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Enhancing Galactomannan Recovery from Coconut Meat: Impact of Autoclaving Pretreatment in a High-Shear Compartment Reactor System

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Abstract

Galactomannan in coconut meat is tightly bound within its fiber matrix, limiting extraction efficiency. Autoclave pretreatment, combining heat, pressure, and moisture, can loosen this structure and improve galactomannan release. This study examined the effects of autoclaving temperature (100°C–130°C) and water addition (0–45%) on the physical and chemical properties of grated coconut prior to extraction. This study examined the effect of autoclaving temperature on the physicochemical properties and extraction yield of galactomannan. Four pretreatment temperatures were evaluated: 100, 110, 120, and 130 °C. The 100°C treatment produced the highest yield (8.45%), swelling power (8.67%), color values (L* = 53.44, a* = 5.48, b* = 9.09), and reducing sugar content (18.03%). Statistical analysis confirmed that autoclaving temperature significantly influenced extraction yield. Overall, 100°C was identified as the optimal pretreatment condition for enhancing galactomannan extraction from coconut meat.

Keywords: Galactomannan extraction; autoclave pretreatment; coconut meat; physicochemical properties.

INTRODUCTION

Coconut is a major Indonesian export commodity, generating about USD 890 million from 1.8 million tons, with more than half of the value coming from processed products such as crude and semi-refined coconut oil (Hestina et al., 2022). Coconut meat contains carbohydrates, lipids, proteins, minerals, vitamins, and galactomannan, a mannose–galactose polysaccharide known for its functional roles as a thickener and emulsion stabilizer (Suryati dan Ishak, 2021). Galactomannan is a functional hydrocolloid widely valued in the food, pharmaceutical, and cosmetic industries due to its thickening, stabilizing, and gelling properties (Flores García et al., 2025). Galactomannan content varies across coconut cultivars, ranging from 0.18–0.20% in genjah varieties to 0.96–4.87% in hybrid coconuts (Tenda *et al*., 1997). Although galactomannan can be extracted from coconut meat, conventional extraction methods often result in low and inconsistent yields. For instance, extraction at 55 °C reported by Annisa *et al*. (2021) produced a yield of 8.49%, yet the values remained unstable due to variations in extraction temperature and duration. These findings indicate that the structural integrity of coconut fiber limits the efficient release of galactomannan.

Thus, pretreatment plays a crucial role in modifying the structural integrity of coconut meat before extraction. Thermal treatments under elevated temperature and pressure, such as autoclaving, can break down the cellulose–hemicellulose–lignin network, promote tissue softening, and enhance the efficiency of hydrocolloid recovery (Muharja *et al*., 2023). However, the optimal autoclaving temperature for maximizing galactomannan release from coconut meat has not been clearly established. Furthermore, extraction efficiency can be improved using a High Shear Compartment Reactor (HSCR), which generates intense shear forces capable of enhancing mass transfer and accelerating polysaccharide solubilization. Yet, the integration of autoclave pretreatment and HSCR-assisted extraction remains largely unexplored. Given these gaps, systematic investigation is needed to understand how autoclaving temperature influences extraction efficiency and the physicochemical characteristics of galactomannan derived from coconut meat. Therefore, the purpose of this study is to evaluate the effect of autoclave-based thermal pretreatment on the yield, physical properties, and chemical characteristics of galactomannan extracted using a High Shear Compartment Reactor. The findings aim to support the diversification of galactomannan

production and enhance the added value of coconut meat as a functional hydrocolloid source.

MATERIALS AND METHODS

Materials

The materials used in this study consisted of primary materials and analytical reagents. The primary raw material was grated mature coconut meat (11–12 months old) obtained from Peterongan Market, Semarang, Central Java. Analytical reagents included technical-grade ethanol 96%, anhydrous glucose (Merck, Germany), arsenomolybdate reagent, NaOH (Merck, Germany), n-hexane, Nelson reagents A and B, aqua deminerals (Brataco, Indonesia), and citric acid (Merck, Germany).

The main processing equipment consisted of a High Shear Compartment Reactor (JRJ300-1, China) (Figure 1) (Affandi et al., 2024), an autoclave (GEA LS50HD, Indonesia), a cabinet dryer (K001-G003, Indonesia), and a water bath (Daihan DH.WSB-18, China). Instruments used for laboratory analyses included a vortex mixer (DLAB, Malaysia), hotplate (IKA C-MAG HS 7, Malaysia), magnetic stirrer, Soxhlet extractor (Iwaki, Japan), 250 mL beakers (Iwaki, Japan), digital balance (SF-400), analytical balance (Ohaus), oven (Memmert UN55, Germany), UV-Vis spectrophotometer (Spectroquant Prove 300, Germany), micropipettes (DLAB, Malaysia), aluminum dishes, petri dishes, centrifuge, thermometer, colorimeter (FRU), 10 mL volumetric flasks, test tubes, Erlenmeyer flasks (250 mL), desiccator, pH meter, and dropper pipettes.

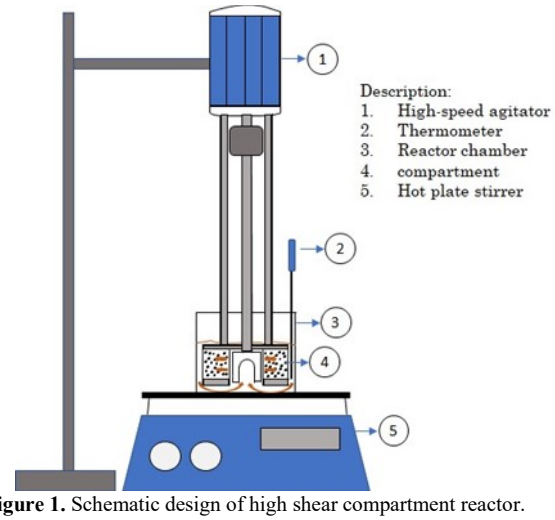

Figure 1. Schematic design of high shear compartment reactor.

Preliminary Study

Identification of coconut meat characteristics and a preliminary study were conducted at the initial stage of the research to confirm the optimum extraction conditions based on the yield obtained from different solvent pH levels. In this preliminary phase, three types of extraction media were prepared: acidic, neutral, and alkaline solvents. The acidic solvent (pH 4) was prepared by dissolving citric acid in distilled water until the desired pH was reached. The neutral solvent (pH 6.5) consisted of distilled water with an inherent pH in the range of 6–7. The alkaline solvent (pH 9) was prepared by adding NaOH to distilled water until the target pH was achieved. Each prepared solvent was subsequently used for galactomannan extraction. The extracts obtained were then dried, and the dried solids were weighed to determine the extraction yield. The solvent pH that produced the highest yield was selected as the optimum condition for further experiments.

Pretreatment by Autoclaving

The study began with a thermal pretreatment process. A total of 50 g of defatted grated coconut meat was weighed and placed into an autoclave. Four autoclaving temperatures (100°C, 110°C, 120°C, and 130°C) were applied for 20 minutes to determine the optimal pretreatment condition based on extraction yield, swelling power, and reducing sugar content. Following autoclaving, the samples were cooled and subsequently prepared for the extraction stage.

Galactomannan Extraction Using HSCR

The extraction process was carried out using a High Shear Compartment Reactor (HSCR). A total of 4 g of autoclaved coconut meat was placed inside the HSCR compartment. Separately, 250 mL of distilled water was heated on a hotplate until the temperature reached 60°C. The HSCR compartment was then immersed in the solvent, and extraction was performed for 3 hours. Following extraction, the mixture was evaporated using a hotplate at 140°C until the sample volume was reduced to 25 mL. Ethanol was added at a ratio of 1:3 (extract: ethanol), and the solution was stored in a refrigerator for 24 hours to allow galactomannan precipitation. The precipitated solid was separated and dried in a cabinet dryer until completely dry. The dried material was then ground using a stainless-steel spatula and stored in sealed plastic bags.

Experimental Design

This study was conducted using a Completely Randomized Design (CRD) consisting of four pretreatment temperature levels (100, 110, 120, and 130 °C). Each treatment was performed in triplicate. The experimental procedure involved sample pretreatment followed by physicochemical and structural characterization of the obtained products. The evaluated parameters included extraction yield, reducing sugar content, swelling power, and color attributes (L*, a*, b*), while functional group profiles were identified using Fourier Transform Infrared (FTIR) spectroscopy. All measurements were analyzed in duplicate to ensure analytical reliability.

Reducing Sugar Analysis (Nelson–Somogyi Method)

Standard Curve Preparation

Reducing sugar content was determined using the Nelson–Somogyi method following the procedure described by Al-kayyis & Susanti (2016) with modification. A stock glucose solution (2000 ppm) was prepared by dissolving 0.2 g of glucose in a 100 mL volumetric flask. This stock solution was subsequently diluted to obtain standard glucose solutions with concentrations of 0, 100, 200, 300, 400, and 500 ppm. Seven test tubes were prepared: six tubes were each filled with 1 mL of the respective glucose standard solution, while one tube containing 1 mL of distilled water served as the blank. To each tube, 1 mL of Nelson reagent A and Nelson reagent B was added. The mixtures were heated in a water bath at 90 °C for 20 min to facilitate the reduction of Cu^{2+} to Cu_2O. After cooling to room temperature, 1 mL of arsenomolybdate reagent was added to each tube to dissolve the formed Cu_2O precipitate. The solutions were vortexed until fully homogenized, and absorbance was measured at 540 nm using a spectrophotometer to construct the standard calibration curve.

Determination of Reducing Sugar Content

Galactomannan samples (70 mg) were weighed and diluted to a defined volume using a volumetric flask. An aliquot of 1 mL of the diluted sample solution was transferred into a test tube, followed by the addition of 1 mL of Nelson reagents A and B. The mixture was heated in a water bath at 90 °C for 20 min, then cooled to room temperature. Subsequently, 1 mL of arsenomolybdate reagent was added, and the tubes were vortexed to ensure complete dissolution of the Cu_2O precipitate. Absorbance was recorded at 540 nm, and reducing sugar concentration was determined based on the standard glucose calibration curve.

Swelling Power Analysis

Swelling power analysis was performed by dispersing 0.1 g of sample into a centrifuge tube, followed by the addition of 10 mL of distilled water. The suspension was heated in a water bath at 60 °C for 30 min to allow hydration and granule swelling, and subsequently centrifuged at 2500 rpm for 15 min to separate the supernatant from the formed sediment paste. Swelling power was then calculated using the following equation:

$$Swelling\ power\ (\%) = \frac{gel\ mass\ (g)}{dry\ sample\ mass\ (g)} \times 100\%$$

Color Measurement

Color characteristics of the powder samples were determined using a portable color reader (colorimeter) based on the CIE Lab* color system. The powdered sample was placed into a clean, dry sample holder and gently leveled to obtain a smooth and uniform surface, minimizing light scattering effects due to surface irregularities. Color measurements were then performed by positioning the color reader sensor perpendicular to the sample surface to ensure consistent illumination and detection geometry. The color parameters recorded included lightness (L*), redness–greenness (a*), and yellowness–blueness (b*). Each sample was measured at least three times at different positions, and the mean values were reported as the representative color attributes of the sample.

Functional Group Analysis by FTIR

Functional groups of the powdered samples were identified using Fourier Transform Infrared (FTIR) Perkin Elmer UATR spectroscopy. Prior to analysis, the sample was oven-dried to remove moisture and then finely ground to ensure homogeneity. FTIR spectra were recorded over the wavenumber range of 4000–400 cm^{-1} at room temperature. The obtained spectra were analyzed to identify characteristic absorption bands corresponding to specific functional groups present in the sample.

Statistical Analysis

The obtained data were subjected to analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level. When significant effects of the treatments on the observed variables were detected, statistical analyses were performed using SPSS software version 26.

RESULTS AND DISCUSSION

Characteristics of Raw Material

In this study, the raw material used was dried grated coconut meat. Several physicochemical parameters were evaluated to characterize the material, including moisture content, fat content, color attributes, and bulk density. The results of the raw material analysis are presented in Table 1. Moisture content decreased from 5.07% to 3.11%, indicating partial dehydration during the oil removal step. Lower residual moisture reduces the formation of lipid–water emulsified barriers and improves solvent penetration during subsequent aqueous extraction (Ammar et al., 2022). A drier matrix also enhances solid–liquid mass transfer by facilitating water uptake during rehydration, which promotes cell wall swelling and improves the release of intracellular polysaccharides such as galactomannan.

Table 1. Characteristics of grated coconut meat as a raw material.

Characteristics	Condition	
	Before oil extraction	After oil extraction
Water content (%)	5,07 ± 0,01	3,11 ± 0,03
oil content (db) (%)	24,27 ± 0,48	11,34 ± 0,64
Colour		
- L	81,82 ± 0,43	51,80 ± 1,28
- a	1,10 ± 0,10	1,88 ± 0,25
- b	6,22 ± 0,14	4,89 ± 0,48
Density (g/mL)	0,32 ± 0,01	0,27 ± 0,00

Oil content plays a significant role in the galactomannan extraction process. The presence of lipids in the raw material can hinder solvent penetration into the cellular matrix, thereby limiting mass transfer and reducing the efficiency of the extraction (Náthia-Neves et al., 2025). Lipid components may form hydrophobic barriers around cell wall structures, restricting solvent accessibility to intracellular galactomannan. This observation is consistent with the findings of Ninsix (2012), who reported that fresh coconut residue contained an oil content of 26.50%, whereas hexane defatting reduced the oil content by 8.49%. The reduction of lipid fractions enhances solvent–solid interactions and facilitates improved recovery of target hydrocolloids during extraction.

Significant changes were also observed in color parameters and density. The decrease in L* value from 81.82 to 51.80 indicates darkening of the material, likely due to thermal exposure and oxidation reactions during oil extraction. The increase in a* (1.10 to 1.88) suggests a shift toward reddish tones, while the decrease in b* (6.22 to 4.89) indicates reduced yellowness. These changes imply partial Maillard-type reactions or pigment concentration effects following oil removal. Although color is not a direct extraction parameter, darker material may indicate mild structural modification of cell wall components, potentially enhancing matrix disruption and facilitating polysaccharide release. However, excessive browning could be associated with polysaccharide degradation if severe thermal conditions are applied. The bulk density decreased from 0.32 to 0.27 g/mL, reflecting structural loosening and increased porosity after oil extraction. Lower density materials typically exhibit higher surface area and improved solvent accessibility, both of which favor solid–liquid extraction processes.

Overall, oil extraction acts as a pretreatment step that modifies the physical structure and chemical environment of coconut meat. The reduction in lipid content and moisture adjustment collectively improve solvent penetration, mass transfer, and accessibility of galactomannan within the cell wall matrix. Consequently, these changes are expected to enhance extraction yield, improve extraction rate, and produce a polysaccharide with fewer lipid-associated impurities, which is advantageous for downstream functional applications.

Effect of pH Conditions on Extraction Yield (Preliminary Study)

The pH value represents the degree of acidity or alkalinity of a solution and is commonly used to express hydrogen ion concentration in dilute acidic, neutral, or basic systems. In extraction processes, pH is a critical parameter because it influences the solubility, stability, and chemical form of the compounds being extracted (Zheng et al., 2022). Variations in pH can alter the physicochemical environment of the solvent, thereby affecting the interaction between the solvent and the plant cell matrix as well as the release of target polysaccharides. Galactomannan extraction from grated coconut meat was carried out using three solvent conditions: acidic, neutral, and alkaline media. The determination of the optimal extraction condition was based on the highest extraction yield obtained from each treatment. The influence of solvent pH on the galactomannan extraction process from coconut meat is illustrated in Figure 2.

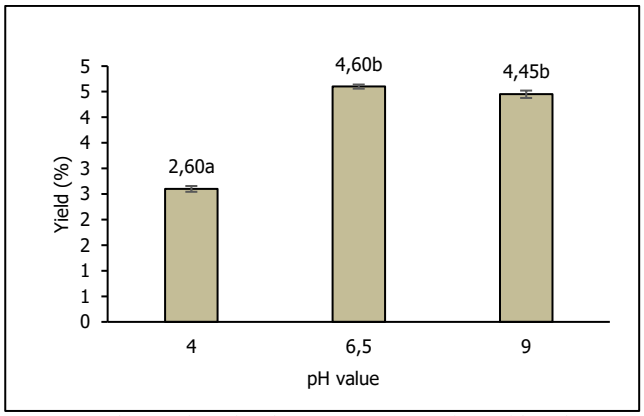

Figure 2. The results of galactomannan extraction with solvent pH variation treatment on yield values.

The highest extraction yield (4.60%) was obtained at pH 6.5, which falls within the neutral range (pH 6–7). Under neutral conditions, the extraction medium remains chemically stable and compatible with the polar nature of galactomannan, thereby enhancing solute–solvent interactions and facilitating the dissolution of the polysaccharide matrix. The predominance of hydroxyl groups in galactomannan promotes hydrogen bonding with water molecules, which improves extraction efficiency and contributes to the higher yield observed (Aryanti et al. 2015). The lowest yield (2.60%) was obtained under acidic conditions, which may be attributed to the presence of citric acid in the extraction medium that promotes structural degradation of polysaccharides. The use of a solvent at pH 3 induced partial hydrolysis of the molecular structure, thereby limiting aggregation during the precipitation stage. Conversely, alkaline extraction at pH 9 decreased polysaccharide solubility and consequently reduced product recovery recovery (Ye et al., 2019). A similar trend was reported by Amyranti & Nurlatifah (2022), where glucomannan extracted from porang tubers using acidic soaking solutions showed lower yields; soaking with 2% ascorbic acid resulted in a yield of 56.10%. Excessively acidic conditions may induce depolymerization of the galactomannan chains in dried coconut meat, thereby limiting recovery of intact polysaccharide molecules. Based on these results, pH 6.5 was selected for subsequent experiments due to its extraction stability, compatibility with distilled water as a solvent, and operational simplicity, as it does not require

the addition of other chemical modifiers while still providing optimal recovery of galactomannan.

Effect on Galactomannan Extraction Yield

The extraction yield of galactomannan in this study ranged from 4.68% to 8.45% (Fig.3), indicating a clear influence of autoclaving temperature on extraction performance. The highest yield was obtained at 100°C (8.45%), suggesting that this temperature provides an optimal pretreatment condition for releasing galactomannan from dried grated coconut meat. Temperatures above 100°C resulted in lower yields, indicating that excessive thermal exposure may negatively impact the structural integrity of the polysaccharide. These findings are consistent with Bahri and Sosidi (2020), who reported that glucomannan content reached its maximum at 100°C (39.60%) and declined when the temperature was increased to 110°C. Elevated temperatures can induce degradation of raw material components; excessive thermal energy increases molecular collisions and promotes polysaccharide breakdown before the extraction process can effectively solubilize the target compound. High temperatures also accelerate hydrolysis, damaging the polymer structure and producing smaller oligosaccharides and monosaccharides that are less recoverable during extraction.

Statistical analysis confirmed significant differences among temperature treatments. This is supported by Ihsan *et al*. (2024), who found that heating up to 100°C enhances the solubility of mannan polysaccharides in water, but further temperature increases cause hydrolysis into low–molecular–weight sugars. The research also reported that temperatures above 80°C may trigger gelatinization and structural degradation of glucomannan, producing glucose and mannose. Artigo *et al*. (2023) also observed a decline in glucomannan extraction yield as process temperature increased.

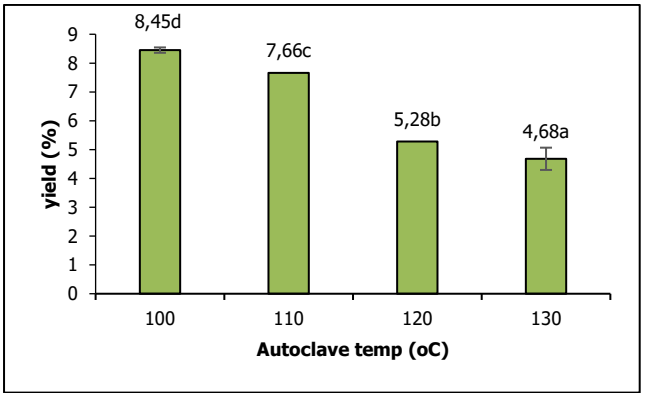

Figure 3. Extraction yield of galactomannan from dried grated coconut as affected by varying autoclaving pretreatment temperatures.

Effect on Reducing Sugars Content

The reducing sugar content of the galactomannan extracted from dried grated coconut in this study ranged from 14.73% to 18.31% (Fig.4), indicating that autoclaving temperature markedly influenced the extent of hydrolysis during pretreatment. The highest reducing sugar content was obtained at 100 °C (18.31%), whereas the lowest value was observed at 130 °C (14.37%). The decline in reducing sugar content at elevated temperatures suggests that excessive thermal input may not favor the formation or stability of reducing sugars. A similar trend has been reported by Suhaela *et al*., (2017), who observed that reducing sugar concentrations tends to decrease as heating temperature increases. This behavior is likely associated with thermal degradation, secondary reactions such as caramelization, or further conversion of reducing sugars into non-detectable intermediates.

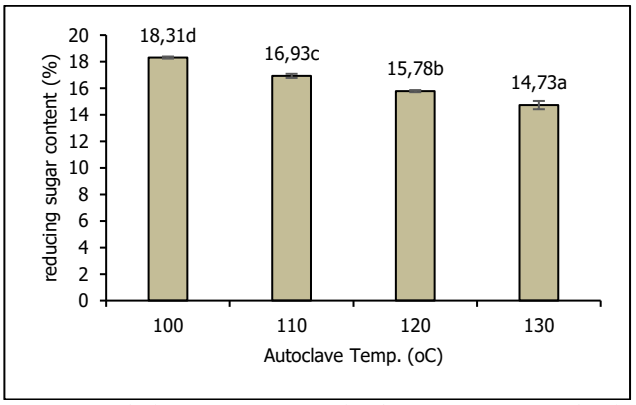

Figure 4. Reducing sugar content of galactomannan extracted using different autoclave pretreatment temperatures.

The results of this study align with findings by Nasrullah *et al*. (2020), who reported reducing sugar yields of 0.22–0.46 g/g dry basis from autoclave-assisted hydrolysis of glucomannan, equivalent to approximately 22–46% of the material being converted into reducing sugars. Their work also demonstrated that autoclave-based hydrolysis produces a higher reducing sugar yield than microwave-assisted hydrolysis, underscoring the effectiveness of moist-heat treatment in breaking down polysaccharide structures. Statistical analysis (Fig. 2) confirmed that autoclaving temperature had a significant effect on reducing sugar formation. According to Nasrullah *et al*. (2020), autoclave heating promotes extensive hydrolysis of polysaccharides, generating substantial amounts of reducing sugars; however, this method is less effective in degrading fibrous components, which may remain as insoluble residues. Moreover, autoclave-assisted hydrolysis is known to promote the formation of secondary by-products such as hydroxymethylfurfural (HMF), which may compete with reducing sugars in subsequent reactions.

The relationship between reducing sugar concentration and absorbance further supports the observed trend. As reported by Bahri and Sosidi (2020), higher reducing sugar levels increase the formation of 3-amino-5-nitrosalicylic acid during colorimetric analysis, consequently raising sample absorbance. Thus, the statistical differences among treatments can be attributed to the combined effects of thermal hydrolysis, sugar

degradation pathways, and analytical detection mechanisms.

Swelling Power Analysis

Swelling power refers to the ability of a material to absorb water and expand under specific conditions, particularly during heating. This property is influenced by factors such as temperature, pH, and the molecular structure of the material. The swelling power test provides information on the amount of water absorbed by one gram of starch granules under excess-water conditions at elevated temperatures (Kumoro et al., 2019). Based on Figure 5, the swelling power of galactomannan extracted under different autoclave pretreatment temperatures ranged from 6.47 to 8.71 g/g. The highest value was observed at 100°C (8.71 g/g). Mandala dan Bayas (2004) noted that temperatures above 80°C promote granule swelling accompanied by partial disruption of crystalline regions. Conversely, the lowest swelling power was recorded at 130°C (6.47 g/g). The reduction in swelling capacity at higher temperatures suggests that excessive autoclave heat can induce degradation of the material, resulting in a denser galactomannan structure that is less capable of absorbing water.

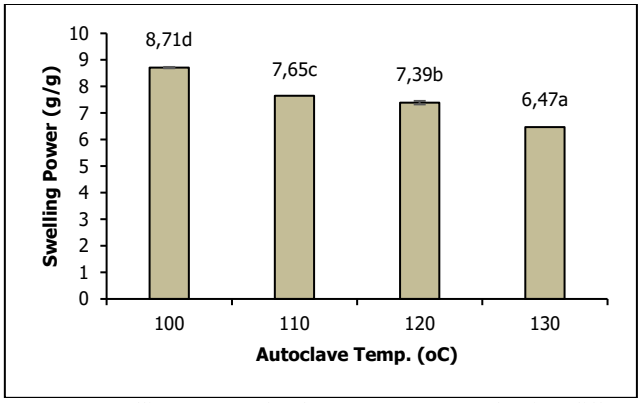

Figure 5. Swelling power of galactomannan extracted using different autoclave pretreatment temperatures.

According to Al Bukhori *et al*. (2019), swelling power increases following hydrolysis because the shortened amylose and amylopectin chains can bind more water. Statistical analysis in this study confirmed that autoclave pretreatment temperature had a significant effect on swelling power. High heating temperatures and pressurized steam inside the autoclave are likely to reduce granule expansion. Swelling behavior is closely linked to the charge distribution and the degree of polymer matrix relaxation, which depend on the internal arrangement of the polymer. A higher degree of crosslinking restricts structural expansion, thereby reducing swelling power (Ibrahim et al., 2025).

Effect on Product Colour

The lightness (L) values presented in Table 2 show a consistent decline with increasing autoclave temperature. The different autoclave pretreatment temperatures significantly affected the L value of the extracted galactomannan. The highest lightness was observed at 100 °C (L = 53.44), while the lowest occurred at 130 °C (L = 46.26). This trend indicates that higher temperatures lead to a darker galactomannan product. The darkening of galactomannan can be attributed to Maillard reactions and thermal degradation. Elevated heating promotes reactions between reducing sugars and amino acids, especially as the removal of moisture during heating accelerates browning. This process leads to the formation of ketoseamines, which subsequently undergo Maillard and Strecker reactions, producing brown melanoidin pigments (Pelealu *et al*., 2011). The intensity of color changes is influenced by both the duration and temperature of heating, as well as the chemical composition of the material's surface (Helmi *et al*., 2021).

Table 2. Color analysis of galactomannan extracted under different autoclave pretreatment temperatures.

Autoclave Temp (°C)	L	a*	b*
100	53,44± 1.02^{c}	5,84± 0.39^{a}	9,09± 0.73^{c}
110	49,38± 0.60^{b}	5,66± 0.18^{a}	8,22± 0.72^{bc}
120	47,47± 0.27^{a}	5,55± 0.20^{a}	6,77± 0.26^{ab}
130	46,26±0.11^{a}	5,28± 0.24^{a}	5,25± 0.33^{a}

The a and b values also showed notable changes with increasing autoclave temperature, indicating shifts in the red–green and yellow–blue chromatic dimensions of the galactomannan. The a values increased slightly at higher temperatures, suggesting a shift toward the red chromatic axis. Meanwhile, the b values showed a decreasing trend as the temperature increased, indicating reduced yellowness in the final product. These patterns collectively support the conclusion that higher thermal treatment intensifies browning reactions and alters pigment development.

The increase in a values aligns with the progression of Maillard reactions, which typically generate reddish–brown intermediates and end-products. The decline in b values may be associated with the degradation of native pigments or chromophores during prolonged heating, consistent with the thermal susceptibility of polysaccharide matrices. Similar trends were reported by Helmi *et al*. (2021),, who found that increasing thermal intensity promotes browning while diminishing yellow tones in carbohydrate-rich materials. Statistical analysis confirmed that autoclave temperature had a significant effect on all color parameters (L*, a*, b*). These findings demonstrate that thermal pretreatment not only influences extraction efficiency but also directly impacts the visual attributes of the resulting galactomannan, which may affect its suitability for specific industrial applications—particularly those requiring color stability.

Functional Groups of Galactomannan Extraction Product

The FTIR spectrum of the extracted product exhibits characteristic absorption bands typical of polysaccharide-based materials, confirming the presence of galactomannan as the major component (Fig. 6). A broad and intense band observed around 3200–3400 cm^{-1} corresponds to O–H stretching vibrations, which are associated with the abundant hydroxyl groups in the mannose and galactose units of the galactomannan backbone (Aquino et al., 2025). The breadth of this band indicates extensive intermolecular and intramolecular hydrogen bonding, a common feature of hydrocolloid polysaccharides. Absorption bands detected near 2920–2850 cm^{-1} are attributed to C–H stretching vibrations of aliphatic –CH and $–CH_2$ groups, reflecting the carbohydrate ring structure (Elangovan et al., 2023). The absence of strong absorption in the 1700–1750 cm^{-1} region suggests a low content of carbonyl-containing impurities such as esters or carboxylic acids (Kouadri et al., 2018), indicating that the extraction process did not introduce significant oxidative degradation.

A noticeable band around 1600–1650 cm^{-1} can be associated with bound water (H–O–H bending) or minor contributions from residual protein components. The region 1400–1450 cm^{-1} is linked to C–H bending vibrations, further supporting the polysaccharide structure. The most diagnostic features appear in the fingerprint region (1200–900 cm^{-1}), where several strong absorption peaks are observed. These bands are assigned to C–O, C–O–C, and C–O–H stretching vibrations of glycosidic linkages and pyranose ring structures (Elangovan et al., 2023). The prominent peaks in this region confirm the presence of β-(1→4)-mannan backbone linkages with galactose side groups, which are structural hallmarks of galactomannan.

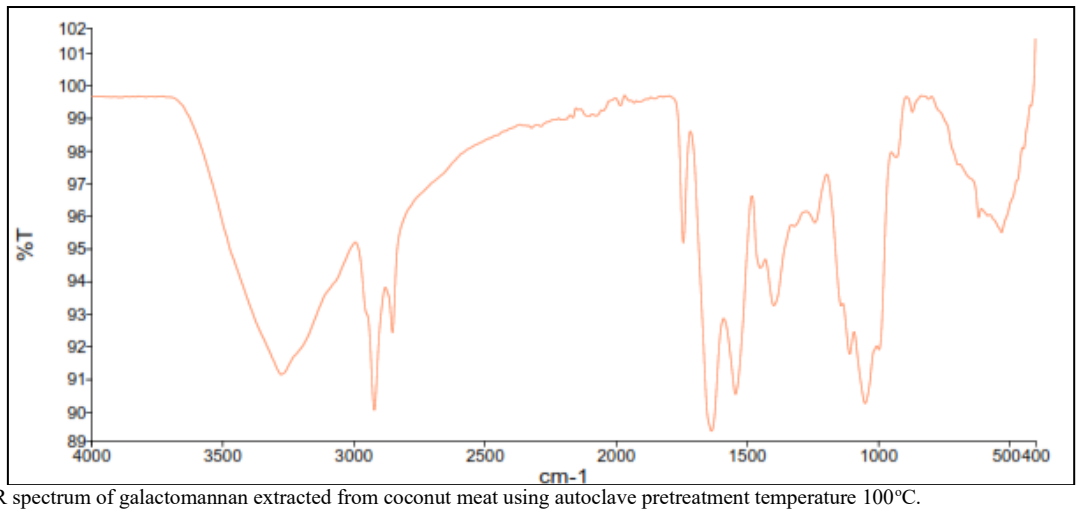

Figure 6. FTIR spectrum of galactomannan extracted from coconut meat using autoclave pretreatment temperature 100°C.

CONCLUSIONS

This study demonstrated that autoclave pretreatment temperature has a significant influence on the extraction performance and physicochemical properties of galactomannan derived from coconut meat. Among all temperature treatments, 100°C produced the most optimal results, yielding the highest extraction yield (8.45%), swelling power (8.67 g/g), reducing sugar content (18.03%), and the lightest color (L* = 53.44). Statistical analysis confirmed that increasing the autoclave temperature led to a significant decrease in yield, swelling ability, and reducing sugar levels, indicating that excessive heat promotes thermal degradation and partial hydrolysis of galactomannan. These findings highlight that 100°C is the optimal autoclave pretreatment temperature for preserving the structural integrity of galactomannan while maximizing extraction efficiency. Future studies may explore the combined effects of pretreatment temperature with other variables such as autoclaving duration, pressure level, or pH adjustment to further optimize extraction efficiency. Additionally, examining the molecular structure, functional properties, and rheological behavior of the extracted galactomannan under different pretreatment conditions would provide deeper insight into its suitability for specific industrial applications. Investigating alternative, environmentally friendly pretreatment techniques, such as steam explosion or enzymatic-assisted extraction, may also offer valuable comparisons for improving yield and product quality.

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Competing Interests: The authors declare that there are no competing interests.

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