PECTIN ISOLUTION BY CITRIC ACID FROM WASTE LIME PEEL

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ABSTRACT

This special project aims to study the extraction conditions of pectin from waste lime peel powder. The study focused on the suitable extraction conditions and using the obtained parameters to simulate the process at an industrial scale. In the preliminary study, pectin was extracted from waste lime peel powder by citric acid solution. The experimental variables were pH, temperature, and extraction time. The results showed that 60 min extraction time gave the highest yield of 25% at pH 2. The chemical properties of the extracted pectin were analyzed by % methoxyl content, equivalent weight, % AUA (anhydrouronic acid), and %DE (degree of esterification). The methoxyl content was 21.57%, indicating as high methoxyl pectin (HMP). This type of pectin has excellent gelling properties for the food and pharmaceutical industries. At the industrial level, a major problem involves high cost of pure ethanol in the precipitation and washing steps. Therefore, the laboratory results became a guideline to simulate an extractive distillation by Aspen Plus v.14 software to recover ethanol. The simulation started with a lime peel flow rate of 100 kmol/hr and a yield of 90%. After the simulation, the pectin production was 23,630 lb/hr. When compared with the laboratory yield of about 20%, the industrial simulation produced about 4.5 times more pectin than the laboratory scale did. In addition, ethanol can be recovered and reused. The simulation encourages the cost feasibility and payback period of the system. The simulation results showed a profit of 235 USD per hour. In conclusion, the laboratory extraction gave a good yield of 24.14% and provided useful data for process simulation in Aspen Plus v.14. The simulation also helped to determine the cost feasibility and payback period of this system.

INTRODUCTION

This study optimizes pectin extraction from waste lime peels using citric acid, investigating pH, temperature, and time for food and pharmaceutical applications. Aspen Plus simulation confirms that ethanol recovery significantly reduces costs, ensuring economic viability and industrial scalability



lime peel powder



pectin



product

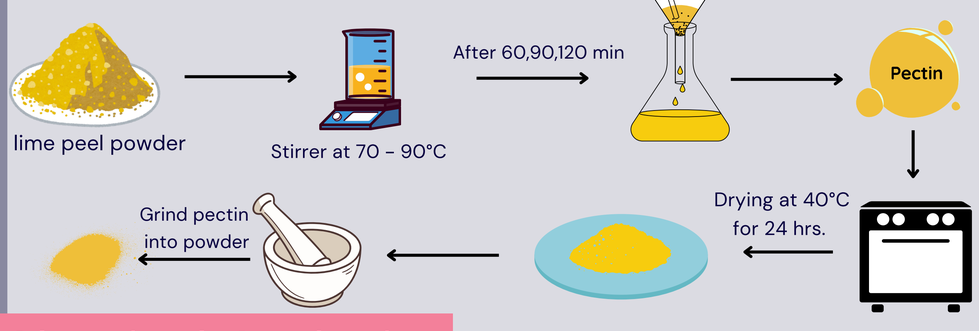
pH 1,2,3 → **temp** 70,80,90°C → **time** 60,90,120 min

OBJECTIVES

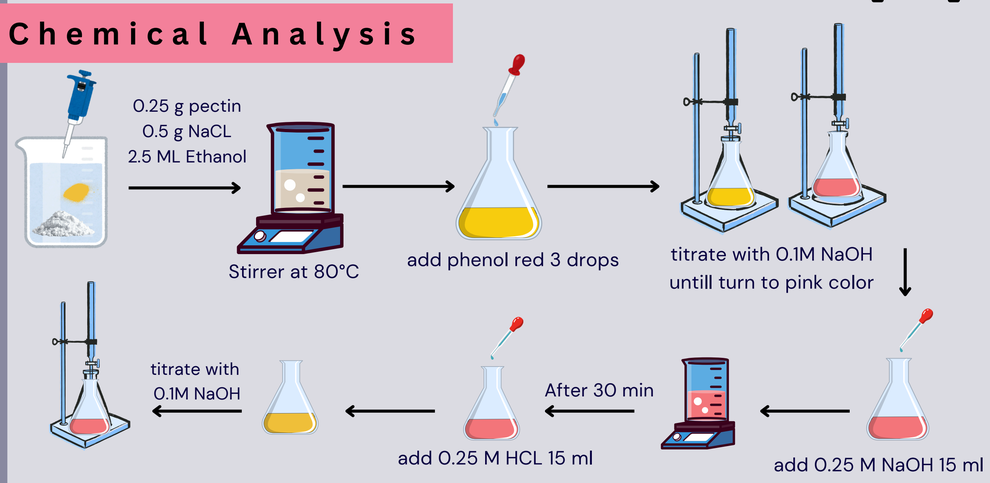
- To study pectin extraction using citric acid with different times, temperatures, and pH levels.
- To analyze pectin properties, including: % Methoxyl content, Anhydrouronic acid (AUA), Degree of Esterification (DE),Equivalent weight
- To simulate industrial pectin extraction using the Aspen Plus V.14 program.

EXPERIMENTAL

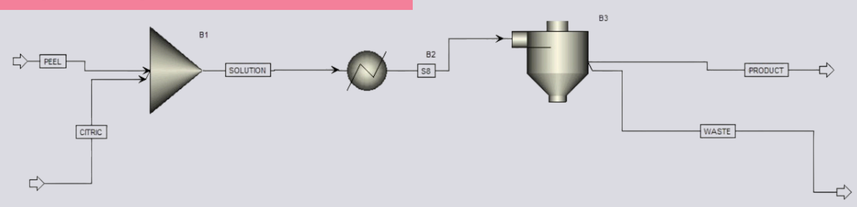
Extraction pectin



Chemical Analysis



Aspen plus V.14



RESULTS & DISCUSSION

%Pectin Yield

Maximum pectin yield obtained at pH 2

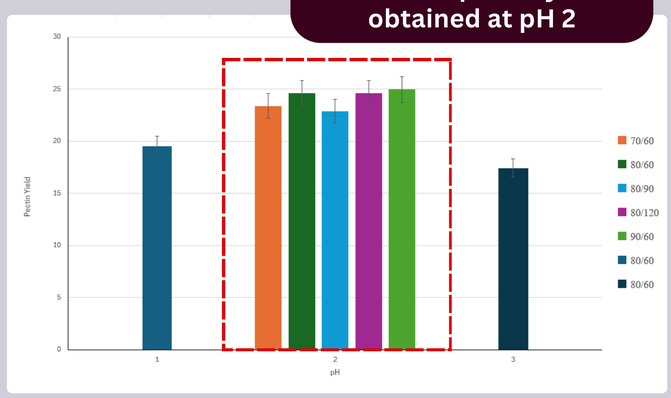


Fig.1 %pectin yileid from extraction

Chemical properties

High Methoxyl Pectin (DE > 50%)

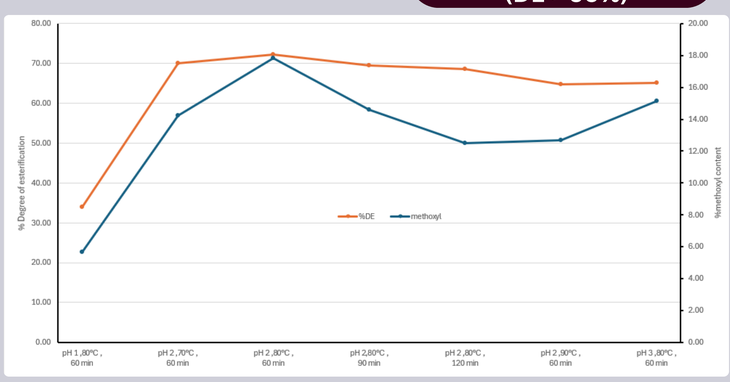


Fig.2 the effects of extraction conditions on methoxyl content and the degree of esterification (DE) of pectin

Particle size analysis

Optimal extraction occurred at pH 2 and 80°C for 60 min

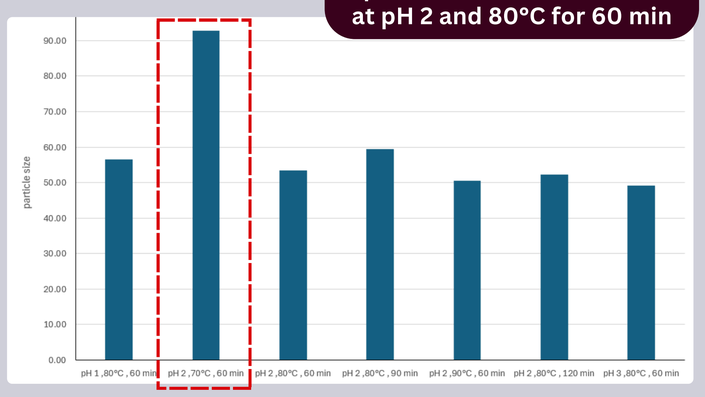


Fig.4 the relationship between extraction conditions and particle size distribution

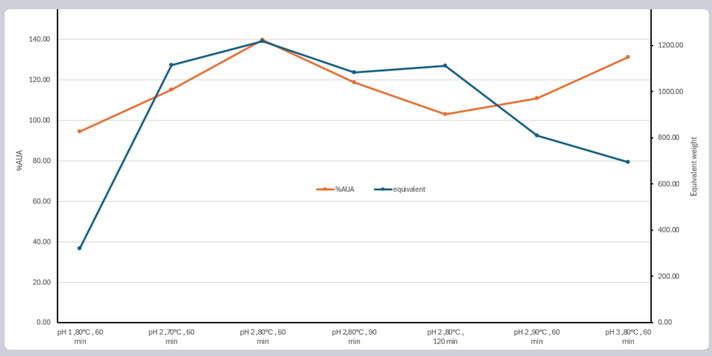


Fig.3 Anhydrouronic Acid Content (%AUA) and Equivalent Weight of the Extracted Pectin

Solubility

Table 1: Solubility of Extracted Pectin in Various Solvents

condition	hot alkali	cold alkali	hot water	cold water
pH 1 ,80°C , 60 min	✓	✓	✗	✗
pH 2 ,70°C , 60 min	✓	✓	✗	✗
pH 2 ,80°C , 60 min	✓	✓	✗	✗
pH 2 ,80°C , 90 min	✓	✓	✗	✗
pH 2 ,80°C , 90 min	✓	✓	✗	✗
pH 2,90°C , 60 min	✓	✓	✗	✗
pH 3 ,90°C , 60 min	✓	✓	✗	✗

Aspen plus V.14

Table 2: Industrial Scale-up Simulation Results (Aspen Plus v.14)

solution	cost flow ($/lbmol)	mole flow (lb/mol)	mass flow (lb/mol)
Citric		22.0462	4235.64
Peel	551.156	220.462	26256.4
Product	785.728	218.258	27442.9
Solution		242.508	30492.1
Waste		24.2508	3049.21

- **Highest Cost: Product leads at $785.728/lbmol**
- **Mass Flow: Product reaches 27,442.9 lb/mol**
- **Maximum Mole Flow: Solution peaks at 242.508 lb/mol**
- **Waste accounts for 10% of the total solution**
- **Secondary Cost: Peel follows at $551.156/lbmol**

CONCLUSIONS

- The results identify the optimal condition at pH 2 and 80°C for 60 minutes, yielding the most efficient pectin production and quality
- pH 2 at 80°C for 60 minutes is the best condition. It produces High Methoxyl Pectin (over 70% DE) with the highest purity and strongest structure
- Data from Aspen plus V.14 the Product has the highest cost flow at $785.728/lbmol, followed by the Peel solution at $551.156/lbmol

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Reference: Akhter, J., Sarkar, S., Sharmin, T., & Mondal, S. C. (2024). Extraction of pectin from powdered citrus peels using various acids: An analysis contrasting orange with lime. Applied Food Research, 4(2), 100614