

**Review article****Potato Peel Pectin as a Valuable Product: A Review****Israa Maan Ahmed<sup>1</sup>, Ali M. Saadi<sup>2\*</sup>**<sup>1</sup>Food Science Department, College of Agriculture and Forests, University of Mosul, Mosul, Iraq<sup>2</sup>Department of Animal Production Technologies, Technical Agricultural College, Northern Technical University, Mosul, Iraq.\*Corresponding author E-mail: [ali.mohammed@ntu.edu.iq](mailto:ali.mohammed@ntu.edu.iq)DOI: <https://doi.org/10.71428/PJS.2026.0111>**Abstract**

As an organic waste product that is disposed of in large volumes worldwide, potato peels constitute an abundant and imposing environmental predator. This consequently is strategically significant research, which is a fresh perspective to re-examine them as an alternative and sustainable source to extract pectin. The aim of this review is to provide an overview of the use of potato peels as a feedstock for pectin production, which is in agreement with the international trends toward the circular economy and less industrial waste. To this end, the review investigates the chemical and physical strategies available for extracting pectin and converting this environmental liability into a product of enhanced economic value. This section includes the comparison between traditional extraction technologies based on mineral acids and novel technologies such as enzyme-assisted extraction or other extraction methods like ultrasonic extraction, and their effect on the functional properties of the end-product. It also points out the technical difficulties in the structural composition and the degree of esterification of potato pectin, which is unlike conventional sources (citrus) pectin. In light of the scientific evidence they analyzed, the study states that potato skins are a strategic resource with the potential to bridge gaps in the food and pharma additive supply industry. The summary ends with a vision for future research focusing on achieving an optimal economic return while underlining the importance of using industrial processes as efficiently as possible without exceeding the minimal environmental footprint.

**Keywords:** Pectin extraction, potato peels, organic waste, sustainability, functional properties.**Introduction**

Potatoes are an important food crop as both a low-cost staple food for many populations and an input for other food industries. They are tuberous edible plants coming from the Andes Mountains in South America (1). The Spanish brought potatoes to Europe in the 16th century, from where this food crop dispersed to become one of the most important tuber vegetables in terms of global food security, as they are highly productive. The main part of the potato is made up of complex carbohydrates (starch) and significant amounts of vitamin C, potassium,

and dietary fiber (particularly if the skin is eaten) (2). In addition to that, they are found to be rich in both carotenoids and phenols, both of which protect the cells against oxidative stress while lowering the chance of chronic diseases (3).

This crop encounters large environmental challenges since its production process must be monitored to control against fungal pathogens such as *Phytophthora infestans* that led to severe famines in the past (4).

To keep pushing the limits of potatoes as an important pillar of global food security, scientists

now use genetic engineering and hybridization techniques to create strains that are more resistant to climate change (5).

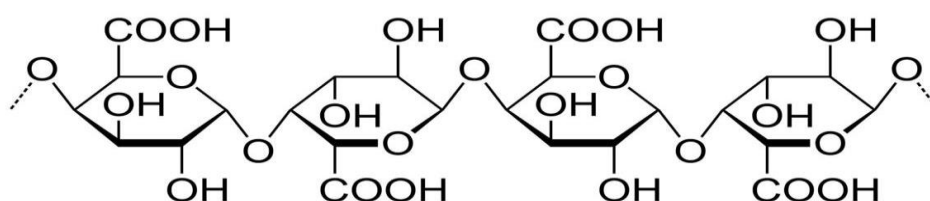
### Pectin

Pectin is one of the most complex structural components that gives plant cell walls flexibility and the ability to withstand mechanical stress (6).

### Chemically

Pectin is a polymer of polysaccharides consisting of linked units of galacturonic acid, and its properties

vary according to the degree of ripeness of the potato. Extracting pectin from potato peels is a recent trend towards sustainability. These peels contain pectin in the form of complex pectin chains that contribute to strengthening the external structure of the tuber (7). Unlike citrus fruits, potato pectin has a unique molecular structure that makes it ideal for developing edible biopackaging, given its high ability to interact with the starch remaining in the peel (8).



## Pectin

Poly- $\alpha$ -(1 $\rightarrow$ 4)-galacturonic acid – Section of the pectin main chain

Figure 1. Pectin structure (9)

### Galacturonic Acid Content

This equation is used to estimate the chemical “purity” of extracted samples, measuring the weight percentage of the basic structural component of pectin. High values in this equation indicate that the extraction and purification process was accurate and resulted in the isolation of pectin from the rest of the polysaccharides and accompanying proteins in potato tissue (10).

### Ash and Moisture Content

The final aspects for the physical characterization of pectin are the ash content, which determines the carbonated minerals and inorganic impurities that are typically left in the final product, expressed in percentage by weight after its combustion, and the moisture content, which is important to assess the dryness and storage stability of the final product.

These estimates normally follow FDA or FAO guidelines that have been designed to demonstrate that such a product is safe for consumption (11).

### Degree of Esterification (DE)

This value, expressed as a percentage (ranging from 0% to 100%), identifies the percentage of carboxyl groups in the pectin that is esterified with methanol, compared to the total number of pectin chains in the form of galacturonic acid, thereby driving the rheological characteristics of this polysaccharide (Del Río et al.). Then, in the laboratory, a two-step titration method using sodium hydroxide (NaOH) is used to extract this value, firstly against the free groups and then saponification against the esterified groups. This equation is fundamental for the classification of pectin, being classified as high-methoxyl (HM) pectin if the value is above 50%,

while with low-concentration of sugar in the gel (12).

### **Extraction process**

To obtain this bioactive component, the husks are dried and powdered, and then soaked in a solution of weak acids like citric acid and subjected to acid hydrolysis (13).

Heat cleaves the covalent pectin-cellulose bonds so that the molecules go into solution in the aqueous phase, after which the pectin-rich liquid can be gently filtered (10). Subsequently, it is precipitated from water-alcohol, adding the ethanol with high concentration to the extracted solution, where the pectin appears as white gelatinous fibers, and they are then separated and oxidized (dried) (14).

### **The importance of pectin in food manufacturing**

The significance of this is based on its better performance in the control of rheology or fluid behavior, acting as a stabilizer that prevents the segregation of components in natural drinks and juices (15).

Another key industrial property, and probably the most important from a functional point of view, is believed to be the ability of pectin to impart a gel microstructure, as it can create a three-dimensional structure that can bind water molecules in a manner to provide the desired uniform texture and glossy appearance in a jam or dessert (16). Pectin is further applied in the dairy industry as stabilizers of protein, which inhibits casein protein coagulation in sour dairy drinks, providing a permanent homogeneous state without sedimentation (17).

Pectin serves as a dough improver in baked goods, sustaining the moisture in the baking product and prolonging its shelf life as well as preventing the bread or cake from quickly becoming dry (18).

It is also the prime source for the development of functional and low-calorie food, where it acts as a natural fat substitute in sauces and in ice cream for

the addition of creaminess without adding to the calorie content (19).

Likewise, pectin has robust opportunities in biopackaging, where it can be utilized to produce thin edible films of pectin to wrap fruit and meat to significantly limit weight loss and prevent food from oxidation and microbial contamination (20).

### **Environmentally friendly extraction techniques**

Comparative studies between old and new techniques, like ultrasound-assisted extraction, have shown that this method helps to minimize the time of the process and solvent consumption and also increase the purity level of pectin and its ability to bind with water in food systems (7).

### **Study of efficiency in drug delivery systems**

Potato pectin has also been shown to be a drug carrier in medically-relevant studies. This type of pectin generates good transportation property for drug molecules due to its resistance against any digestive enzymes in our small intestine (21).

### **Comparison with apple pectin**

Research indicated that potato pectin has a lower degree of methylation than apple pectin; it needs a higher quantity of calcium ions to form a gel, which provides broad prospects for the functional food industry for diabetic and obese patients (11).

### **Factors affecting extraction**

Extraction depends on several factors:

#### **1- pH**

Hydrolysis is mainly dependent on combined ion concentration, as hydrogen ions can destabilize the covalent bond between pectin and the cell wall of the plant. Higher acidity also increases the rate of extraction, although it can also result in the destruction of negatively charged acid molecules that lead to a lower quality pectin (22).

#### **2- Temperature**

plays a dual role: it increases the solubility of pectin in an acidic medium and enhances the permeability of the solvent into the peel tissue, facilitating the

release of polymers into the solution. However, exceeding temperatures of 90°C for long periods may lead to thermal degradation, where the pectin chain loses its length and ability to crystallize (7).

### 3- Extraction time

Time is directly related to the amount of pectin extracted up to a certain point called the equilibrium point, where most of the soluble pectin is depleted from the husks. Continuing to heat beyond this point does not increase the yield, but rather contributes to the appearance of unwanted impurities and increases the darkness of the extracted pectin as a result of Maillard reactions (13).

### 4- Solvent to solid ratio

The ratio of liquid to mass in the husks influences the strength of the gradient. More solvent can extract those decomposed molecules from the solid, out of the solid's surface. An optimal ratio needs to be selected economically, as a high positive ratio will decrease the quantity of alcohol that will be needed to be utilized later during the precipitation stage and gas stage, thus saving energy costs for evaporation (11).

### 5- Type of acid solvent

The behavior of strong acids like HCl is different from that of weak acids such as citric acid, as the former lead to a higher yield in a shorter time, at the expense of structural changes to pectin. Instead, researchers have opted for organic acids at times because, in general, they are milder on the polymer structure and are seen as safer and more environmentally friendly (10).

### Pectin efficiency equation

These are the first metrics for the success of the extraction process mathematically. The equation describes the mass of pectin received after final drying on the dry weight of the raw material (potato peels). It is mathematically expressed to mirror the efficiency of the acid solvent to cleave linkages within the cell wall and liberate polymers (8).

## Uses of pectin

### 1- Food Industry and Texturization

Pectin tops the list of the most sought-after natural additives in the food manufacturing sector, where it is mainly used as a gelling agent and texture stabilizer in the manufacture of jams and sweets. Since potato pectin tends to be low in methoxyl, it is an ideal choice for diet foods (low in sugar) due to its ability to form a cohesive gel network in the presence of calcium ions without the need for high concentrations of sugars (23).

### 2- Advanced Pharmaceutical Drug Delivery Systems

In the pharmaceutical area, pectin is used in the development of controlled drug delivery systems as a promising biopolymer. It is relatively stable in the stomach's acidic medium, and the bacteria of the colon degradability allows it to be applied as a carrier for large intestine drug delivery systems, thereby (colon-specific drug delivery). Pectin protects the active principle from digestive juices and directs them to the desired areas. So, side effects are reduced, and treatment becomes more effective (24).

### 3- Bio-packaging and Edible Films

Given global initiatives to minimize reliance on plastics, pectin is an ideal material for the development of environmentally friendly films. They offered favorable mechanical properties in addition to oxygen barrier performance, making them suitable for preserving sensitive foods from oxidation. These films can also be incorporated with antimicrobial compounds or antioxidants isolated from potato skins y to form "active packaging" (20).

### 4- Stability of dairy and acidified drinks

Because pectin prevents the aggregation and precipitation of casein proteins at low pH values, it is an important stabilizer of acidified dairy drinks. Pectin binds protein molecules through electrostatic interaction to maintain a homogeneous product with a smooth texture and an appealing appearance to

consumers, as it is one of the most important ingredients in the yogurt and functional beverage industries (25).

### 5- Bakery Products Enhancement

Pectin enhances gluten matrix elasticity and water-absorbing capacity of the dough in bakery dough. Of course, this means more loaf volume and a softer crumb. Moreover, pectin retards starch retrogradation, which is helpful in staling prevention of baking products, which remain fresh for a longer time, and minimizes food waste (26).

### Conclusion

This means that potato peels are a strategic resource that helps us get closer to a circular economy. We assert their significance rather than viewing them as a waste burden, presenting them as an alternative and sustainable source of pectin. A thorough explanation of the acid-forces mechanism and new extraction techniques, such as ultrasonic-assisted extraction, showed that the potato pectin with a lot of functional groups and few esters could better control how it is used on an industrial scale. It can be used to stabilize the texture of food, replace fat in low-calorie foods, smartly carry targeted colonic drugs, and make edible bio-coating films. Finally, the review by Ali et al. concludes that these peels could be a good way to fill the gap for environmentally friendly and affordable food and drug additives because they are linked to environmental standards.

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