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PHYSICOCHEMICAL CHARACTERISTICS OF GUM ARABIC FROM *Acacia Mearnsii* GROWN IN ALAHAN PANJANG, WEST SUMATERA

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ABSTRAK

Gum akasia yang dihasilkan oleh spesies tanaman *Acacia mearnsii* merupakan bahan alami yang memiliki potensi besar untuk berbagai aplikasi industri karena sifat fisikokimianya yang unik. Penelitian ini bertujuan untuk mengkarakterisasi gum dari tanaman *Acacia mearnsii* yang tumbuh di Alahan Panjang, Sumatera Barat. Karakterisasi dilakukan menggunakan teknik *Fourier Transform Infrared Spectroscopy* (FTIR), *X-Ray Fluorescence* (XRF), dan *X-Ray Diffraction* (XRD). Hasil FTIR mengungkapkan keberadaan gugus hidroksil (-OH), karbonil (-C=O), dan glikosidik (C-O-C), yang mengindikasikan struktur polisakarida kompleks pada senyawa gum yang dianalisis. Analisis XRF menunjukkan dominasi kalsium oksida (CaO) dengan konsentrasi 81,652%, diikuti oleh kalium oksida (K_2O) sebesar 10,052% dan fosfat (P_2O_5) sebesar 6,341%. Sementara itu, pola difraksi XRD mengidentifikasi difraksi yang mendekati amorf dengan beberapa puncak kristal yang lemah. Kombinasi hasil ini menunjukkan bahwa gum akasia memiliki sifat kimia dan fisik yang mendukung penggunaannya sebagai bahan pengemulsi, pengental, dan pengisi dalam berbagai industri, seperti pangan, farmasi, dan kosmetik.

Kata kunci:
Fisikokimia
Gum akasia
X-ray

ABSTRACT

Acacia gum produced from *Acacia mearnsii* is a natural material with great potential for various industrial applications due to its unique physicochemical properties. This study aimed to characterize gum acacia from Alahan Panjang, West Sumatra. Characterizatio was done using Fourier Transform Infrared Spectroscopy (FTIR), X-ray fluorescence (XRF), and X-ray diffraction (XRD) techniques. FTIR results revealed the presence of hydroxyl (-OH), carbonyl (-C=O), and glycosidic (C-O-C) groups, indicating the complex polysaccharide structure of the gum. XRF analysis showed the dominance of calcium oxide (CaO) with a concentration of 81.652%, followed by potassium oxide (K_2O) at 10.052% and phosphate (P_2O_5) at 6.341%. Meanwhile, the XRD diffraction pattern identified a near amorphous diffraction with some weak crystalline peaks. This combination of results suggests that gum acacia has chemical and physical properties that support its use as an emulsifier, thickener, and filler in various industries, such as food, pharmaceutical, and cosmetics.

Keywords:
Acacia gum
Physicochemical
X-ray

INTRODUCTION

The acacia tree is a plant that has ability to grow in various types of climates, including tropical and subtropical regions. The tree can grow quickly and has a deep root system, allowing it to survive in areas with limited water availability. The acacia tree generally has a hard trunk that is greyish-brown in colour, with branches that often form in a distinctive pattern. The wood from the acacia tree is generally hard and durable, making it often used as a building material, for furniture making, and even as fuel. In addition, another equally important potential is the gum or resin produced from the acacia trunk, which forms as a biological response to stress or damage to the tree's tissue.

Acacia gum (*Acacia mearnsii*) is a natural substance widely used in the food, pharmaceutical, and cosmetic industries due to its unique physicochemical properties. This gum contains complex polysaccharides with the ability to form gels, high solubility in water, and stability in various pH conditions. These properties make it an important ingredient as an emulsifier, stabilizer, and thickener in various products. The uniqueness of acacia gum is influenced by the geographical location and environmental conditions where it grows, which affect its chemical composition and physical properties. (El-Mohdy, 2019; Eltahir *et* al., 2020).

Alahan Panjang region, West Sumatra, has agroclimatic conditions that support the growth of *Acacia mearnsii*, such as mineral-rich volcanic soil and high rainfall. These conditions can affect the chemical compound content in the gum, including mineral levels such as calcium, potassium, and phosphorus, which contribute to its quality and characteristics. However, research on the physicochemical properties of acacia gum from this region is still limited, so in-depth studies are needed to identify its potential benefits and applications (Rahmawati *et* al., 2020; Hossain *et* al., 2021).

Analytical techniques such as Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Fluorescence (XRF), and X-Ray Diffraction (XRD) play an important role in the characterization of acacia gum. FTIR is used to identify the functional groups present in acacia gum, such as hydroxyl (-OH), carbonyl (-C=O), and other groups, which are important for understanding the chemical properties and molecular interactions in the gum. XRF provides quantitative information about the mineral elements present, while XRD is used to identify the crystalline structure in the gum. The combination of these three techniques allows for a deeper understanding of the physicochemical properties of acacia gum, which can be used for applications in various industries, including food and pharmaceuticals (Hossain *et* al., 2021; Faryadi *et* al., 2023).

MATERIAL AND METHODS

Acacia gum sample was harvested from trees that were more than 5 years old. The hardened gum was collected and put into plastic. The gum's mineral content was analysed using the X-ray fluorescence Spectrometer EPSILON-3 (PANalytical) technique while their crystallinity properties were analysed using an X-ray diffractometer (Xpert Powder PANalytical PW 30/40). The operating conditions were run at 40 kV and 30 mA, with the scanning angle 2θ set from 5^o to 50^o at a scanning rate of 0.002^o/s and a scanning step of 0.02^o. The crystallinity was measured by the per cent ratio between the diffraction peak and the total diffraction area, and the functional group analysis and compound characteristics analysis were observed using a Fourier Infra-Red Spectrometer Frontier (Perkin Elmer).

RESULTS AND DISCUSSION

XRF (X-Ray Fluorescence)

Based on the mineral composition of gum acacia was analyzed using the X-ray fluorescence (XRF) method. This method has several advantages, including the relatively small sample required (about 1 g), the fact that it does not require standards in conducting the analysis, high accuracy and precision, and the fact that it can determine almost all mineral content in biological materials that can be directly known results.

Table 1. Mineral content in percent (%) of gum acacia using XRF analysis

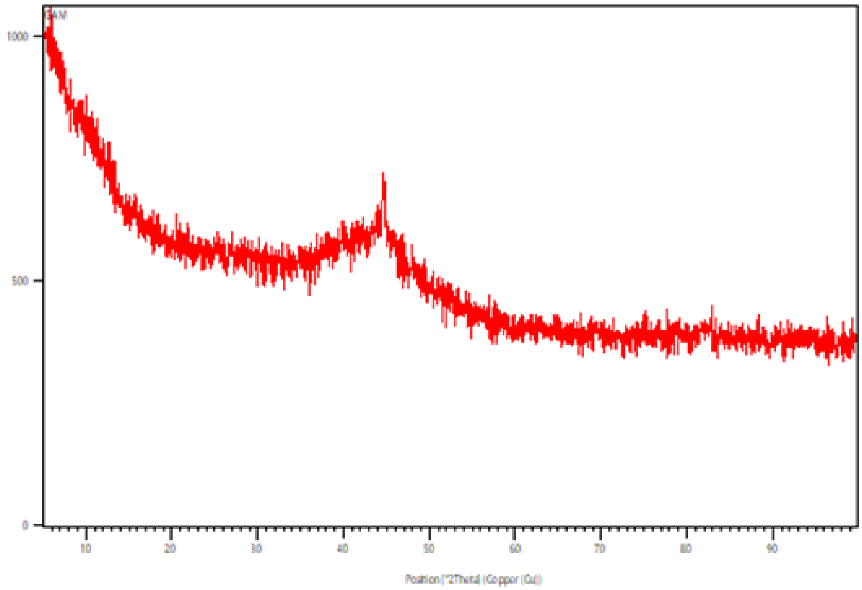
Element		Geology		Oxides	
Compound	**Conc**	**Compound**	**Conc**	**Compound**	**Conc**
Al	0	Al_2O_3	0	Al_2O_3	0
P	1.011	P_2O_5	6.341	P_2O_5	6.331
K	10.984	K_2O	10.052	K_2O	10.031
Ca	85.352	CaO	81.652	CaO	81.438
Mn	0.269	Mn	0.166	MnO	0.214
Fe	0.405	Fe_2O_3	0.358	Fe_2O_3	0.357
Zn	0.091	Zn	0.056	ZnO	0.07
Ag	0.956	Ag	0.736	Ag_2O	0.789
In	0.932	In	0.639	In_2O_3	0.771

Table 1 shows that the highest mineral content in gum acacia is calcium, with a CaO compound concentration of 81.652%. The high calcium content indicates structural strengthening properties and thermal stability in gum-based materials. In addition, calcium oxide is often used in industrial applications such as fillers in composites and as a pH-regulating agent in pharmaceutical products (Eltahir *et* al., 2020; Hossain *et* al., 2021). The addition of calcium oxide (CaO) into the gum acacia matrix has the potential to strengthen the material structure through a cross-linking mechanism. Calcium ions (Ca^{2+}) from CaO can interact with carboxylic groups (-COO) or hydroxyl groups (-OH) in the gum polymer, forming cross-links that increase the density of the polymer network. Previous studies on alginate and carrageenan showed that increasing the concentration of Ca^{2+} ions resulted in better mechanical properties, including increased elastic modulus and tensile strength (Ridlo *et* al., 2023)

Furthermore, the content of potassium and phosphorus minerals with a concentration of K_2O compounds of 10.052% and P_2O_5 compounds of 6.341%. Potassium can play a role in stabilizing the molecular structure of gum polysaccharides, increasing their ability as emulsifiers or thickeners (Rahmawati *et* al., 2020). Phosphate is often used as an emulsifier or pH regulator (El-Mohdy, 2019). Compounds found in small but relevant amounts of Mn and Zn may exert a natural preservative effect (Smith *et* al., 2020), while Fe may contribute to the gum's color properties or thermal stability. Although relatively low in content, compounds such as Ag_2O and In_2O_3 indicate the possible presence of minor metallic elements that could be a sign of the environment or soil conditions in which the tree grows (Faryadi *et* al., 2020).

XRD (X-Ray Diffractometer)

The crystallinity of gum acacia can be determined using the X-ray diffraction method so that the integration of the curves under the peaks of the amorphous and crystalline regions can be determined. The XRD diffraction pattern shows sharp and well-defined diffraction peaks, indicating a crystalline structure. Based on the XRD results, gum acacia showed a near-amorphous diffraction pattern with some weak crystalline peaks. The diffraction pattern shows the distribution of polymeric material with minor crystalline components that may be derived from the mineral content or other inorganic compounds in the gum. Weak peaks observed at certain 2θ angles indicate the presence of mineral components such as calcium and potassium, which were also confirmed in XRF analysis. Significant peaks appeared at 2θ angles of about 30°, 45°, and 65°, which correspond to the phase of calcium carbonate ($CaCO_3$) and some other minerals.



Picture 1. X-ray diffraction pattern of gum acacia

The predominance presence of calcium oxide (CaO) in the XRF data is consistent with the XRD diffraction patterns, indicating the presence of calcium-based minerals. This combination of results suggests that the acacia gum samples have chemical and physical characteristics suitable for applications such as fillers in the composite industry or adhesives.

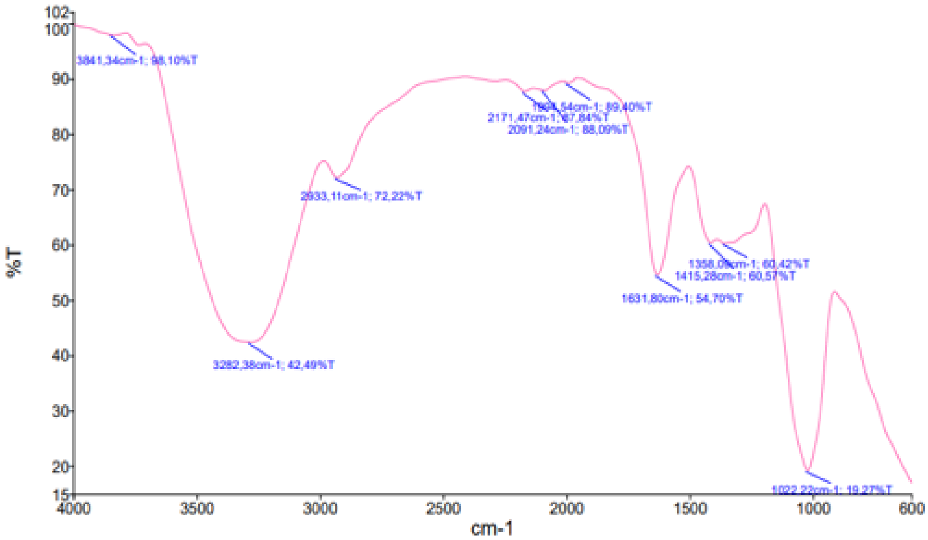
FTIR (Fourier Infra Red Spectrometer Frontier)

The FTIR spectrum of gum acacia showed major absorption peaks, indicating the presence of functional groups typical of polysaccharides, which can be seen in Table 2.

Tabel 2. Functional group data on FTIR in gum of *Acacia mearnsii*

Absorption Peak (cm^{-1})	Connected Function Group	Interpretation
3282.38	O-H Stretching	Hydroxyl group, indicating hydrophilic nature and hydrogen bonding involvement.
2933.11	C-H Stretching	Alkane group (-CH), indicating a hydrocarbon chain.
1631.80	C=O Stretching	Carbonyl groups, derived from esters or carboxylic acids..
1022.22	C-O Stretching, C-O-C Vibrations	Glycosidic group, signifying a polysaccharide structure.

The peak at 3282.38 cm^{-1} confirms the hydrophilic nature of gum, which contributes to its solubility in water. The peak at 1022.22 cm^{-1} signifies typical glycosidic bonds in polysaccharide structures, supporting its use as an emulsifier and thickener in industrial products (Eltahir *et* al., 2020; Faryadi *et* al., 2023). The presence of carbonyl and hydrocarbon groups indicates the chemical versatility of gum, which is essential for a wide range of applications.



Picture 2. FTIR spectra of acacia gum (Acacia Mearnsii)

CONCLUSION

FTIR, XRF and XRD analysis results revealed that gum from *Acacia mearnssi* grown in Alahan Panjang has complex and versatile physicochemical properties. The polysaccharide functional groups, high calcium oxide content, and crystalline phase of calcium carbonate make this gum suitable for applications as emulsifiers, thickeners, and fillers in the food, pharmaceutical, and cosmetic industries.

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