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ALTERNATIVE PECTIN PRODUCTION METHODS AND SOURCES

Melih GÜZEL[1*], Nedra TEKTAŞ TAŞAN[2], Özlem AKPINAR[3]

[1]Department of Food Processing, Gumushane University, Şiran Mustafa Beyaz Vocational School, Gumushane Turkey
[2, 3]Department of Food Engineering, Tokat Gaziosmanpaşa Universty, Tokat, Turkey
*Corresponding author: melihguzel010@hotmail.com

ABSTRACT

Pectin is a polysaccharide, found in the cell wall of high plants that imparts flexibility and mechanical strength to plants by interacting with other cell wall elements. It is widely used in the food, cosmetic and pharmaceutical industries, as thickener, texturizing, emulsifying, stabilizing and gelling agent. The most commonly used method for pectin production is the acid extraction method. Due to the low extraction efficiency with limited yield, many methods have been developed such as enzyme, microwave and ultrasound-assisted extractions and subcritical water extraction. Pectin is commercially produced from mainly citrus peels followed by apple pomace, sunflower head and sugar beet pulps and the properties of the pectin depend on the source that are isolated from. Finding alternative sources methods are necessary that can compete with the production cost and properties of the commercial pectin sources. In this study, alternative pectin production methods, pectin sources and possibilities for the industrial use of the pectin produced with them were reviewed.

Keywords: *Extraction methods, Pectin sources, Food waste, Pectin properties.*

INTRODUCTION

The pectic components found in plants were first identified by French chemist Louis Nicolas Vauquelin in 1790 and isolated in 1825 by French chemist Henri Braconnot. Pectin is a multifunctional component of a cell wall, a high-value functional food component used as a gelling and stabilizing agent (Georgiev *et al.*, 2012) It is composed mainly of an α-1,4-D-galacturonic acid residue. It is water-soluble and can form a gel with sugar and acid under favorable conditions. It is present in different fruits and vegetables in different qualities and amounts (Arslan, 1994) and the properties of the pectin depend on the source that are isolated from.
This study covers alternative pectin production methods, pectin sources and possibilities for the industrial use of the pectin produced with them.

Pectin and Structure

Pectin is a structural heteropolysaccharide that is naturally found in the cell walls and intercellular regions of plant tissues. It plays an important role in the growth and development of the plant and provides mechanical resistance to the plant (Zhang *et al*., 2013). It coexists with hemicellulose and cellulose in the primary cell wall of plants (Buggenhout *et al*., 2009) (Figure 1).

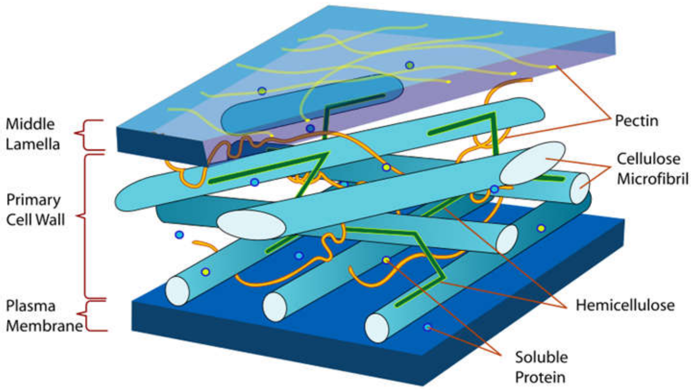

Figure 1. The position of pectin in the primary cell wall model (Anonymous, 2019).

The pectin molecule consists of four basic structures: homogalacturonan, ramnogalacturonan I, ramnogalacturonan II and xylogalacturon (Willats *et al*., 2001) (Fig. 2). The galacturonic acid units of pectin are partly esterified with methanol. Amount with less than 50% is named as low methoxyl pectin and above 50% is named as high methoxyl pectin. The gelling rate of pectin depends on the degree of esterification, and as the degree of esterification increases, the rate of gelling increases. Gelling rate is an important parameter affecting the texture of the food product. High methoxylated pectin forms gel with high amount sugars (more than 50%) and acid, while low methoxylated pectins form gel with multivalent cations (such as Ca^{+2}, Mg^{+2}) at low sugar concentrations (Arslan, 1994).

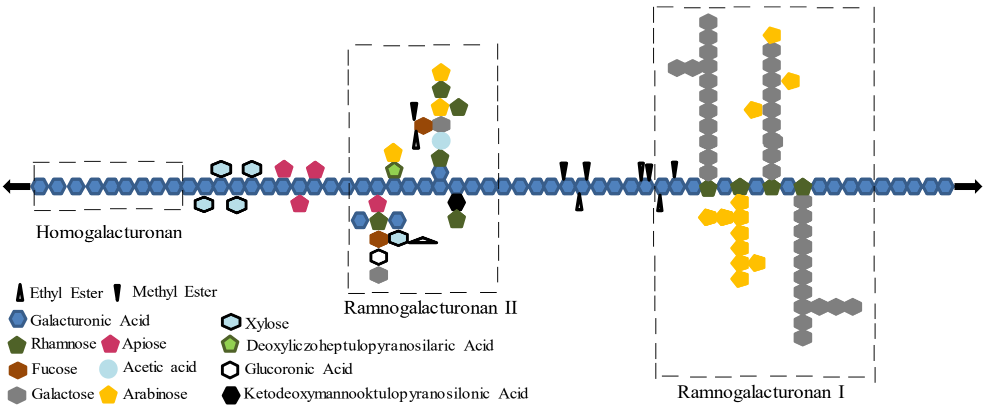

Figure 2. Structure of pectin (Harholt *et al.,* 2010)

Pectin Resources

Pectin is found in the most of plant tissues, but the amount for the production of it is not sufficient for all plants. In some plants, it is found in high amount, but pectin is not suitable for food use. The most important pectin sources are apple pomace, citrus peels, sunflower head and sugar beet pulp. Among them citrus peels are mostly used as a raw material in pectin production due to its high quality, high yield and widespread availability (Yıldırım, 2013). However, alternative sources; cocoa husks (Chan and Choo, 2013), mulberry branch bark (Liu *et al*., 2011), sisal wastes (Santos *et al*., 2015), watermelon peel (Prakash *et al*., 2014), orange, apple, pomegranate, melon and kiwifruit peels (Güzel and Akpınar, 2019), pumpkin (Ptichkina *et al.*, 2008), banana peels (Oliveira *et al*., 2016), potato pulp (Yang *et al*., 2018), wolf apple (*Solanum lycocarpum*) (Torralbo *et al*., 2012) and carrot pulp (Wikiera *et al*., 2015; Jafari *et al*., 2017) are also being investigated for pectin production. The pectin yields obtained from different sources are summarized in Table 1.

Table 1. Pectin contents of some fruits and vegetables

Source	**Pectin (%)**	**References**
Orange peel	2.95, 11.46, 28.27	Georgiev *et al.,* 2012; Güzel and Akpınar, 2019; Hosseini *et al*., 2019
Apple	14.5	Wikiera *et al.,* 2015
Banana	5.2-12.2	Oliveira *et al.,* 2016
Sugar beet	22.4	Mesbahı *et al.,* 2005
Pear	0.9-1.4	Çelik, 2007; Baker, 1997
Tomato	2.4-4.8	Çelik, 2007; Baker, 1997
Strawberry	0.6-0.7	Çelik, 2007; Baker, 1997
Carrot	5-15.2	Jafari *et al.*, 2017
Melon rind	6.54	Güzel and Akpınar, 2019
Kiwifruit peel	8.03	Güzel and Akpınar, 2019
Grapefruit peel	20.93-27.51	Wang *et al.,* 2015; Taşan, 2018
Pomegranate peel	3.92 -11.18	Pereira *et al.,* 2016; Güzel and Akpınar, 2019
Artichoke (*Cynara scolymus L.)*	22.14	Sabater *et al*., 2018
Pomelo (*Citrus grandis(L.) Osbeck*)	19.6	Liew *et al.,* 2018

Pectin Production Methods

Pectin production consists of the extraction of it with the acid and precipitation of it with alcohol followed by filtration, purification, drying and grinding (Yıldırım, 2013). The most important factor affecting the yield and quality of pectin is the extraction stage, especially acid type, pH, time, temperature, solvent/solid ratio, solvent type, raw material and particle size (Perussello *et al.,* 2017). In the conventional acid extraction method, pectin is extracted using different acids (sulfuric, nitric, citric, phosphoric, acetic or hydrochloric acid) at an extraction temperature of 80-100°C and concentrations of 0.05-2M (Georgiev *et al.,* 2012). Although acid extraction is economical, the acids used in the extract can damage the pectin structure and cause environmental problems. In addition, during pectin extraction, the yield and quality of pectin decrease depending on time and temperature (Adetunji *et al.,* 2017). Pectin depolymerization is occured more in extraction of it with mineral acid than extraction with organic acid. For this reason, different extraction methods are investigated to isolate the pectin with high yield at low temperatures and in short time with less or no acidic solvent use (Min *et al.,* 2011). Ultrasound-assisted extraction, sub-critical water extraction, microwave-assisted extraction, enzymatic extraction are some of them.

Enzymatic extraction of pectin has become research interest in the last years (Puri *et al.,* 2012). There are two approaches for the enzymatic extraction of pectin. These are the isolation of pectin by the use of pectin degrading enzmeys, and the isolation of pectin by cell wall degrading enzymes such as cellulases, amylases, hemicellulases and arabanases. However, the second approach is more common for the enzymatic pectin extraction. Enzymatic extraction is an environmentally safe method. It produces less waste problems than the conventional method, enzyme are specific and, the structural and functional properties of the extracted polysaccharides are retained better. The molecular weight of the released polymer is higher than the pectin obtained in the classical method. It also reduces the need for specific pre-treatment steps in (eg removal of sugars and color pigments) (Adetunji *et al.,* 2017). There are some problems for the industrial use of enzymes in the pectin production. The first is the cost of enzymes. The other one is the difficulty of the scale up the extraction process because different enzymes have different responses to environmental conditions such as temperature and food matrix. In addition, the extraction process is longer than the classical method (Adetunji *et al.,* 2017). In previous studies, it was found that pectins extracted by enzymatic method had more galactronic acid than pectins extracted with acids, had higher methylation degree (Wikiera *et al.,* 2015) and had higher yields (Sabater *et al.,* 2018). In other studies (it was determined that pectins with high yields and superior properties were obtained by enzymatic extraction Ptichkina *et al.,* 2008; Min *et al.,* 2011; Yang *et al.,* 2018).

Subcritical water is liquid water at high pressure, which can reach temperatures higher than the normal boiling point without a change phase. Subcritical water extraction is also known as pressurized hot water extraction. High temperatures help to break down analyte-sample matrix interactions such as van der waals forces, hydrogen bonding and dipole attraction, and increase extraction by accelerating extraction kinetics (Adetunji *et al.,* 2017). The disadvantages of this method are the hydrolysis of the pectin chain during extraction, the difficulty to control the process conditions, the dependence of the yield on the matrix and the high process costs (Adetunji *et al.,* 2017). However the method is fast and environmentally friendly. It was reported that the pectin yields by this method were

higher than by conventional and microwave pectin extraction methods and the pectins had better physicochemical, rheological and gelling properties than the others (Wang *et al.,* 2014).
Ultrasound assisted extraction method provides faster heat-mass transfer and low solvent usage. In addition, this process has many advantages such as low energy consumption, low extraction temperature, selective extraction, small equipment size, faster operation and elimination of some process steps used in conventional extraction steps. However, ultrasound assisted pectin extraction is an expensive system and the yield varies according to the materials used. Although ultrasound has started to be used in many fields, it is not widely used in the food industry due to its high investment costs (Adetunji *et al.,* 2017). In studies, it was determined that non-continuous ultrasound application provided higher efficiency than continuous ultrasound application (Bagherian *et al.,* 2011), this method increased the yield of pectin compared to the classical method and reduced extraction time without changing the pectin microstructures (Wang *et al.,* 2015).
Microwave assisted pectin extraction is a method applied in electromagnetic waves ranging from 0.3–300 GHz (Wang *et al.,* 2016). During microwave assisted extraction, microwaves pass through the plant tissue, the absorbed energy produces volumetric heating from the dipole rotation of polar molecules such as water, which causes vibration as there is molecular collision, leading to heat generation inside the plant tissue (Kute *et al.,* 2015). The most important advantages of this method are less solvent usage, less extraction time, high yield and lower energy consumption (Maran *et al.,* 2013). In this method, pectin extraction is affected by many parameters such as plant material, solvent type and volume, pH, microwave power, temperature, time (Košťálová *et al.,* 2016). When the studies were examined, it was determined that the extraction time was shorter compared to other methods and the increase in microwave power increased the pectin yields. In the studies, it was founded that the yields decreased at microwave power higher than 420 W (Maran *et al.,* 2015). It was also stated that during this method there was a risk that other polysaccharides could be extracted, so the method had to be improved (Kazemi *et al.,* 2019).

CONCLUSIONS

Commercially the most important pectin sources are citrus peels, apple pomace, sunflower heads and sugar beet pulps. Studies have also showed that high amount of pectin can be extracted from different food wastes such as fruit and vegetable peels. The use of food waste as a pectin source can reduce the pectin production cost and the disposal of the waste. Recently alternative pectin production methods have been developed for the shortening the process time and reducing the chemicals used in the extraction. Among them microwave and enzymatic assisted extractions are the most promising methods due to high pectin yield, less solvent, temperature and energy requirement, low extraction time and consequently less damage to pectin structure.

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