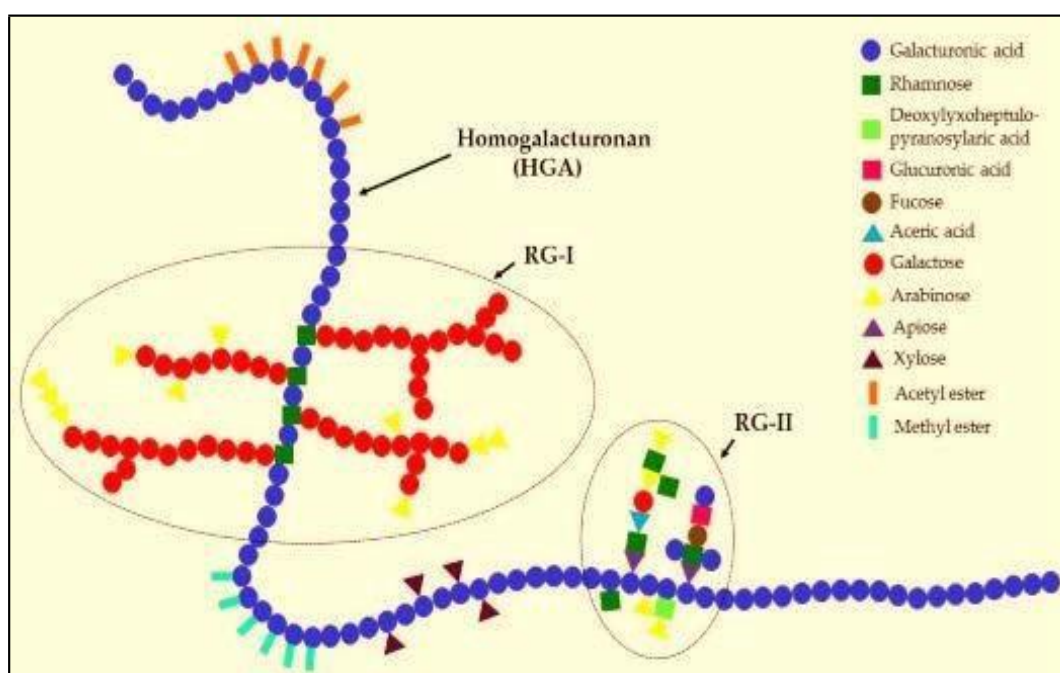


Fig.1. A scheme of primary structure of pectin

**METHODS OF
PREPARATION**

PECTIN

Sample Preparation

The samples (Cola milleni, Irvingia gabonensis and Theobroma cacao) peel and husk were sun dried for one week and making powder using blender. The powdered samples were sieved with a fine mesh of size 14mm. The sieved samples were kept in an air tight container prior to extraction process.

Extraction of Pectin (Oloye, 2013)

Extraction of pectin from the samples was performed under acid condition. The dried powder pectin was extracted by mixing with acidified distilled water inside a water

bath at different temperatures ranges from 50 - 100°C and different time from 30 – 150 mins. After contact time reflux, the samples were filtered through cheesecloth and cooled; it was then centrifuged for 20 mins at 3,500 rpm. Ethanol 96% was added to the supernatant and allowed to stand for one hour for pectin precipitation. The precipitated pectin was separated by filtration, washed thrice its volumes with absolute ethanol and washed twice with water to remove impurity. The extracts were separately dried in an oven at 50°C and the pectin yield was determined. The dried pectin samples were stored in aluminium foils at 4°C until used.

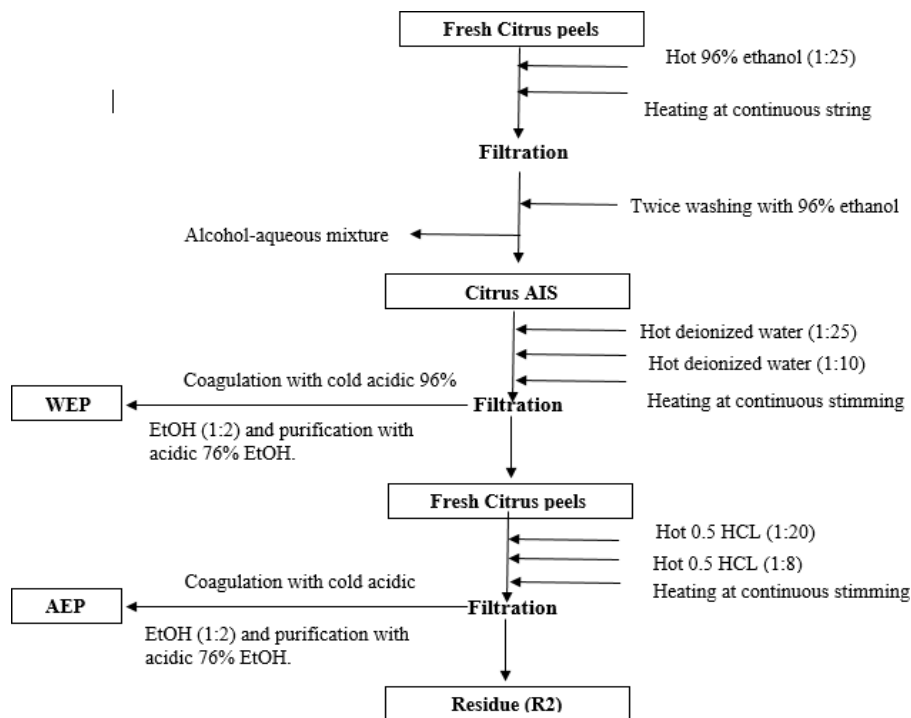


Fig.2. Preparation of pectin extraction from orange and lemon peels

Chemical Constituents: The neutral sugars that essentially form the side chains on the pectin molecules are namely: galactose, arabinose, xylose, and fructose. They also contain Saponin, Tannin, Alkaloid, Flavonoid, Steroid, Terpenoid, Glycoside and Phenol. (Oloye, 2013)

ROLE OF CITRUS PECTIN IN BIOLOGICAL ACTIVITY

Immunomodulatory Activity:

Immunomodulators are natural or synthetic substances that have a regulating effect on the immune system. Plant-derived polysaccharides, including pectin can directly activate the immune function of macrophages, promote the production of cytokines, and therefore regulate the immune system on multiple levels. The immunomodulatory activities of the oligomer fractions are still observed in the studies. Enzymatic digestion of pectin, which also show the value of the backbone of pectin.

The carbohydrate chain of pectin determines immunosuppressive activity. It was found that pectin containing more than 80% of galacturonic acid residues suppress the activity of macrophages and inhibit the delayed-type hypersensitivity reaction. In addition, the branched region

of the pectin macromolecule mediates the stimulation of phagocytosis and increased production of antibodies. (Popov & Ovodov, 2013)

Anti-inflammatory Effect:

Inflammation has been considered as a main risk factor for different progressive illnesses in human beings, such as neurological disorders, cancer, metabolic diseases, and cardiovascular disease, and a primary strategy to prevent these diseases is to target the reduction of chronic inflammation. (Leivas C.L et al., 2016) The intake of dietary fibers such as plant cell wall polysaccharides enhances the efficiency of treatment of inflammatory processes. Much attention has been focused in recent years on pectin.

Popov et al. has studied the anti-inflammatory activity of citrus pectin in vivo after oral administration in mice. (Popov S.V et al., 2013) Three models of inflammation were used: cytokine production by blood leukocytes in response to lipopolysaccharide, acetic acid-induced colitis, and endotoxin shock.

The results of the study demonstrate that low methyl-esterified citrus pectin inhibits local and systemic inflammation, while

pectin with a higher degree of esterification can inhibit intestinal inflammation.

Antioxidant Activity:

Oxidation is vital to plenty of organisms that can generate energy to supply biological processes. In normal circumstances, free radicals govern cell growth, and suppress viruses and bacteria. Nevertheless, in large quantities and without regulation, the production of free radicals induced by oxygen cause cell damage, which renders the pathological progressions. The oxidative stress is associated with chronic obstructive pulmonary disease, asthma, diabetes, inflammation, cardiovascular diseases, and myocardial infarction. (Wang, J et al., 2016)

Antitumor Activity:

Many in vitro and in vivo studies concerning the antitumor activity of native and modified pectin revealed a decrease of adhesion and cell proliferation, as well as the induction of apoptosis and migration. (Bush, P et al., 2014) Maxwell et al. have assessed pectin from different sources (potato, sugar beet, larch, and citrus) for effects against colon cancer cells. (Maxwell,E.G et al.,2015) Extracts of

potato pectin lowered the proliferation of colon cancer cells by the alteration of dose.

Sugar beet pectin extracts presenting various structures of pectin showed high anti-proliferative action against colon cancer cells. (Maxwell, E.G et al., 2016) The alkali treatment of pectin surged the antitumor activity of sugar beet pectin due to an apoptosis promotion. The pectic polysaccharide from apple can induce the death of cancer cells death and suppress the growth of tumors in vivo, as Delphi and Sepehri described. (Delphi, L et al., 2016)

Hypoglycemic / Anti-diabetic Effect:

Research was conducted to study the anti-diabetic effect of citrus pectin in diabetic rats and the potential benefits of citrus pectin to produce anti-diabetic effects in cases of T2DM caused by a low-dose streptozotocin and a fat-laden diet. Many tests have demonstrated that anti-diabetic polysaccharides effectively improve glucose tolerance.

Low-dose citrus pectin (500 mg/kg bw per day), the medium-dose citrus pectin (1000 mg/kg bw per day) and the high-dose

citrus pectin (2000 mg/kg bw per day) intragastrically administered.

Citrus pectin reduced fasting blood glucose levels, benefited hyperlipidemia, and refined hepatic glycogen content glucose tolerance in the diabetic rats. Citrus pectin modulated the expression of the basic proteins in the PI3K/Akt signaling pathway, which could have influenced the enhancement of insulin sensitivity in the diabetic rats, possibly by signifying the anti-diabetic effect of citrus pectin. (Liu, Dong, Yang, & Pan, 2016)

Neuroprotective Effect:

We investigated the neuroprotective activities of ginseng pectin (GP) against hydrogen peroxide (H₂O₂)-induced neuronal toxicity in different neuronal cells. GP protects neuronal cells from hydrogen peroxide-induced cell death. GP protects cortical neuron cell neurites from degeneration. GP neuroprotective effect occurs through the activation of ERK/MAPK and Akt survival signaling pathways. Ginsenoside Rb1 has been shown to protect neuronal cells against hydrogen peroxide-induced cell damage possibly by scavenging free radicals, inhibiting the production of nitric oxide,

preventing lipid peroxidation and avoiding decrease in SOD activity.

GP showed similar protective effects on neuronal cells against H₂O₂-induced oxidative stress via regulating the pro-survival ERK/MAPK and Akt pathways. Moreover, GP preserved the structural integrity of neurons, suggesting that it may be a new neurotrophin. In conclusion, GP appears to be anti-oxidant without side-effects, which may eventually lead to further development of therapeutics for neurodegenerative diseases. (Fan et al., 2012)

Glycogen regulation

Pectin decreased PKC (protein kinase-c) activity in liver and increased PKC activity in brain. (Kramer HK, 1997) Pectin also enhanced glycogenesis and reduced glycogenolysis. Activation of PKC stimulate the serotonin receptor or transporter in brain. (Vijayalakshmi, 2014).MCP prevents blood-brain barrier disruption possibly by inhibiting galectin-3.

DISCUSSION

Pectin structure provide significant immunomodulatory properties. However, future research studies necessary to verify

the immune activity in vivo and determine how the mechanisms of pectin affect macrophages and other immunocytes for safe clinical applications.

Studies of the antimicrobial properties of pectins show a general tendency for the development of nanocomposites and nanoemulsions on their base. Both exhibit noticeable inhibitory effects, mainly against Gram-negative *Escherichia coli* and Gram-positive *Staphylococcus aureus*. The analysis of the reviewed studies shows that pectin polysaccharides from various source demonstrate antioxidant activity. It was also shown that pectins of diverse chemical structure (HG, RG-I, RG-II) exhibit antioxidant properties. Hypoglycemic activity of pectins is useful for the development of low-toxicity antidiabetic agents.

Drugs based on dietary and medicinal plants don't cause side effects, which helps pectin promising for further research. Anti-inflammatory properties of pectin is given great attention in the literature, because pectin have a great potential for anti-inflammatory multi-purpose therapy. Another fast-growing field of pectin useful application is anti-cancer therapy, which is due to safety of pectin and its derivatives.

However, the lack of research on pectin polysaccharide protection mechanisms and clinical trials has limited the application of pectin in the field of medicine thus far.

CONCLUSION

Recently updated knowledge about Citrus pectin play beneficial role in various biological activity. Pectin extracted from Citrus fruits, *Cola milleni*, *Irvingia gabonensis* and *Theobroma cacao*. Pectin also enhanced glycogenesis and reduced glycogenolysis. Results of a study of the bioactivity of pectin polysaccharides, including its various pharmacological action, such as its immunoregulatory, anti-inflammatory, hypoglycemic, antibacterial, antioxidant and antitumor activities, Neuroprotective have been summarized.

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