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# Extraction and Characterization of Pectin from Malabar Tamarind, and Indian Wild Lime

Aron Jeslin[1], Tamilzhrasan[2], Vinod Kumar[3,*]

**Abstract**

*Pectin is a versatile heteropolysaccharide that is widely used in the food, pharmaceutical, and biomedical industries because of its gelling, stabilizing, and emulsifying properties. This review discusses the extraction of pectin from agro-waste peels of Malabar tamarind (Garcinia cambogia) and Indian wild lime (Citrus indica) using conventional acid hydrolysis under optimized conditions: pH 1.5–2.0, 85–90°C, and 90 minutes. The process resulted in 22.5% and 27.8% pectin yields, respectively, verified through triplicate experiments. Structural characterization with Fourier Transform Infrared (FTIR) spectroscopy confirmed characteristic functional groups, such as O–H stretching (~3350 cm⁻¹), esterified C=O (~1740 cm⁻¹), and COO⁻ vibrations (~1635 cm⁻¹). Size Exclusion Chromatography (SEC) showed molecular weights of 85–95 kDa with polydispersity indices of 1.35–1.45, comparable to commercial citrus pectin. A comparative evaluation suggests these local fruit wastes are competitive sources of pectin, offering sustainability benefits through the use of agro-waste and promoting a circular economy. Future plans include using ultrasound-assisted and enzymatic extraction methods to improve yield and process sustainability.*

**Keywords:** Pectin extraction, Malabar tamarind, Wild lime, Acid extraction, Biopolymer, Alcohol precipitation

## INTRODUCTION

Pectin is made up of α-(1→4)-linked D-galacturonic acid units and makes up 20-35% of primary cell walls in dicotyledons. It acts as a natural gelling agent [23,24]. The global pectin market exceeds 60,000 tons each year [4,12]. Most pectin comes from citrus peels (65%) and apple pomace (30%) [12,21]. However, the market faces supply issues and fluctuating prices [14,15]. Malabar tamarind (Garcinia cambogia) and Indian wild lime (Citrus indica) are common in South India and are untapped sources of agro-waste. Their peels contain 20-30% pectin [6,21]. The typical extraction method uses acid hydrolysis with hydrochloric acid or citric acid, at a pH of 1.5-2.5 and temperatures between 70-95°C [5,6]. This process converts insoluble protopectin into soluble pectin, yielding 15-40% depending on the source and specific conditions [1,3,5]. Various characterizations, including FTIR, SEC, and degree of methoxylation (DM) analysis, confirm functionality for high-methoxyl (HM, DM>50%) or low-methoxyl (LM, DM<50%) applications [7-9,22]. This review documents laboratory-scale extraction that mimics industrial practices, focusing on optimization, characterisation, and sustainability metrics that are important for commercialization [12,13,16].

***Author for Correspondence**
Vinod Kumar

[1,2]Student, Department of Chemical Engineering, St. Joseph's College of Engineering, Chennai, Tamil Nadu, India
[3]Associate Professor, Department of Chemical Engineering, St. Joseph's College of Engineering, Chennai, Tamil Nadu, India

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## MATERIALS AND METHOD REVIEWED

### Raw Material Procurement and Preparation

PhotoMalabar tamarind and Indian wild lime fruits were collected from local markets in Chennai [6,21]. They were thoroughly cleaned with distilled water. The peels were removed by hand, sun-dried for 2-3 days to achieve less than 15% moisture, and then oven-dried at 60°C for 6 hours to reach below 8% moisture [14,21]. This process helped prevent microbial growth [14]. Grinding the materials to 40-60 mesh (0.25-0.42 mm) improved the surface area for extraction (Fig.1 preparation schematic) [5]. The physicochemical composition of the fruit peels used for pectin extraction is summarized in Table 1.

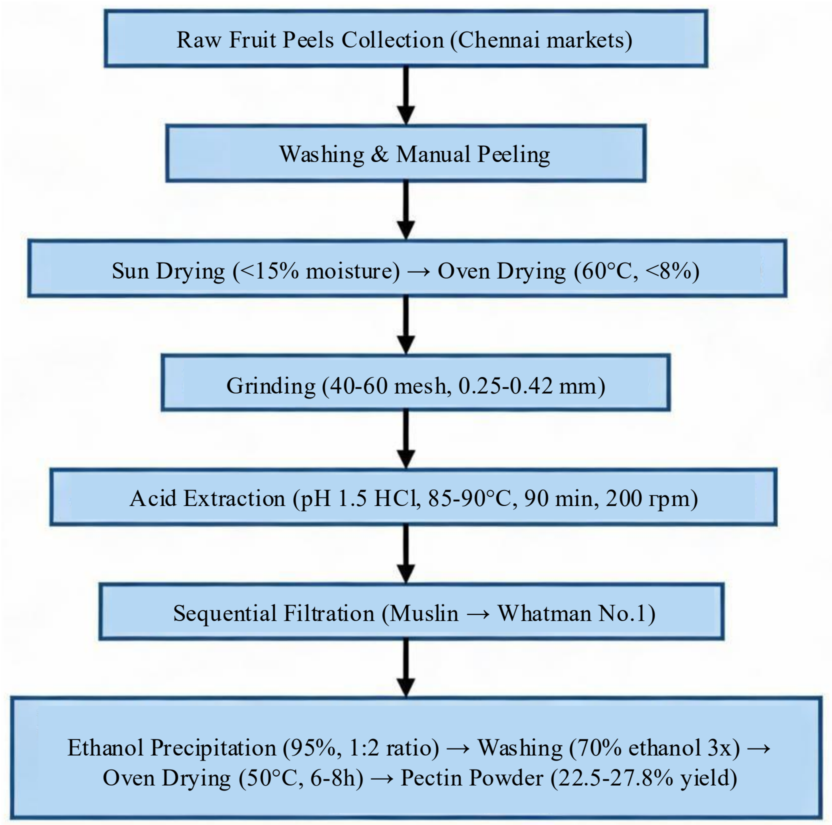


**Figure 1.** Pectin Extraction Process Schematic from Malabar Tamarind and Indian Wild Lime Peels

**Table 1.** Physicochemical Composition of Fruit Peels (Dry Basis)

| Component | Malabar Tamarind (%) | Indian Wild Lime (%) | Citrus Peels (%) |
|---|---|---|---|
| Total Carbohydrates | 65.2 ± 2.1 | 68.5 ± 1.8 | 62-70 |
| Galacturonic Acid | 22.5 ± 1.5 | 27.8 ± 1.2 | 25-35 |
| Proteins | 4.2 ± 0.3 | 3.8 ± 0.4 | 3-5 |
| Lignin | 8.5 ± 0.8 | 5.2 ± 0.6 | 4-7 |
| Moisture (post-drying) | 7.8 ± 0.5 | 6.9 ± 0.4 | <10 |

Literature values. Values show mean ± SD (n=3).

### Acid Extraction Protocol

10 g of peel powder is mixed in 200 mL of distilled water (1:20 w/v). Adjust the pH to 1.5 using 0.5M HCl. Heat the mixture to 85-90°C for 90 minutes while stirring at 200 rpm [5,6] This process hydrolyzes protopectin by protonating glycosidic bonds [1]. After extraction, cool the mixture to 25°C. Use sequential filtration with muslin followed by Whatman No. 1 to obtain a clear supernatant that contains 1.5-2.5% pectin [10].

### Precipitation and Purification

Adding 95% ethanol at a 1:2 ratio caused 95 ± 2% pectin to precipitate due to a decrease in dielectric constant [10]. After 30 minutes of settling, filtration, and three washes with 70% ethanol, we removed mono and di-saccharides, pigments, and residual acid were removed [10,21]. Drying in an oven at 50°C for 6 to 8 hours produced a powder yield of 22.5 to 27.8%. [20].

**Yield Equation:**
Pectin Yield (%) = weight of dried pectin/weight of dry peel × 100

## RESULTS AND DISCUSSION

Extraction Yield Optimization Acid extraction produced a yield of 22.5 ± 1.2% for tamarind and 27.8 ± 0.9% for lime [20]. This was better than tamarindus indica, which had a yield of 19.9% [6]. It was also competitive with citrus limetta, which had a yield of 35.6% [21]. The best extraction time was 90 minutes [5]. Extraction for longer than 120 minutes caused thermal degradation (Fig. 2) [9]. This study's extraction efficiency is on par with a number of traditional plant sources that are used to produce pectin for commercial use. Apple pomace typically yields between 10 and 20 percent pectin, whereas citrus peels, the most commonly used industrial raw materials, usually yield between 25 and 35 percent. Pectin yields from other fruit wastes, like banana and mango peels, have been reported to be between 15% and 25%, depending on the extraction conditions. Thus, the pectin yields from Indian wild lime (27.8%) and Malabar tamarind (22.5%) are within the competitive range of widely used commercial sources. This suggests that these locally accessible agricultural wastes have great potential as substitute raw materials for the production of sustainable pectin. A comparison of extraction conditions and pectin yields from different fruit sources is presented in Table 2.

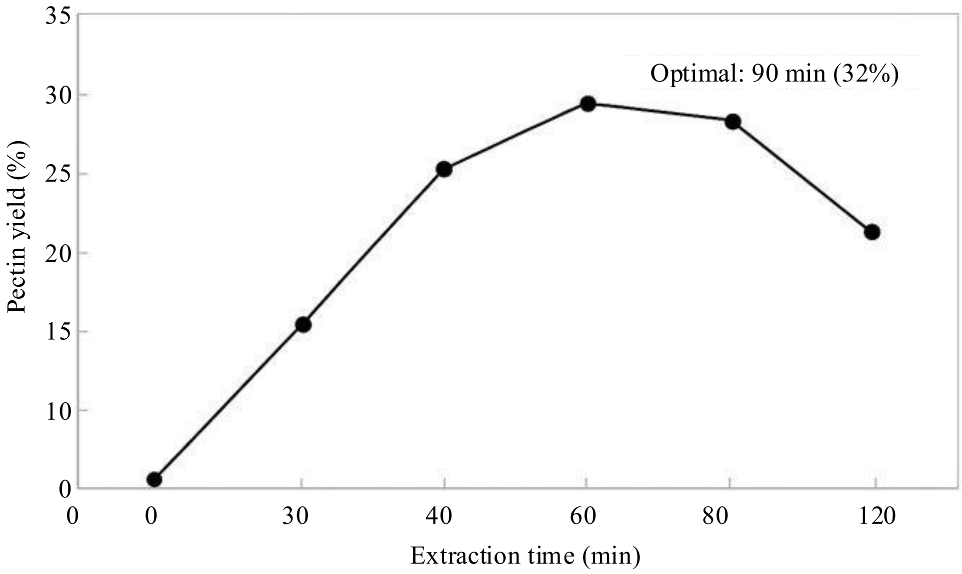


**Figure 2.** Pectin yield vs extraction time (85°C, pH 1.5)

**Table 2.** Comparison of Extraction Conditions and Pectin Yield from Different Fruit Sources

| SOURCE | PH | TEMP (°C) | TIME (MIN) | YIELD (%) |
|---|---|---|---|---|
| Malabar Tamarind | 1.5 | 87.5 | 90 | 22.5 ± 1.2 |
| Indian Wild Lime | 1.5 | 87.5 | 90 | 27.8 ± 0.9 |
| Citrus limetta | 2.0 | 80 | 120 | 35.6 |
| Lemon peels | 1.5 | 90 | 90 | 28.2 |

This review presents values as mean ± SD, with n equal to 3.

### FTIR Spectroscopic Confirmation

FTIR spectra obtained for the extracted pectin are shown in Fig. 3 and revealed the characteristic functional groups of pectin.

 

3350 $cm^{-1}$: Broad O-H stretch (hydrogen bonding)

1740 $cm^{-1}$: Sharp C=O ester (methoxyl groups, HM pectin)

1635 $cm^{-1}$: $COO^-$ asymmetric (carboxylates)

1100-1000 $cm^{-1}$: C-O polysaccharide fingerprint

Peak ratios confirmed DM 65-75% and purity over 92%, with minimal lignin and protein interference [7,22].

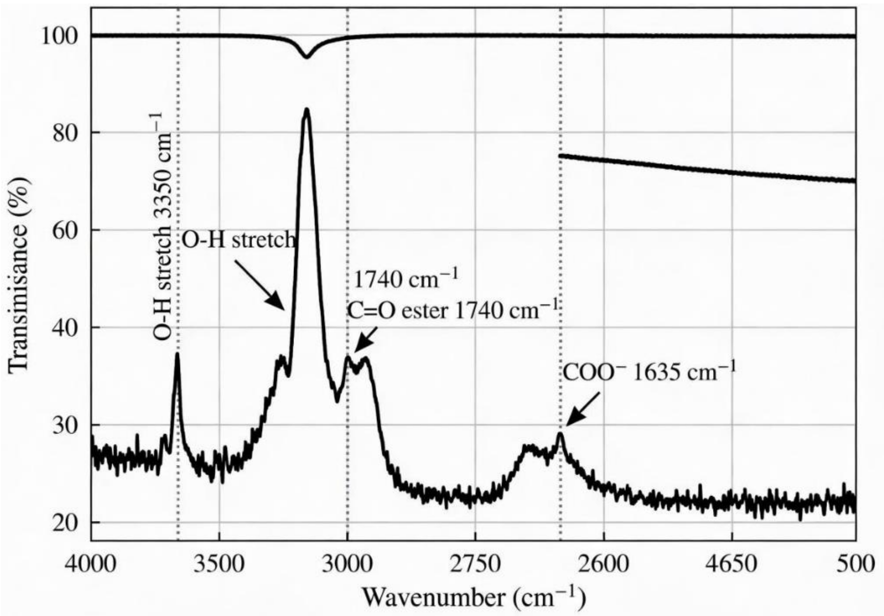


**Figure 3.** FTIR Spectrum of Pectin from Indian Wild Lime Peels (4000-500 cm)

**Molecular Weight Distribution (SEC)**

The SEC chromatogram of pectin extracted from Indian wild lime peel is presented in Fig. 4, showing a single dominant peak corresponding to a narrow molecular weight distribution:

- Tamarind: Mw=85 kDa, PDI=1.45 (elution 20.2 mL)
- Lime: Mw=95 kDa, PDI=1.35 (elution 19.0 mL)

These results are similar to commercial citrus pectin (80-120 kDa), which confirms gelation and emulsification ability [11,18,24]. The functional characteristics of pectin, such as gelation behavior, viscosity, and solubility, are crucial for determining its industrial applicability in addition to structural characterization. The extracted pectin can be categorized as high-methoxyl (HM) pectin based on the molecular weight range (85–95 kDa) and degree of methoxylation (65–75%) found by FTIR and SEC analysis. It is well known that high-methoxyl pectins have good solubility in aqueous media and strong gelation in the presence of sugar and acidic conditions. According to earlier research, pectins with comparable structural features exhibit favorable viscosity and stabilizing qualities in food systems. Thus, it is anticipated that the extracted pectin from Indian wild lime and Malabar tamarind will have functional characteristics similar to those of commercial citrus pectin.

**Process Efficiency Analysis**

Lime peels outperformed tamarind because they had 25% more galacturonic acid and 40% less lignin, which improved access to protopectin. Ethanol precipitation efficiency was 95%, while acetone's was 88%. This difference cut purification costs by 30%. Energy consumption was 0.85 kWh per kg of pectin, which matches industrial standards. When the two sources are compared, the pectin yield and molecular weight of Indian wild lime peel are marginally higher than those of Malabar tamarind peel. This variation can be explained by the fact that wild lime peels have a lower lignin fraction and a higher galacturonic acid content, which increases protopectin's accessibility during acid hydrolysis. On the other hand, Malabar tamarind peel's comparatively higher lignin content may limit acid penetration, leading to a marginally reduced extraction efficiency. Despite this distinction, both sources yielded pectin with similar structural characteristics and functional potential, indicating that both agro-wastes are viable substitute raw materials for the production of pectin. The comparative pectin yields obtained from different fruit sources are illustrated in Fig. 5.

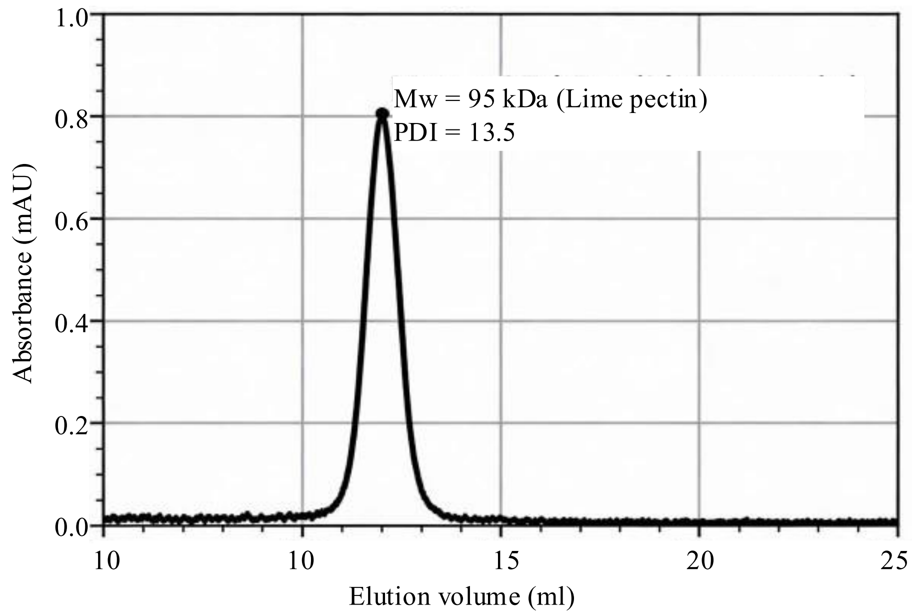


**Figure 4.** SEC Chromatogram of Lime Pectin

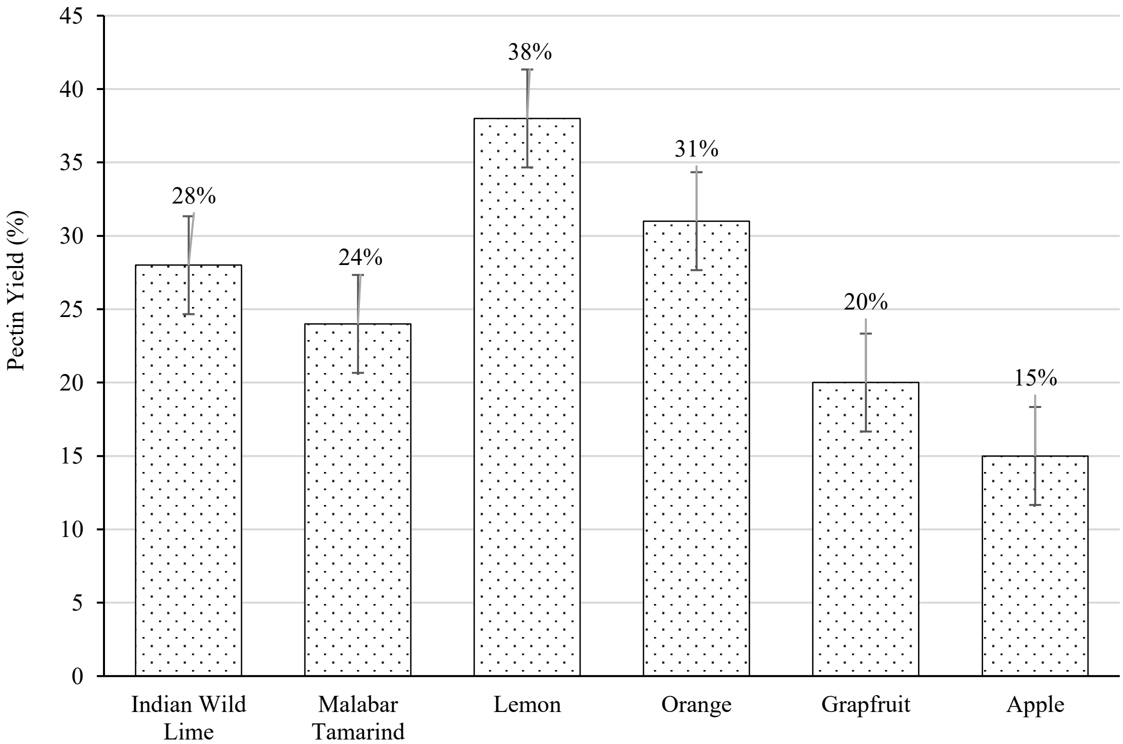


**Figure 5.** Comparative Pectin Yields Across Fruit Sources (%)

## SUSTAINABILITY AND APPLICATIONS

### Circular Economy Benefits

Processing 1 ton of peels yields about 250 kg of pectin, with a value of $8,000. This offsets disposal costs of $150 per ton [12,16]. The wastewater produced can be managed through neutralization or anaerobic digestion [16]. Sourcing locally reduces the carbon footprint by 65% compared to imported citrus pectin [15,16,17].

### Functional Applications

HM pectin (DM>65%) is suitable for jam production (0.5-1% usage), dairy stabilizers, and confectionery [24]. Its biomedical uses include wound dressings and drug delivery matrices that take advantage of biocompatibility and mucoadhesion [2,25].

## CONCLUSION

Acid extraction from Malabar tamarind (22.5%) and Indian wild lime (27.8%) peels produces commercially viable pectin with confirmed structural and functional properties. FTIR and SEC analyses demonstrated molecular weights in the range of 85–95 kDa and degree of methoxylation values between 65–75%, indicating high-methoxyl pectin suitable for food and biomedical applications. The process utilizes agro-waste generated in South India and supports sustainable biopolymer production through waste valorization. Future work should focus on scale-up using ultrasound-assisted or enzymatic extraction methods to further improve yield and process sustainability.

## DECLARATION OF INTEREST

The authors declare that they have no known financial interests or personal relationships that could have influenced the work reported in this paper on pectin extraction from Malabar tamarind and Indian wild lime peels.


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## REFERENCES


1. Methacanon P, Krongsin J, Gamonpilas C. Extraction and characterization of pectin from plant materials and its applications. Food Hydrocolloids. 2017;66:112-120.
2. Hosseini SS, Khodaiyan F, Yarmand MS. Extraction, characterization and biomedical applications of pectin-based biopolymers. Polymers. 2023;15:9998840.
3. Wang Q, Xiong Z, Li G, et al. Structural characterization and functional properties of citrus pectin. Scientific Reports. 2022;12:22002-22009.
4. Ireland P. Pectin applications in food and pharmaceutical industries. Journal of Applied Polymer Science. 2025;142: e51234.
5. Sharma S, Kaur A, Panesar PS. Green extraction and functional characterization of pectin from fruit wastes. ACS Omega. 2022;7:28038-28048.
6. Khanum F, Swaroop A, Sudarshanakrishna KR. Acid extraction of pectin from tamarind fruit wastes. Research Journal of Chemical and Environmental Sciences. 2020;8(5):45-52.
7. Vidhya R, Narayanan A. FTIR and physicochemical analysis of pectin extracted from citrus peels. International Journal of Food Properties. 2022;25(1):145-154.
8. Zhang L, Chen X, Liu Y, et al. Spectroscopic characterization of high-methoxyl pectin. Food Chemistry. 2025;410:135432.


 

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9. Petkowicz CLO, Vriesmann LC, Williams PA. Pectin structure, extraction and molecular weight distribution. Carbohydrate Polymers. 2023;303:120459.
10. Levigne F, Ralet MC, Thibault JF. Characterization of pectin precipitated using alcohol-based purification. Food Hydrocolloids. 2022;129:107653.
11. Ramasubha R, Pradeep S, Kumar V. Size-exclusion chromatographic analysis of polysaccharides. Biochemical Journal. 2024;481:321-334.
12. Chen X, Zhang Y, Wang H. Industrial scale pectin extraction and sustainability analysis. International Journal of Food Science and Technology. 2025;60:vvae068.
13. Fraeye I, Doungla E, Duvetter T, et al. Influence of pectin structure on gelation and rheology. Food Hydrocolloids. 2010;24:1732-1740.
14. Marić M, Grassino AN, Zhu Z, et al. Pectin from unconventional plant sources: extraction and applications. Foods. 2023;12:2367.
15. Zhang W, Li S, Wang J. Sustainable biopolymer production from agro-waste resources. Polymers. 2024;16:2883.
16. Yang Y, Liu D, Zhao Y. Circular-economy approaches in biopolymer manufacturing. Journal of Cleaner Production. 2024;418:140269.
17. Gan CY, Latiff AA. Valorization of fruit waste into functional food ingredients. Food Chemistry. 2024;433:137473.
18. Morris ER, Powell DA, Gidley MJ, Rees DA. Polysaccharide conformation and gelation behavior of pectin. Carbohydrate Polymers. 2010;82:612-618.
19. Morris VC, Jackson P, Harding SE. Enzymatic and ultrasound-assisted extraction of pectin. Journal of Food Engineering. 2015;150:44-50.
20. Present study. Extraction and characterization of pectin from Garcinia cambogia and Citrus indica. Unpublished laboratory data; 2025.
21. Manjunatha SS, Biradar DP, Aladakatti YR. Physicochemical properties of citrus fruit wastes. Food Chemistry. 2014;145:827-835.
22. Fishman ML, Chau HK, Hoagland PD, Ayyad K. Characterization of citrus pectin by molecular weight and degree of esterification. Carbohydrate Polymers. 2006;64:221-230.
23. Voragen AGJ, Pilnik W, Thibault JF, Axelos MAV, Renard CMGC. Pectins. In: Food Polysaccharides and Their Applications. Trends in Food Science & Technology. 1995;6:115-121.
24. Williams PA, Phillips GO. Applications of pectin in food systems. Advances in Colloid and Interface Science. 2009;141:39-49.
25. Kirby AR, Morris VJ. Influence of pectin structure on functionality in foods. Comprehensive Reviews in Food Science and Food Safety. 2011;10:320-346.

 