

A Review: Different Extraction Techniques of Pectin

MDJC Sandarani*

Department of Food Science and Technology, Faculty of Livestock Fisheries and Nutrition, Wayamba University of Sri Lanka, Makandura, Sri Lanka

*Corresponding author: MDJC Sandarani, Department of Food Science and Technology, Faculty of Livestock Fisheries and Nutrition, Wayamba University of Sri Lanka, Makandura, Sri Lanka; E-mail: jayanichathurika69@gmail.com

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Abstract

Pectin is recently investigated for different applications in food industry, medicinal and pharmaceutical field. Extraction of pectin using different techniques have become a great challenge and yet to be discovered. Recent studies involving extraction of pectin using acids, microwave assisted and enzymes are reviewed, with the aim to capture the state of art on current research about pectin extraction. Extraction techniques have been discussed in related to different acids and enzymes.

Keywords: Acids; Enzymes; Extraction; Microwave; Pectin

Introduction

The complex hetero polysaccharide known as pectin is found in the primary cell wall of dicotyledonous plants and it is extensively employed as a gelling agent, thickener, stabilizer emulsifier and edible coating in food industry. It is made out of D-galacturonic acid, L-rhamnose, L-arabinose and D-galactose. They are linked by α (1 to 4) linkages [1-8].

There are two types of pectin depending on their Degree of Methylation (DM), pectin is referred to as high methoxy pectin (DM>50) or low methoxy pectin (DM<50). High methoxy pectin can form gels in an acidic medium (pH 2.0-3.5) if sucrose is present at a concentration higher than 55 weight %. Low methoxy pectin can form gels over a larger pH range (2.0-6.0) in the presence of a divalent ion, such as calcium [9].

Recovery of pectin is crucial unit operation in food industry in order to provide adequate supply for the growing demand [10,11]. Pectin is extracted at high temperature by hydrolyzing proto pectin in to pectin at commercial level, but there are novel perspectives in pectin production [12-21].

Conventional method is comprised with two main steps, hydrolysis of proto-pectin in to pectin using acids and subsequently precipitated by ethanol [22-24]. However, acid treatments have several draw backs, due to that, novel methods such as Microwave Assisted Extraction, enzymatic extraction, supercritical water extraction and ultra sound extraction have become more popular [25-28]. Microwave Assisted Extraction exhibits large handling capacity, short processing time and good purity. Enzymatic extraction exhibits mild conditions, low energy consumption and no pollution [29-31].

Pectin structure, uses and applications were extensively reviewed [32-34]. However, there are limited review articles based on different extraction techniques of pectin. The main purpose of this article is to highlight about extraction techniques of pectin.

Acid extraction of pectin

Pectin has been extracted using chemical methods in order to examine the structural features and functional properties of pectin. The chemical agents used for pectin extraction are divided into four groups. They are water and buffers, calcium-ion chelators, acids and bases. Acids are the strongest extracting agents of pectin as they facilitate extraction of insoluble pectin that is tightly bound to the cell matrix of the plant material and result in higher yields [35-37].

Pectin is generally enriched in galacturonic acid. Various studies have shown the effects of acid extractant strength on yield of pectin, chemical, and/or physicochemical characteristics [38]. Most commonly used acids are acetic, citric, lactic, malic, tartaric (organic), hydrochloric, nitric, oxalic, phosphoric and sulfuric acids [39-41].

It has found that an increase in acid strength (that is, decreasing pH) plays an important role in increasing the galacturonic acid content. Moreover, acid type and concentration affect the yield, physicochemical and functional properties of pectin [42,43]. In contrast, some of the results of studies are contradictory [44].

Hydrochloric acid shown to be the highest yield of pectin among hydrochloric, nitric and citric acid extracted from guava peel, citrus fruits, banana and cocoa pods. pH and temperature ranged from 1 to 3 and 60°C to 85°C sequently [45-48]. Presence of high concentration of hydrogen ions, stimulate the hydrolysis of pectin from proto pectin. Higher ionic strength acids have an improved capability to precipitate pectin due to their higher affinity for cations such as Ca^{2+} which stabilizes the pectin molecule. However, hydrochloric acid produced pectin with a smaller DM range in which LM pectin [49]. In hot acid media pectin can be degraded rapidly due to high lability and sensitivity for acid. Therefore, Pectin extracted using hot acid is low methoxylated due to demethylation and fragmentation of the polygalacturonic chain. Moreover, LM pectin occurs in a broad pH range, at most up to pH 6 [50-53].

Nitric acid is also used commonly to acidify hot water in order to extract pectin. The pectin yield increased with increasing extractant strength of nitric acid. The highest yield (10.9%) was obtained as the extractant strength was increased up to pH 1.2 from cinnamon [54].

Sulfuric acid has reported the highest yield for pectin extracted from dragon fruit peels [1]. In addition, highest yield were reported for sulfuric acid among hydrochloric, acetic and benzoic acid for Moroccan Orange peels [55]. In contrast, some studies have reported that there is no significant effect of type acid on the yield of pectin from apple [56].

Lowest yield were reported for the citric acid. Some studies had reported that acid type strongly influenced the macromolecular and gelling properties of isolated pectin. It also reported that citric acid is the least pectin degrading (depolymerizing and de esterifying) extracting agent. Citric acid can be used to isolate pectin with better gelling properties. However, some studies suggested the use of citric acid because of its higher yield and better quality than other acids [57,58].

The yield of ambarella pectin extraction varied from 16% to 22% dry weight of AIR, depending on the extraction condition used. The highest yields were obtained with Oxalic Acid/Ammonium Oxalate (OAAO) and the lowest with water [59].

Microwave extraction of pectin

Microwave Assisted Extraction involves dielectric heating of plant molecules through the exposure of microwaves. Dipolar rotation of water is taken place due to the absorbance of microwave energy, which leads to generation of heat inside the plant tissues. Microwave-Assisted Extraction (MAE) has been recently investigated by many researchers and found that it can lead to a considerable increase in the yield and quality of extracted pectin [60-62].

When orange peels are subjected to microwave radiation, there is inactivation of pectin esterase enzyme and destruction of orange skin cells due to rapid heat generation in microwave environment [63]. Since the pectin esterase interacts with the pectic substances in the orange peels and reduces their solubility, their inactivation improves the pectin extraction. Moreover, due to the disintegration of parenchyma cells, there is also increase in specific surface area, which facilitates the water absorption capacity of the plant cell. It has been used to reduce extraction time and energy [64,65].

When increasing the microwave power pectin yield has been increased due to the increase in microwave irradiation energy, the penetration of solvent into the plant matrix can be enhanced and can efficiently deliver to plant cells for pectin extraction. Molecular interaction with the electromagnetic field offers a rapid transfer of energy to the solvent and matrix, allowing the dissolution of components to be extracted. As a polar solvent, water can efficiently absorb microwave energy and leads to efficient heating. Moreover, the microwave irradiation accelerates cell rupture by sudden temperature rise and internal pressure increase inside the cells of plant sample, which promotes the destruction of sample surface and in turns the exudation of pectin within the plant cells into the surrounding solvents and increase [66,67].

The increasing micro wave irradiation energy can enhance the penetration of solvent in to the plant matrix and deliver efficiently to materials through molecular interaction with the electromagnetic field and offer a rapid transfer of energy to the solvent and matrix, allowing the dissolution of components to be extracted.

Water can efficiently absorb microwave energy and leads to efficient heating as it is a polar solvent. Moreover, the microwave irradiation accelerates cell rupture by sudden temperature rise and internal

pressure increase inside the cells of plant sample, which promotes the destruction of sample surface and in turns the exudation of pectin within the plant cells into the surrounding solvents and increased the extraction yield [68]. Similarly, optimization of extraction process of pectin from apple pomace using Microwave Assisted Extraction, found to be the highest yield from apple pomace and also lower extraction time when compared to conventional heating [69].

In contrast, there is no any significant difference in yield and quality characteristics extracted from both conventional extraction and Microwave Assisted Extraction except moisture and ash content. Increase in microwave power did not affect yield and quality characteristics of pectin from jackfruit rinds [70].

In addition, pectin extracted using traditional method is not only poor in term of quantity but also quality in which prolonged exposure of pectin to the heat treatment during extraction leads to pectin degradation [71].

Enzymatic extraction

Plant cell wall is composed of an entangled network of different polysaccharides including pectin. Cell wall degrading enzymes with minimum pectinolytic activity are used to hydrolyze non pectin plant cell wall components in enzymatic extraction of pectin [72,73].

Enzymatic extraction of pectin is environmentally safe and more effective in terms of pectin yield. Different enzymes such as polygalacturonase, hemicellulose, protease and microbial mixed enzymes, cellulose, α -amylase, cellulase, alcalase and α -amylase and neurase, Xylase, cellulose, b-glucosidase, endopolygalacturonase and pectinesterase are used in pectin extraction as enzymes have the ability to degrade pectin and modify the physicochemical properties of the pectin [74-82].

Cellulase enzyme

Cellulase enzyme has been used for isolation of pectin from chicory roots and cauliflower and has shown positive effects towards hydrolyzing of cellulose from the cell wall and releasing of pectin from the cell wall [83].

Use of the cellulase led to the biggest yield and Poly Galacturonic Acid (PGA) content in pectin extracted from pumpkin due to the degradation of the cellulose matrix. Furthermore, pectin was extracted from pumpkin using an enzyme complex which contained cellulase has given the highest yield (14% on dry weight basis) due to degradation of cellulose matrix and other insoluble constituents of the plant cell wall. In contrast, it is believed that it has a pectinesterase activity, which could have an effect on degree of esterification [84].

Polygalacturonase enzyme

Polygalacturonase have been used to extract pectin from apple and pears and observed a great performance in yield which indicates a higher affinity of the PGI enzyme for this substrate. Yield of pectin was 20% and 60% higher than with chemical extraction for apple and pears respectively. These results indicate that pear pomace seems to be a better substrate for pectin enzymatic extraction rather than apple pomace [85].

The commercial enzyme used originates from a selected strain of *Aspergillus niger* and has mixed activities of pectinlyase, pectinesterase and polygalacturonase. Pectin yield from cladodes is not significantly

different between enzymatic extraction and classical method. But it offers lower extraction temperature and easier treatment of purification of the effluents [86].

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