

Chemical characterisation of six wood species from Côte d'Ivoire: macromolecular composition, extractives yields and profiling by GC-MS and FTIR

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Photo 1.
Sampling site of trees.
Photo H. A. A. Ouattara.

Doi : 10.19182/bft2026.363.a37970 – Droit d'auteur 2026, Bois et Forêts des Tropiques – Cirad – Date de soumission : 25 septembre 2025 ; date d'acceptation : 5 janvier 2026 ; date de publication : 1^{er} mars 2026.



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Citer l'article / To cite the article

Ouattara, H. A. A., N'guessan, J. L. L., Niamké, B. F., Ahoké, M. E. M. F., Yao, N. J. C., Amusan, N., Adima, A. A. (2026). Chemical characterisation of six wood species from Côte d'Ivoire: macromolecular composition, extractives yields and profiling by GC-MS and FTIR. Bois et Forêts des Tropiques, 363 : 1-22. Doi: <https://doi.org/10.19182/bft2026.363.a37970>

RÉSUMÉ

Caractérisation chimique de six essences de bois de Côte d'Ivoire : composition macromoléculaire, rendements en extraits et profilage par GC-MS et FTIR

Cette étude visait à caractériser les extraits de six essences de bois durs tropicaux de Côte d'Ivoire, notamment *Milicia excelsa* (iroko), *Khaya ivorensis* (acajou), *Triplochiton scleroxylon* (samba), *Gmelina arborea* (gmelina), *Piptadeniastrum africanum* (dabema) et *Acacia mangium* (acacia) par quantification macromoléculaire, FTIR et analyses GC-MS. Les objectifs étaient d'évaluer les rendements d'extraction en fonction du solvant, d'identifier et de classer les principaux groupes d'extraits, d'évaluer la composition en polysaccharides et en lignine des différentes espèces, et de mettre en évidence les métabolites d'importance industrielle et biologique, y compris ceux rapportés ici pour la première fois. Les rendements d'extraction variaient considérablement d'une espèce à l'autre. *Gmelina arborea* (gmelina) affichait les niveaux les plus élevés, dépassant 10 %, en particulier dans les fractions de dichlorométhane riches en composés polaires. L'iroko et l'acajou présentaient des rendements intermédiaires compris entre 6 et 8 %, enrichis en fractions phénoliques, tandis que le dabema, l'acacia et le samba produisaient des quantités plus faibles. Les spectres FTIR ont révélé des absorptions caractéristiques d'hydroxyle, de carbonyle et d'aromatiques, en accord avec les familles chimiques confirmées par GC-MS. Cette analyse a permis d'identifier une grande diversité de métabolites tels que la chlorophorine, la catéchine, le resvératrol, le lupéol, le gmelinol et les principaux acides gras, notamment les acides palmitique et stéarique. Il convient de noter que le gmelinol dans *Gmelina arborea* et l'oxyresvératrol dans l'iroko sont signalés ici pour la première fois dans les bois durs ivoiriens. En outre, les teneurs en polysaccharides et en lignine variaient considérablement d'une espèce à l'autre. La cellulose variait de 29,65 % dans l'iroko à 42,01 % dans l'acacia, l'holocellulose s'étendait de 69,33 % dans le dabema à 74,69 % dans l'acacia, et la lignine fluctuait entre 21,54 % dans l'acacia et 28,49 % dans le gmelina. Ces variations reflètent les différences interspécifiques dans la structure du bois et peuvent expliquer en partie la diversité des profils extractifs et de la durabilité. Dans l'ensemble, les résultats soulignent le potentiel bioactif significatif des bois durs ivoiriens et soutiennent la valorisation des sous-produits des scieries en tant que sources durables de composés à haute valeur ajoutée.

Mots-clés : *Milicia excelsa* (iroko), *Khaya ivorensis* (acajou), *Triplochiton scleroxylon* (samba), *Gmelina arborea* (gmelina), *Piptadeniastrum africanum* (dabema), *Acacia mangium* (acacia), GC-MS, FTIR, bois tropical, extrait de bois, composition du bois, Côte d'Ivoire.

ABSTRACT

Chemical characterisation of six wood species from Côte d'Ivoire: macromolecular composition, extractives yields and profiling by GC-MS and FTIR

This study aimed to characterise extracts from six tropical hardwoods of Côte d'Ivoire, notably *Milicia excelsa* (iroko), *Khaya ivorensis* (mahogany), *Triplochiton scleroxylon* (samba), *Gmelina arborea* (gmelina), *Piptadeniastrum africanum* (dabema), and *Acacia mangium* (acacia), through macromolecular quantification, FTIR, and GC-MS analyses. The objectives were to evaluate solvent-dependent extraction yields, to identify and classify major groups of extractives, to assess polysaccharide and lignin composition across species, and to highlight metabolites of industrial and biological significance, including those reported here for the first time. Extraction yields varied markedly among species. *Gmelina arborea* (gmelina) displayed the highest levels, exceeding 10%, particularly in dichloromethane fractions rich in polar compounds. Iroko and mahogany showed intermediate yields between 6 and 8%, enriched in phenolic fractions, while dabema, acacia, and samba produced lower amounts. FTIR spectra revealed characteristic hydroxyl, carbonyl, and aromatic absorptions, in agreement with the chemical families confirmed by GC-MS. This analysis identified a wide diversity of metabolites, such as chlorophorin, catechin, resveratrol, lupeol, gmelinol, and major fatty acids, including palmitic and stearic acids. Notably, gmelinol in *Gmelina arborea* and oxyresveratrol in iroko are reported here for the first time in Ivorian hardwoods. In addition, the polysaccharide and lignin contents varied considerably among species. Cellulose ranged from 29.65% in iroko to 42.01% in acacia, holocellulose extended from 69.33% in dabema to 74.69% in acacia, and lignin fluctuated between 21.54% in acacia and 28.49% in gmelina. These variations reflect interspecific differences in wood structure and may partly account for the diversity of extractive profiles and durability. Overall, the results highlight the significant bioactive potential of Ivorian hardwoods and support the valorisation of sawmill by-products as sustainable sources of high value-added compounds.

Keywords: *Milicia excelsa* (iroko), *Khaya ivorensis* (mahogany), *Triplochiton scleroxylon* (samba), *Gmelina arborea* (gmelina), *Piptadeniastrum africanum* (dabema), *Acacia mangium* (acacia), GC-MS, FTIR, tropical wood, wood extract, wood composition, Côte d'Ivoire.

RESUMEN

Caracterización química de seis especies de madera de Costa de Marfil: composición macromolecular, rendimiento de extractos y perfilado mediante GC-MS y FTIR

El objetivo de este estudio era caracterizar los extractos de seis maderas duras tropicales de Costa de Marfil, en concreto *Milicia excelsa* (iroko), *Khaya ivorensis* (caoba), *Triplochiton scleroxylon* (samba), *Gmelina arborea* (gmelina), *Piptadeniastrum africanum* (dabema) y *Acacia mangium* (acacia), mediante cuantificación macromolecular, FTIR y análisis GC-MS. Los objetivos eran evaluar los rendimientos de extracción dependientes del disolvente, identificar y clasificar los principales grupos de extractos, evaluar la composición de polisacáridos y lignina en todas las especies y destacar los metabolitos de importancia industrial y biológica, incluidos los que se describen aquí por primera vez. Los rendimientos de extracción variaron notablemente entre las especies. *Gmelina arborea* (gmelina) presentó los niveles más altos, superiores al 10 %, especialmente en fracciones de diclorometano ricas en compuestos polares. El iroko y la caoba mostraron rendimientos intermedios entre el 6 % y el 8 %, enriquecidos en fracciones fenólicas, mientras que la dabema, la acacia y la samba produjeron cantidades menores. Los espectros FTIR revelaron absorciones características de hidroxilo, carbonilo y aromáticas, en consonancia con las familias químicas confirmadas por GC-MS. Este análisis identificó una amplia diversidad de metabolitos, como clorofirina, catequina, resveratrol, lupeol, gmelinol y ácidos grasos principales, incluidos los ácidos palmítico y esteárico. Cabe destacar que el gmelinol en *Gmelina arborea* y el oxi-resveratrol en el iroko se describen aquí por primera vez en las maderas duras de Costa de Marfil. Además, el contenido de polisacáridos y lignina varió considerablemente entre las especies. La celulosa osciló entre el 29,65 % en el iroko y el 42,01 % en la acacia, la holocelulosa se extendió desde el 69,33 % en la dabema hasta el 74,69 % en la acacia, y la lignina fluctuó entre el 21,54 % en la acacia y el 28,49 % en la gmelina. Estas variaciones reflejan diferencias interspecíficas en la estructura de la madera y pueden explicar en parte la diversidad de perfiles extractivos y la durabilidad. En general, los resultados ponen de relieve el importante potencial bioactivo de las maderas duras de Costa de Marfil y respaldan la valorización de los subproductos de los aserraderos como fuentes sostenibles de compuestos de alto valor añadido.

Palabras clave: *Milicia excelsa* (iroko), *Khaya ivorensis* (caoba), *Triplochiton scleroxylon* (samba), *Gmelina arborea* (gmelina), *Piptadeniastrum africanum* (dabema), *Acacia mangium* (acacia), GC-MS, FTIR, madera tropical, extracto de madera, composición de la madera, Costa de Marfil.

Introduction

Wood is a natural material produced by trees and is defined differently by each user according to their interests. There are two main categories of trees: coniferous and deciduous. Within the same species and depending on geographical origin and position in the tree, the chemical composition of the wood and its physical and mechanical properties vary with the species (Haddadou et al., 2012). Wood consists mainly of three polymers: cellulose, hemicellulose, and lignin. It also contains low-molecular-weight organic substances known as extractives or secondary metabolites, as well as inorganic substances corresponding to the ash obtained after wood combustion (Niamké et al., 2021). Although macromolecules are present in large quantities in wood, there is little difference in the chemical structure of the three main constituents of wood, i.e., cellulose, lignin and hemicelluloses, in contrast to the wide variation in the composition of extractives from one species to another (Hon & Shiraishi, 2000), which reinforces the importance of quantifying and determining them to enhance their value. Extractives are found in the porous structure of wood and are even more concentrated in the heartwood. They can be readily extracted using appropriate solvents (organic, aqueous, etc.) (Launay, 2017). Indeed, Côte d'Ivoire is a wood-producing and exporting country. Côte d'Ivoire exported 315,114,948 m³ of timber, according to the 2017 activity report of the *Direction de la Production et de l'Industrie Forestière* (DPIF, Forestry Production and Industry Directorate) of the Ministry of Water and Forests. In Côte d'Ivoire, there are 387 *Périmètres d'Exploitation Forestière* (PEF, Forestry Operation Area), constituting the rural domain and covering an area of around 14,210,096 ha, or 44% of the national territory, for a theoretical annual logging quota estimated at 3,553,846.15 m³. The timber harvested in these logging areas generates substantial environmental waste, from companies in primary processing (felling, sawing, slicing, peeling) to tertiary processing (joineries, etc.). Wood residues of no value to these companies are burnt, buried, or disposed of in the natural environment as waste, thereby contributing to pollution of air, surface water, and soil. In particular, the city of Yamoussoukro, with 39 logging perimeters, produces 292,840,412 m³ of wood, or 7,508,128 per PEF according to the 2017 activity report of the DPIF, which produces significant quantities of wood "waste" (N'guessan et al., 2023). This study aimed to add value to wood waste produced and otherwise neglected by the industry and, at the same time, to address an environmental problem: pollution. To do this, we first had to determine the types of wood used in this industry, then identify the chemical properties of this wood waste, and finally develop a more effective method for its recovery. To

this end, a survey was carried out among carpenters in the town of Yamoussoukro, after which we selected the wood and trained the carpenters to collect, store and transport the sawdust by wood species for chemical analysis at the *Institut National Polytechnique Felix Houphouët Boigny* (INP-HB, Felix Houphouët Boigny National Polytechnic Institute) in Yamoussoukro, to quantify the macromolecules in this sawdust, quantify sawdust extractives and determine the chemical and functional properties of the extractives contained in each of the wood species collected, with a view to better valorising these compounds.

Material and methods

Material

The experiments were conducted on heartwood sawdust from six (6) Côte d'Ivoire tree species that are frequently received and worked by carpenters in the town of Yamoussoukro. The tree species from which the heartwood sawdust was collected are as follows: mahogany sawdust (*Khaya ivorensis*), dabema sawdust (*Piptadeniastrum africanum*), acacia sawdust (*Acacia mangium*), samba sawdust (*Triplochiton scleroxylon*), gmelina sawdust (*Gmelina arborea*), and white iroko sawdust (*Milicia excelsa*).

Methods

Sampling

Sawdust was collected from the central board (4 m in length and 4 cm in thickness) obtained from the heartwood of each species, using three boards per species (figure 1). The moisture content of sawdust was estimated at approxi-

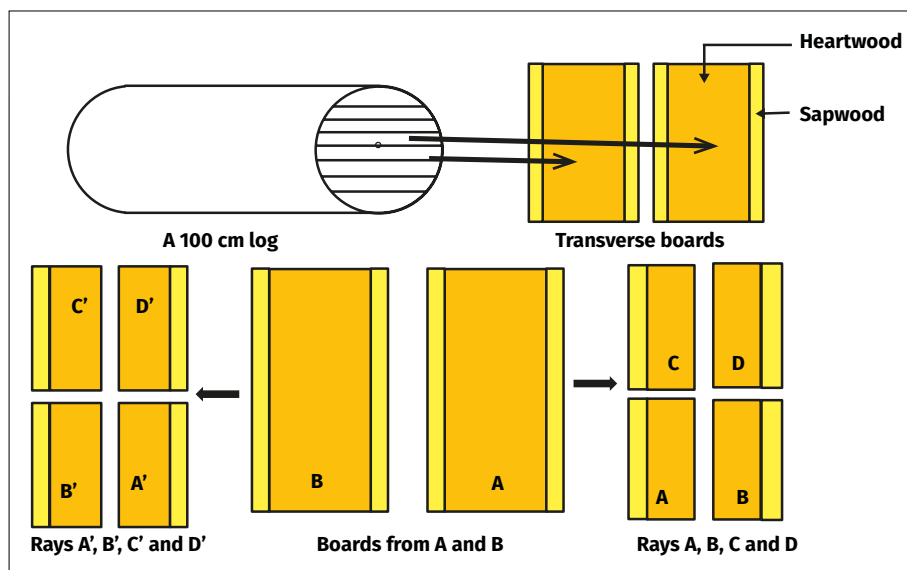


Figure 1.

Sampling plan for wood planks. The light yellow corresponds to the sapwood, and the dark yellow to the heartwood.

mately 15%. This value was determined by the oven-dry method at $103 \pm 2 \text{ }^{\circ}\text{C}$ until a constant mass was reached, in accordance with the procedure described by N'guessan et al. (2025).

These samples were stored in bags designed for sample collection and storage. These bags were supplied to carpenters during their training on the collection and storage of wood samples at INP-HB. The wood heartwood samples were stabilised for 24 h at $22 \text{ }^{\circ}\text{C}$ and 65% relative humidity in a dedicated room at the INP-HB laboratory of natural substances chemistry. For further analysis, the samples were ground separately by species using the same Retsch SM100 mill (Retsch® group, Haan, Germany), then sieved to a particle size of $\phi = 0.160 \text{ mm}$ to facilitate extraction and optimise extraction yields.

Extraction and quantification of extractives from sawdust

The sawdust extraction was successively performed in a Soxhlet apparatus using 10 g of pre-dried heartwood sawdust placed in cartridges and 150 mL of solvents of increasing polarity: dichloromethane (99.9%, Carlo Erba), acetone (99.9%, Carlo Erba), a toluene (99.5%, Carlo Erba)/ethanol (96%, Carlo Erba) mixture (2/1, v/v), and ultrapure water produced by a PURELAB Option Q purification system (Elga). Each extraction was carried out for 24 hours at the specific reflux temperature of each solvent: $45 \text{ }^{\circ}\text{C}$

for dichloromethane, $60 \text{ }^{\circ}\text{C}$ for acetone, and $103 \text{ }^{\circ}\text{C}$ for the toluene/ethanol and water mixtures. All extractions were performed in triplicate. After extraction, the solvent was evaporated under vacuum using a rotary evaporator. The bottom of the balloons, still containing a small amount of solvent-extract mixture, was transferred to pre-weighed pillboxes, then allowed to evaporate under heat at $50 \text{ }^{\circ}\text{C}$ until a constant mass was obtained:

$$\text{Extract content (\%)} = \frac{M(p+e) - M_p}{M_s} \times 100 \quad (\text{Equation 1})$$

$M(p+e)$ is the mass of the pill dispenser with extracts, M_p is the mass of the empty pillbox, and M_s represents the mass of the oven-dried sawdust before each extraction.

Klason lignin content of sawdust

The protocol for determining Klason lignin in sawdust follows Sluiter (2008) and was repeated in triplicate. $300 \pm 10 \text{ mg}$ of sawdust stripped of its extractives and dried for at least 48 h at $103 \text{ }^{\circ}\text{C}$ was placed in a 100 mL flask to which was added $3.00 \pm 0.01 \text{ mL}$ (or $4.92 \pm 0.01 \text{ g}$) of sulfuric acid H_2SO_4 (72%) and left to stir at $30 \text{ }^{\circ}\text{C}$ for one hour. After this step, $84.00 \pm 0.01 \text{ mL}$ of distilled water was added to the contents to dilute the sulfuric acid to 4%, and the mixture was then placed in an autoclave at $120 \text{ }^{\circ}\text{C}$ for 1 h 30 min. The resulting pressurised mixture was filtered through a Büchner funnel, and 1 mL of the filtrate was collected from the flask. The Klason lignin residues remaining on the filter paper were rinsed with distilled water, transferred to glass jars, and oven-dried at $103 \text{ }^{\circ}\text{C}$ for 24 hours until a constant



Photo 2.
Soxhlet extraction.
Photo H. A. Ouattara.

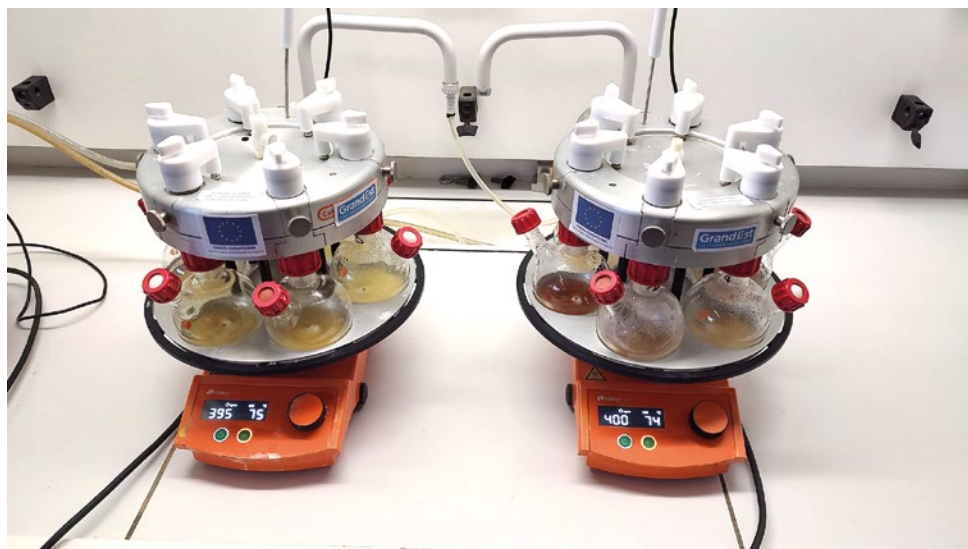


Photo 3.
Degradation of lignin.
Photo H. A. Ouattara.

mass was obtained. A spectrophotometer reading at 205 nm was taken for the 30-fold diluted filtrate to obtain the sulfuric acid-soluble lignin content (Equation 2), with the following formula:

$$TKL(\%) = ASL(\%) + AIL(\%) \quad (\text{Equation 2})$$

where TKL is the total Klason lignin, ASL is the acid-soluble Klason lignin, and AIL is the acid-insoluble Klason lignin. Their respective equations are given below (Equation 3 and Equation 4).

$$ASL(\%) = \frac{A \times Vol \times Fd}{\epsilon \times Ms \times c} \times 100 \quad (\text{Equation 3})$$

$$AIL(\%) = \frac{M(\text{residue})}{Ms} \times 100 \quad (\text{Equation 4})$$

A is the absorbance read at 205 nm, Vol is the total volume (86.73 mL), Fd is the dilution factor, ϵ is the molar extinction coefficient (1 L/mol.cm), Ms is the mass of sawdust used (≈ 300 mg), c is the absorption capacity at the wavelength used (110), and M (residue) is the mass of dried lignin residues.

Holocellulose content of sawdust

The holocellulose content of sawdust was determined using the sodium chlorite acid method (Brosse et al., 2009). 500 mg of sawdust, freed of extractives, was placed in a 250 mL flask containing 30 mL of distilled water and heated to 75 °C for 7 hours. At the end of each hour, 0.1 mL of acetic acid and 2 mL of 15% aqueous sodium chlorite were added. At the end of the reaction, the mixture was filtered through a Büchner funnel. The holocellulose residue was washed with distilled water until the yellow colouration and chlorine dioxide odour were eliminated. The residue was then dried at 103 °C to a constant mass. This procedure was performed in triplicate for all samples. The holocellulose content was calculated using Equation 5:

$$\text{Holocellulose content}(\%) = \frac{M(\text{residue})}{Ms} \times 100 \quad (\text{Equation 5})$$

with M (residue) the mass of holocellulose obtained after drying, and Ms the mass of sawdust (500 mg).

α -Cellulose and hemicellulose content of sawdust

The method for determining the α -Cellulose content of sawdust is described by Rowell (2012). The previously obtained holocellulose fraction was introduced into a 250 mL flask, to which 10 mL of a 17.5% NaOH solution was added, and the mixture was stirred at room temperature. Every 5 minutes for the next 15 minutes, 5 mL of the NaOH solution (17.5%) was added to the stirred mixture, then the mixture was left to stir for 30 minutes, after which it was diluted with 33 mL of distilled water and left to stand for 1 hour. The solution containing α -cellulose was centrifuged for 5 min at 4400 rpm. The supernatant containing solubilised hemicelluloses was removed, and the cellulose pellet was treated on a Büchner funnel with water, then 15 mL acetic acid (10%) and water again. The α -cellulose was dried at 103 °C for at least 8 hours and then weighed, determining with the following formulas:

$$\alpha.\text{cellulose content}(\%) = \frac{M(\text{residue})}{Ms} \times 100 \quad (\text{Equation 6})$$

$$\text{Hemicellulose content}(\%) = \text{Holocellulose content} - \alpha.\text{cellulose content} \quad (\text{Equation 7})$$

Chemical analysis

• FTIR analysis

For infrared spectroscopy analyses of our various extract fractions, around 2 mg of solid-state extracts were used using a Nicolet 6700 Thermo-Scientific infrared spectrophotometer with a Smart Orbit attenuated total reflectance attachment. A pressure applicator with a rotary knob was used to press the solid extract and improve contact with the ATR diamond crystal. Infrared radiation from the spectrometer strikes the crystal at a fixed angle of incidence of 45 degrees, is reflected within the crystal, and penetrates the sample via an evanescent wave. Evaluation of the average IR region from 4000 to 400 cm^{-1} allows



Photo 4.

Degradation of holocellulose.
Photo H. A. Ouattara.

sample characterisation. IR spectra were processed using the OMNIC software integrated into the control computer. Four spectra per species were collected based on the four extract fractions.

- GC-MS analysis

Based on the protocol followed by Ella Nkogo et al. (2024), with a few modifications, GC-MS analysis was carried out using a DB-5MS column (stationary phase: 95% dimethyl / 5% diphenyl polysiloxane; length: 30 m; internal diameter: 0.25 mm; film thickness: 0.25 μm) on a PerkinElmer Clarus 680 gas chromatograph coupled to a PerkinElmer Clarus SQ8 mass spectrometer, all controlled by TurboMass v.6.1 software and equipped with the NIST database (National Institute of Standards and Technology, Gaithersburg, MD, USA; 2011 edition). Before injection, all extract samples were derivatised to facilitate the detection of all compounds present (Ella Nkogo et al., 2024). To this end, 1–2 mg of dry extracts were solubilised in 40 μL of BSTFA in a 2 mL vial. The vial containing the mixture was sealed and maintained at 70 $^{\circ}\text{C}$ for at least 12 h to allow the silylation reaction to proceed. BSTFA was then evaporated, and the derivatised extracts were dissolved in 1 mL of ethyl acetate. An aliquot of 1 μL of this solution was injected into the gas chromatograph at an inlet temperature of 250 $^{\circ}\text{C}$ in splitless mode, using helium as the carrier gas. The oven temperature program was as follows: 80 $^{\circ}\text{C}$ for 2 min; heating at a rate of 10 $^{\circ}\text{C}\cdot\text{min}^{-1}$ to 190 $^{\circ}\text{C}$; followed by heating at a rate of 15 $^{\circ}\text{C}\cdot\text{min}^{-1}$ to 280 $^{\circ}\text{C}$ and holding at this temperature for 10 min; then heating at a rate of 10 $^{\circ}\text{C}\cdot\text{min}^{-1}$ to 300 $^{\circ}\text{C}$ and holding for 14 min. The temperature programme could be slightly modified to improve the resolution of certain samples, which sometimes resulted in retention-time variations for specific compounds. A helium flow rate of 1 $\text{mL}\cdot\text{min}^{-1}$ was used as the mobile phase. After chromatographic separation, the compounds were introduced into the mass spectrometer via a transfer line maintained at 250 $^{\circ}\text{C}$, and ionisation was performed by electron impact at 70 eV. Compound identification was achieved by comparing the obtained mass spectra with those of the NIST 11 library using NIST

MS Search software version 2.0 (2011). Identification was considered reliable when both the direct match (MATCH) and reverse match (REMATCH) coefficients exceeded 800.

Relative quantification of the identified compounds was performed by integrating peak areas in the chromatograms using TurboMass v6.1 chromatographic data processing software (PerkinElmer). The reported percentages are relative values calculated by expressing the peak area of each compound as a proportion of the total peak area detected in each extract. Data processing and compositional calculations were performed in Excel 2016, and results were expressed as percentages (%).

Results

Heartwood and macromolecules content

The content of heartwood extracts and structural polymers is presented in tables I and II. Table I reports the extractive contents of the various heartwoods obtained through successive extraction with dichloromethane, acetone, toluene/ethanol, and water. The results demonstrate that extraction yields vary depending on both wood species and solvent polarity. In gmelina, the total extract content exceeded 10%, with approximately 50% of the extract recovered using dichloromethane. The overall extractive contents of white iroko and mahogany ranged between 6 and 8%. In contrast, acacia, samba, and dabema exhibited markedly lower extractive levels, below 2%, 3%, and 6%, respectively. For these species, toluene/ethanol proved to be the most efficient solvent, enabling the selective recovery of phenolic compounds.

Table II presents the polysaccharide and lignin contents of the studied species. The results clearly indicate interspecific variability in wood macromolecular composition. Among the six species investigated, *A. mangium* and *G. arborea* displayed the highest simultaneous cellulose

Table I.

Extract rate by solvent of mahogany sawdust (*Khaya ivorensis*), dabema sawdust (*Piptadeniastrum africanum*), acacia sawdust (*Acacia mangium*), samba sawdust (*Triplochiton scleroxylon*), gmelina sawdust (*Gmelina arborea*), and white iroko sawdust (*Milicia excelsa*).

Wood species (Heartwood)	Extract content (% w/w)				
	Dichloromethane	Acetone	Toluene/Ethanol	Water	Total
Mahogany	1.07 $\pm$ 0.05	2.95 $\pm$ 0.12	2.86 $\pm$ 0.11	0.27 $\pm$ 0.02	7.14 $\pm$ 0.17
Dabema	0.67 $\pm$ 0.04	2.00 $\pm$ 0.09	2.21 $\pm$ 0.10	0.25 $\pm$ 0.02	5.13 $\pm$ 0.14
Acacia	0.31 $\pm$ 0.02	0.24 $\pm$ 0.02	1.11 $\pm$ 0.06	0.08 $\pm$ 0.01	1.75 $\pm$ 0.07
Samba	0.40 $\pm$ 0.03	0.43 $\pm$ 0.03	1.20 $\pm$ 0.07	0.38 $\pm$ 0.03	2.42 $\pm$ 0.09
Gmelina	4.02 $\pm$ 0.16	3.14 $\pm$ 0.13	2.85 $\pm$ 0.12	0.28 $\pm$ 0.02	10.32 $\pm$ 0.24
White Iroko	1.59 $\pm$ 0.07	3.86 $\pm$ 0.15	1.72 $\pm$ 0.08	0.17 $\pm$ 0.02	7.34 $\pm$ 0.19

Table II.

Wood polysaccharide and lignin content of mahogany sawdust (*Khaya ivorensis*), dabema sawdust (*Piptadeniastrum africanum*), acacia sawdust (*Acacia mangium*), samba sawdust (*Triplochiton scleroxylon*), gmelina sawdust (*Gmelina arborea*), and white iroko sawdust (*Milicia excelsa*).

Wood species (Heartwood)	Polysaccharide and lignin content (% w/w)		
	Cellulose	Holocellulose	Lignin
Mahogany	33.10 $\pm$ 0.85	71.15 $\pm$ 1.10	24.82 $\pm$ 0.70
Dabema	32.58 $\pm$ 0.80	69.33 $\pm$ 1.05	24.20 $\pm$ 0.65
Acacia	42.01 $\pm$ 1.05	74.69 $\pm$ 1.20	21.54 $\pm$ 0.60
Samba	31.56 $\pm$ 0.78	73.93 $\pm$ 1.15	25.84 $\pm$ 0.75
Gmelina	41.72 $\pm$ 1.10	71.04 $\pm$ 1.05	28.49 $\pm$ 0.85
White Iroko	29.65 $\pm$ 0.70	74.51 $\pm$ 1.18	24.79 $\pm$ 0.72

and holocellulose contents. Regarding lignin, all species exhibited values between 21% and 29%. These average lignin levels provide a basis for estimating the potential yield of phenolic compounds generated during the combustion of these woody species.

Analysis of wood extract composition

Acacia (*Acacia mangium*)

Figure 2 displays the infrared spectra of the extracts obtained from *A. mangium* heartwood using dichloromethane, acetone, and toluene/ethanol. The dichloromethane extract exhibits more absorption bands than the other fractions, suggesting greater chemical diversity. All extracts show broad absorption between 3,400 and 3,200 cm^{-1} , corresponding to O–H stretching vibrations characteristic of hydroxyl groups. In the dichloromethane extract, C–H stretching of aliphatic CH_2 and CH_3 groups is clearly observed at 2,916; 2,850; and 2,462 cm^{-1} , whereas only CH_2 -related bands are detected in the acetone and toluene/ethanol fractions. Furthermore, all extracts display prominent absorptions in the ranges 1,750–1,700 cm^{-1} and 1,300–1,000 cm^{-1} , associated with C=O stretching and C–O stretching vibrations, respectively, confirming the presence of carboxylic acid functionalities. Table III summarises the chemical profiles of *A. mangium*. Complementary GC–MS analysis of the same extracts (table III) revealed distinct chemical profiles: the dichloromethane extract was dominated by fatty acids and fatty alcohols (26.55%) alongside a high proportion of triterpenes (73.2%); the acetone fraction was enriched in sugars (59.79%), palmitic acid (27.52%), and triterpenes (20.11%); while the toluene/ethanol extract contained primarily lupenone and related triterpenoids, with lupeol accounting for 12%.

Mahogany (*Khaya ivorensis*)

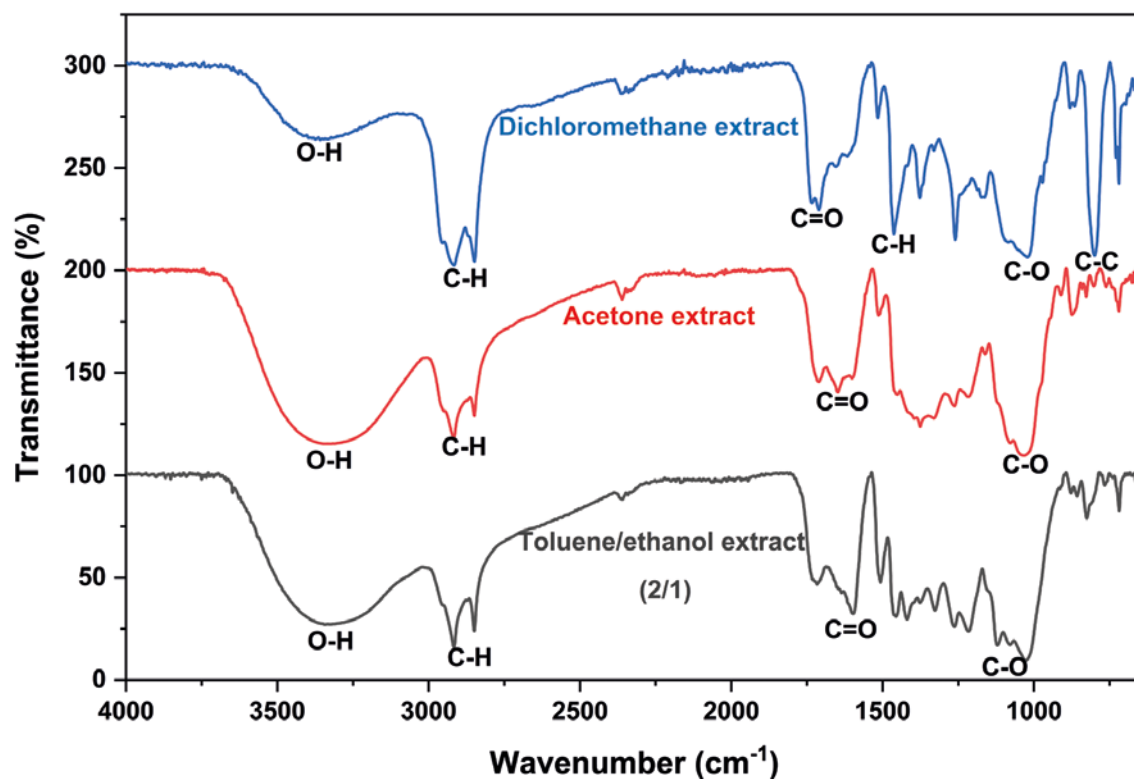
Figure 3 presents the infrared spectra of the mahogany (*K. ivorensis*) extracts obtained using dichloromethane, acetone, and toluene/ethanol as solvents. The dichloromethane extract is distinguished by the occurrence of specific compounds, as evidenced by the absorption bands at 2,930; 2,850; and 1,466 cm^{-1} , which are characteristic of CH_2 and CH_3 stretching vibrations. Additional peaks at 1,737 and 1,180 cm^{-1} indicate the simultaneous presence of carbonyl (C=O) and C–O functional groups. By contrast, the acetone and toluene/ethanol extracts exhibit intense absorptions at 3,313 and 3,300 cm^{-1} , corresponding to O–H

Table III.

Compounds identified in acacia (*Acacia mangium*) heartwood extracts.

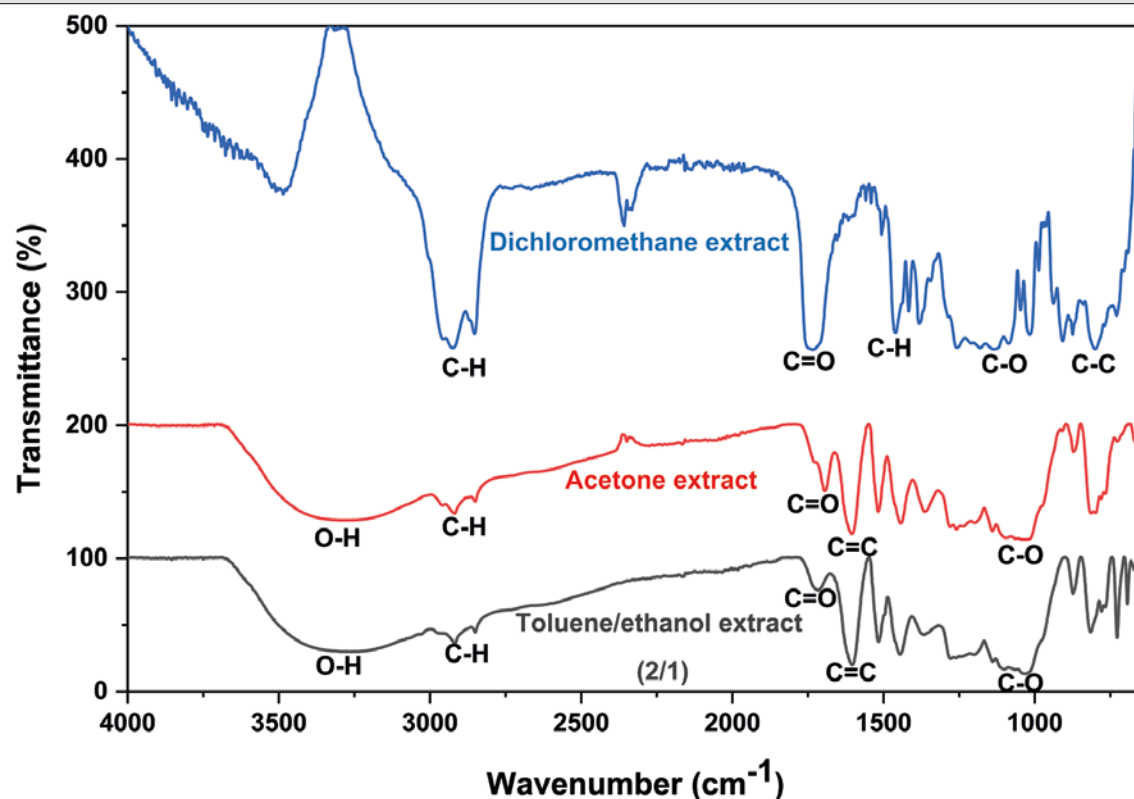
Solvent	Retention time (min)	Molecule name	Composition (%)	Formula
Dichloromethane	13.22	Lauric acid	3.33	$\text{C}_{12}\text{H}_{24}\text{O}_2$
	15.07	Myristic acid	1.26	$\text{C}_{14}\text{H}_{28}\text{O}_2$
	15.94 ; 22.94	Palmitic alcohol	2.01 ; 1.93	$\text{C}_{16}\text{H}_{34}\text{O}$
	16.56	Palmitic acid	11.23	$\text{C}_{16}\text{H}_{32}\text{O}_2$
	17.13	Oleic alcohol	3.77	$\text{C}_{18}\text{H}_{36}\text{O}$
	17.29	Stearyl alcohol	0.97	$\text{C}_{18}\text{H}_{38}\text{O}$
	17.69	Oleic acid	2.05	$\text{C}_{18}\text{H}_{34}\text{O}_2$
	26.80	Campesterol	6.72	$\text{C}_{28}\text{H}_{48}\text{O}$
	27.10	Stigmasterol	9.81	$\text{C}_{29}\text{H}_{48}\text{O}$
	27.90	Stigmast-5-ene	27.95	$\text{C}_{29}\text{H}_{50}$
	28.38	Campest-4-en-3-one	1.71	$\text{C}_{28}\text{H}_{46}\text{O}$
	28.75	4.22-Stigmastadiene-3-one	3.15	$\text{C}_{29}\text{H}_{46}\text{O}$
	28.92	Lupeol	12.37	$\text{C}_{30}\text{H}_{50}\text{O}$
	29.75	γ -Sitostenone	11.73	$\text{C}_{29}\text{H}_{48}\text{O}$
Acetone	12.76	L-Rhamnose	5.61	$\text{C}_6\text{H}_{12}\text{O}_5$
	13.74	D-(+)-Arabitol	16.13	$\text{C}_5\text{H}_{12}\text{O}_5$
	14.19	D-Fucitol	4.95	$\text{C}_6\text{H}_{14}\text{O}_5$
	14.78	D-Pinitol	15.37	$\text{C}_7\text{H}_{14}\text{O}_6$
	15.31	Galactopyranose	2.17	$\text{C}_6\text{H}_{12}\text{O}_6$
	15.59	D-Glucitol	11.89	$\text{C}_6\text{H}_{14}\text{O}_6$
	16.01 ; 16.56	Palmitic acid	17.81 ; 9.71	$\text{C}_{16}\text{H}_{32}\text{O}_2$
	16.78	Inositol	3.67	$\text{C}_6\text{H}_{12}\text{O}_6$
	26.77	/	2.69	/
	27.11	Stigmasterol	2.89	$\text{C}_{29}\text{H}_{48}\text{O}$
	27.90	Stigmast-5-ene	9.12	$\text{C}_{29}\text{H}_{50}$
	28.92	Lupeol	5.31	$\text{C}_{30}\text{H}_{50}\text{O}$
	29.78	γ -Sitostenone	2.79	$\text{C}_{29}\text{H}_{48}\text{O}$
Toluene/Ethanol	4.48	2,4,6-trimethylpyridine	8.80	$\text{C}_8\text{H}_{11}\text{N}$
	5.24	Lactic acid	1.43	$\text{C}_3\text{H}_6\text{O}_3$
	11.03	/	6.30	/
	11.82 ; 14.79	/	18.03 ; 2.23	/
	13.52	/	9.13	/
	15.80 ; 16.78	Inositol	3.81 ; 6.76	$\text{C}_6\text{H}_{12}\text{O}_6$
	16.27	/	9.88	/
	17.63	/	2.87	/
	17.91	Stearic acid	4.27	$\text{C}_{18}\text{H}_{36}\text{O}_2$
	18.80	/	2.49	/
	19.6	/	7.84	/
	19.81	/	2.32	/
	20.82	/	1.84	/
	28.93	Lupeol	12	$\text{C}_{30}\text{H}_{50}\text{O}$

*(/): Unidentified compounds

**Figure 2.**

Infrared spectra of acacia sawdust (*Acacia mangium*) extracts.

N.B. : The y-axis does not allow the intensity values at each wavelength to be measured. The graph only allows one to assess the extent to which the peaks are broadened as a function of wavelength.

**Figure 3.**

Infrared spectra of mahogany sawdust (*Khaya ivorensis*) extracts.

N.B. : The y-axis does not allow the intensity values at each wavelength to be measured. The graph only allows one to assess the extent to which the peaks are broadened as a function of wavelength.

Table IV.
Compounds identified in mahogany (*Khaya Ivorensis*) heartwood extracts.

Solvent	Retention time (min)	Molecule name	Composition (%)	Formula
Dichloromethane	12.66	Globulol	2.77	C ₁₅ H ₂₆ O
	13.26	T-Cadinol	17.83	C ₁₅ H ₂₆ O
	14.64	Ethyl myristate	6.84	C ₁₆ H ₃₂ O ₂
	15.07	Myristic acid	2.13	C ₁₄ H ₂₈ O ₂
	15.26	Dibutyl phthalate	1.71	C ₁₆ H ₂₂ O ₄
	15.94	Palmitic alcohol	1.44	C ₁₆ H ₃₄ O
	16.56	Palmitic acid	26.45	C ₁₆ H ₃₂ O ₂
	17.13	Oleic alcohol	3.21	C ₁₈ H ₃₆ O
	17.60	/	9.47	C ₁₇ H ₂₄ O ₃
	19.95 ; 20.66	Heptacosane	0.74 ; 2.01	C ₂₇ H ₅₆
	27.11	Stigmasterol	5.30	C ₂₉ H ₄₈ O
	27.91	Stigmast-5-ene	20.09	C ₂₉ H ₅₀
Acetone	8.28	Glycerol	0.33	C ₃ H ₈ O ₃
	9.79	/	0.35	/
	11.32	Erythritol	0.34	C ₄ H ₁₀ O ₄
	12.73 ; 13.48	L-Rhamnose	1.03 ; 1.63	C ₆ H ₁₂ O ₅
	13.26	T-Cadinol	3.17	C ₁₅ H ₂₆ O
	14.61	D-(-)-Fructofuranose	2.48	C ₆ H ₁₂ O ₆
	15.31	D-Galactose	1.42	C ₆ H ₁₂ O ₆
	15.95	D-Glucose	0.71	C ₆ H ₁₂ O ₆
	16.77	Inositol	0.52	C ₆ H ₁₂ O ₆
	17.38	/	0.88	/
	18.44	/	0.39	/
	21.89 ; 22.15	Catechin	6.86 ; 54.96	C ₁₅ H ₁₄ O ₆
Toluene/Ethanol	23.31 ; 23.64	7-Galloyl catechin	17.51 ; 7.42	C ₂₂ H ₁₈ O ₁₀
	13.45	Epiglobulol	1.65	C ₁₅ H ₂₆ O
	13.75	Adonitol	2.24	C ₅ H ₁₂ O ₅
	14.63	D-Fructofuranose	0.96	C ₆ H ₁₂ O ₆
	14.67	D-Fructose	1.10	C ₆ H ₁₂ O ₆
	15.32	D-Glucose	2.77	C ₆ H ₁₂ O ₆
	15.79	Inositol	30.33	C ₆ H ₁₂ O ₆
	15.96	D-Glucopyranose	1.42	C ₆ H ₁₂ O ₆
	16.51	/	14.80	/
	20.00	Sucrose	1.09	C ₁₂ H ₂₂ O ₁₁
	20.06	/	0.53	/
	20.80	D-Trehalose	2.68	C ₁₂ H ₂₂ O ₁₁
	21.67	/	3.15	/
	22.11	Catechin	27.57	C ₁₅ H ₁₄ O ₆
	23.29	7-Galloyl catechin	9.26	C ₂₂ H ₁₈ O ₁₀
	23.62	/	5.86	/
	*(/): Unidentified compounds			

stretching vibrations of aromatic structures. These fractions also display strong bands at 1,620 and 1,610 cm⁻¹ for C=C stretching and at 1,086 and 1,080 cm⁻¹ for C–O stretching. Furthermore, weaker signals were observed around 2,927–2,940 cm⁻¹, attributable to aliphatic C–H bonds, and at 1,729–1,730 cm⁻¹ for carbonyl (C=O) groups.

Table IV summarises the chemical profiles of *K. ivorensis*. GC-MS analysis further corroborated this chemical diversity. In the dichloromethane extract, 20.6% of sesquiterpenes, 25.39% of triterpenes, and 40.07% of fatty acids, fatty alcohols, and waxes were identified. The acetone extract was dominated by catechins and gallocatechins (86.75%), with additional contributions from sugars (8.46%) and sesquiterpenes (3.17%). In the toluene/ethanol extract, sugars (42.59%) and catechins/gallocatechins (36.83%) were the major constituents, accompanied by 1.65% sesquiterpenes.

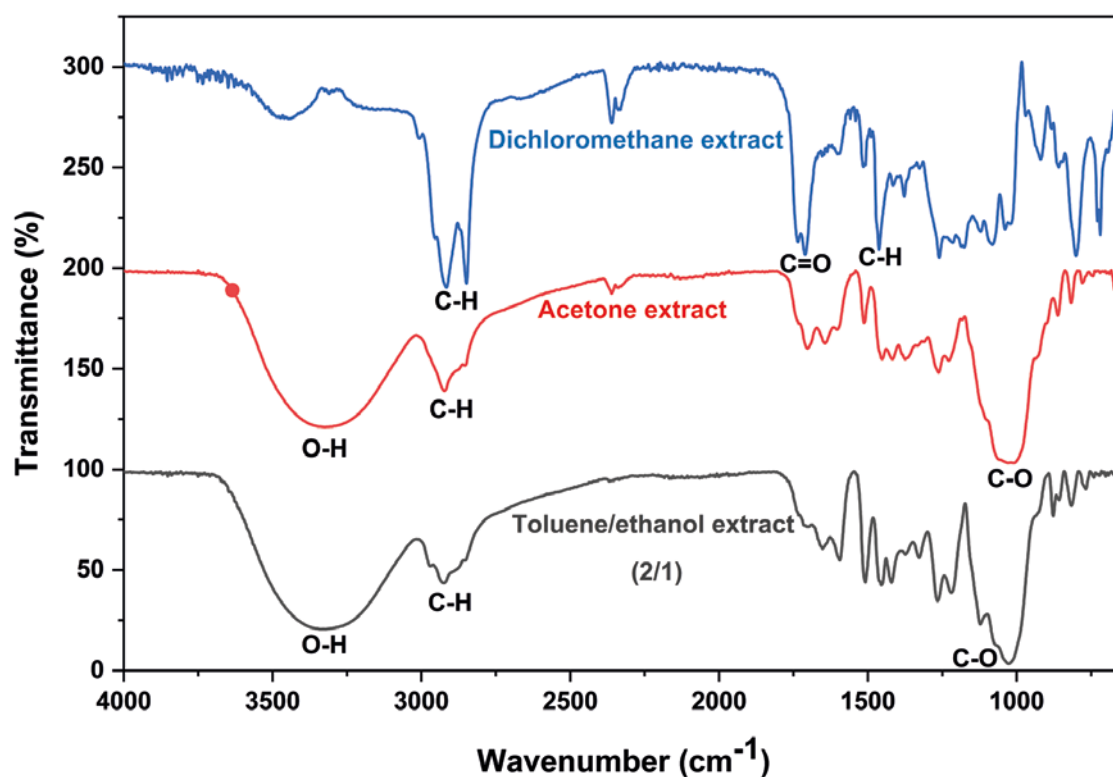
Dabema (*Piptadeniastrum africanum*)

Figure 4 presents the infrared spectra of the different extracts obtained from *P. africanum* heartwood using dichloromethane, acetone, and toluene/ethanol as solvents. The dichloromethane extract reveals distinct compositional features compared to the other fractions. In this extract, absorption bands at 2,915; 2,848; 1,710; and 1,463 cm⁻¹ correspond to CH₂ and CH₃ stretching vibrations, as well as C=O stretching. In contrast, the acetone and toluene/ethanol extracts exhibit strong absorption bands at 3,325 and 3,350 cm⁻¹, characteristic of O–H stretching vibrations associated with aromatic structures. Additional absorptions at 2,924 cm⁻¹ are indicative of C–H stretching, while signals at 1,006 and 1,020 cm⁻¹ confirm the presence of C–O stretching vibrations.

Table V summarises the chemical profiles of *P. africanum* extracts. The dichloromethane fraction is characterised by 29.11% of sugars, 44.31% of fatty acids and long-chain alcohols (notably palmitic acid), and 19.6% of triterpenes. The acetone extract contained only sugars, such as pinitol, inositol, and glucose, whereas sugars, including glucose, sucrose, and mannose, dominated the toluene/ethanol fraction.

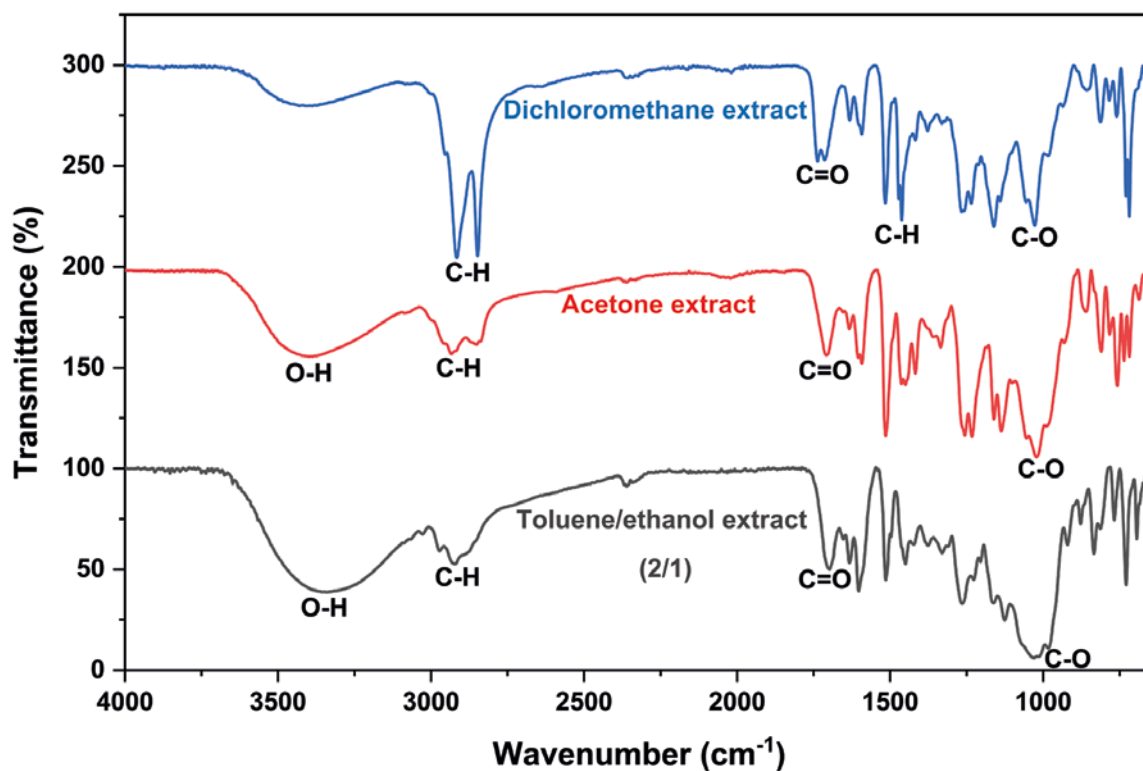
Gmelina (*Gmelina arborea*)

Figure 5 presents the infrared spectra of different *G. arborea* extracts obtained using dichloromethane, acetone, and toluene/ethanol as solvents. The dichloromethane extract is characterised by distinct compounds that

**Figure 4.**

Infrared spectra of dabema sawdust (*Piptadeniastrum africanum*) extracts.

N.B. : The y-axis does not allow the intensity values at each wavelength to be measured. The graph only allows one to assess the extent to which the peaks are broadened as a function of wavelength.

**Figure 5.**

Infrared spectra of gmelina sawdust (*Gmelina arborea*) extracts.

N.B. : The y-axis does not allow the intensity values at each wavelength to be measured. The graph only allows one to assess the extent to which the peaks are broadened as a function of wavelength.

Table V.Compounds identified in dabema (*Piptadeniastrum africanum*) heartwood extracts.

Solvent	Retention time (min)	Molecule name	Composition (%)	Formula
Dichloromethane	11.34	Erythritol	1.58	C ₄ H ₁₀ O ₄
	13.20	Lauric acid	3.83	C ₁₂ H ₂₄ O ₂
	14.63	Inositol	5.69	C ₆ H ₁₂ O ₆
	14.78	D-Pinitol	21.84	C ₇ H ₁₄ O ₆
	15.07	Myristic acid	1.40	C ₁₄ H ₂₈ O ₂
	15.84	Pentadecanoic acid	1.63	C ₁₅ H ₃₀ O ₂
	16.42	palmitelaidic acid	1.89	C ₁₆ H ₃₀ O ₂
	16.56	Palmitic acid	22.26	C ₁₆ H ₃₂ O ₂
	17.13	Oleic alcohol	3.33	C ₁₈ H ₃₆ O
	17.28 ; 17.69	Oleic acid	4.58 ; 5.39	C ₁₈ H ₃₄ O ₂
	21.84 ; 22.07	cypermethrin	3.06 ; 2.16	C ₂₂ H ₁₉ Cl ₂ NO ₃
	25.53	/	1.75	/
	27.90	α-Spinasterol	8.24	C ₂₉ H ₄₈ O
	28.79	Stigmast-7-en-3-ol	5.52	C ₂₉ H ₅₀ O
	28.92	Lupeol	5.84	C ₃₀ H ₅₀ O
Acetone	7.22 ; 8.31	Glycerol	0.55 ; 0.85	C ₃ H ₈ O ₃
	10.91	Butane-1,2,3-triol	0.91	C ₄ H ₁₀ O ₃
	11.02	Erythritol	1.80	C ₄ H ₁₀ O ₄
	11.34	Threitol	2.41	C ₄ H ₁₀ O ₄
	14.05 ; 14.62	Fructose	3.47 ; 9.68	C ₆ H ₁₂ O ₆
	14.79	D-Pinitol	20.40	C ₇ H ₁₄ O ₆
	14.91	Inositol	18.73	C ₆ H ₁₂ O ₆
	15.31 ; 15.95	Glucose	10.53 ; 19.03	C ₆ H ₁₂ O ₆
	15.78	Lyxose	14.75	C ₅ H ₁₀ O ₅
	19.28	Turanose	0.34	C ₁₂ H ₂₂ O ₁₁
	19.68 ; 20	Sucrose	0.86 ; 2.96	C ₁₂ H ₂₂ O ₁₁
	19.97	Asperuloside	0.62	C ₁₈ H ₂₂ O ₁₁
Toluene/Ethanol	20.06	/	2.12	/
	11.29	Erythritol	0.48	C ₄ H ₁₀ O ₄
	12.16 ; 12.64	Ribose	0.08 ; 0.20	C ₅ H ₁₀ O ₅
	12.44	Arabinose	0.14	C ₅ H ₁₀ O ₅
	13.69	Xylitol	0.20	C ₅ H ₁₂ O ₅
	14.01 ; 14.51	Fructose	2.38 ; 4.51	C ₆ H ₁₂ O ₆
	14.27	Tagatose	3.64	C ₆ H ₁₂ O ₆
	14.75	Pinitol	11.83	C ₇ H ₁₄ O ₆
	14.87	Galactose	4.48	C ₆ H ₁₂ O ₆
	15.29 ; 15.56	Mannose	17.57 ; 6.81	C ₆ H ₁₂ O ₆
	15.42	/	2.05	/
	15.76 ; 16.76	Inositol	6.13 ; 1.63	C ₆ H ₁₂ O ₆
	15.94	Glucose	19.41	C ₆ H ₁₂ O ₆
	20.12	Sucrose	14.96	C ₁₂ H ₂₂ O ₁₁
	21.14	Mannobiose	3.49	C ₁₂ H ₂₂ O ₁₁

*(/): Unidentified compounds

**Photo 5.**Wood storage warehouse.
Photo H. A. A. Ouattara.

are absent from the other fractions. In this extract, the absorption bands at 2,918; 2,851; 1,728; 1,466; and 1,030 cm⁻¹ correspond to CH₂ stretching vibrations, carbonyl (C=O) groups of carboxylic acids and other carbonyl-containing compounds, CH₃ vibrations of aliphatic chains, and C–O stretching of esters, respectively. The acetone and toluene/ethanol extracts exhibit intense absorption bands at 3400 and 3360 cm⁻¹, indicative of O–H stretching vibrations from aromatic structures. Additional bands at 2,924 and 2,922 cm⁻¹ correspond to C–H stretching, while peaks at 1,700 and 1,701 cm⁻¹ confirm the presence of carbonyl functionalities. Furthermore, signals observed at 1,021 and 1,022 cm⁻¹ are attributed to C–O bonds.

Table VI summarises the chemical profiles of *G. arborea* extracts. The dichloromethane extract contains 10.18% of phenolic derivatives, 40.88% of fatty acids and long-chain alcohols, and 11.88% of gmelinol. The acetone extract is primarily composed of 14.01% sugars, 11.56% veratric acid, and 60.70% gmelinol. The toluene/ethanol extract contains 62.81% of fatty acids and waxes, including capric and stearic acids, 22.66% of gmelinol, and 8.49% of sugars. These results highlight the solvent-dependent distribution of both polar and non-polar bioactive compounds in *G. arborea* heartwood, with potential implications for natural product extraction and valorisation.

Table VI.Compounds identified in gmelina (*Gmelina arborea*) heartwood extracts.

Solvent	Retention time (min)	Molecule name	Composition (%)	Formula
Dichloromethane	11.12	3,4-Dimethoxyphenol	5.10	C ₈ H ₁₀ O ₃
	13.91	Veratric acid	5.08	C ₉ H ₁₀ O ₄
	15.95	Palmitic alcohol	0.43	C ₁₆ H ₃₄ O
	16.58	Palmitic acid	0.49	C ₁₆ H ₃₂ O
	17.14	Oleic alcohol	0.93	C ₁₈ H ₃₆ O
	17.70	Oleic acid	0.95	C ₁₈ H ₃₄ O ₂
	18.56	/	1.51	/
	18.74	/	1.30	/
	19.01	Lauric diethanolamide	0.82	C ₁₆ H ₃₃ NO ₃
	19.58	/	0.26	/
	20.97	Lignoceric alcohol	0.19	C ₂₄ H ₅₀ O
	21.79	Lignoceric acid	0.22	C ₂₄ H ₄₈ O ₂
	22.94	Cerylic alcohol	4.32	C ₂₆ H ₅₄ O
	25.58	Montanyl alcohol	33.35	C ₂₈ H ₅₈ O ₂
	26.73	Gmelinol	11.88	C ₂₂ H ₂₆ O ₇
	27.09	Stigmasterol	2.78	C ₂₉ H ₄₈ O
	28.03	/	30.39	/
Acetone	8.94	Succinic acid	2.95	C ₆ H ₆ O ₄
	12 ; 75	L-Rhamnose	3.38	C ₆ H ₁₂ O ₅
	13.20 ; 13.91	Veratric acid	9.12 ; 2.53	C ₉ H ₁₀ O ₄
	14.93	/	2.03	/
	15.32	D-Glucose	4.01	C ₆ H ₁₂ O ₆
	15.60	α-D-Mannopyranose	2.44	C ₆ H ₁₂ O ₆
	15.79	β-D-Talopyranose	1.07	C ₆ H ₁₂ O ₆
	15.95	β-D-Glucopyranose	3.11	C ₆ H ₁₂ O ₆
	18.56 ; 27.22	/	0.96 ; 1.53	/
	18.64	/	6.15	/
Toluene/Ethanol	26.72 ; 27.64	Gmelinol	21.08 ; 39.62	C ₂₂ H ₂₆ O ₇
	8.93 ; 9.42	Succinic acid	1.91 ; 0.33	C ₄ H ₆ O ₄
	10.07	Ethyl caprate	27.74	C ₁₂ H ₂₄ O ₂
	10.83	Capric acid	17.63	C ₁₀ H ₂₀ O ₂
	12.75	L-Rhamnose	0.68	C ₆ H ₁₂ O ₅
	14.01	Veratric acid	1.69	C ₉ H ₁₀ O ₄
	14.67	D-(-)-Fructopyranose	0.38	C ₆ H ₁₂ O ₆
	15.31	D-Glucopyranose	3.24	C ₆ H ₁₂ O ₆
	15.61	D-Galactopyranose	1.90	C ₆ H ₁₂ O ₆
	15.95	D-Glucose	1.75	C ₆ H ₁₂ O ₆
	16.26	Palmitic acid	0.69	C ₁₆ H ₃₂ O
	16.78	Inositol	0.54	C ₆ H ₁₂ O ₆
	17.57	Ethyl stearate	15.51	C ₂₀ H ₄₀ O ₂
	17.87	Stearic acid	1.24	C ₁₈ H ₃₆ O ₂
	18.64 ; 18.92	Glucosamine	0.84 ; 1.27	C ₆ H ₁₃ NO ₃
	26.79 ; 27.63	Gmelinol	13.75 ; 8.91	C ₂₂ H ₂₆ O ₇

*(/) : Unidentified compounds

White iroko (*Milicia excelsa*)

Figure 6 shows the infrared spectra of the various extracts obtained using the solvents dichloromethane, acetone and toluene/ethanol from *M. excelsa*. All extracts appear to contain similar compounds. In the dichloromethane extract, peaks at 3,300; 2,920; 1,715; 1,460; and 1,050 cm⁻¹ correspond, respectively, to the OH hydroxyl vibrations of an aromatic ring, CH₂ of the carbon chains, C=O present in carboxylic acids and other compounds closing the carbonyl function, CH₃ of the carbon chains, and the C-O bond. The acetone and toluene/ethanol extracts show strong absorption bands at 3,310 and 3,250 cm⁻¹, characteristic of the O-H elongation vibrations of aromatic structures. In addition, there are absorption peaks at 2,925; 2,926 cm⁻¹ and 1,440; 1,465 cm⁻¹ for the CH bonds and also a signal at 1,702 cm⁻¹ for the C=O bond. Finally, signals at 1,021 and 1,022 cm⁻¹ are assigned to the C-O bond.

Table VII summarises the chemical profiles of *M. excelsa* extracts. It shows dichloromethane extract (19.61% of aromatics, 3.26% of fatty acids and alcohols, and 53.66% of chlorophorin); acetone extract (5.62% of fatty acids, 23.1% of stilbene (resveratrol), and 47.91% of chlorophorin); toluene ethanol extract (31.12% of sugars, 7.31% of palmitic acid, 9.09% of stilbene, and 29.44% of chlorophorin).

Samba (*Triplochiton scleroxylon*)

Figure 7 shows the infrared spectra of the extracts obtained using dichloromethane, acetone, and toluene/ethanol from *T. scleroxylon*. The dichloromethane extract contains compounds that differ from those in the other extracts. In dichloromethane, the peaks at 2,922; 1,710; 1,463; and 1,020 cm⁻¹ correspond, respectively, to the vibrations of CH₂ in the carbon chains of terpenes, waxes and fats; C=O in carboxylic acids and other compounds closing the carbonyl function; CH₃ in the carbon chains of alkanes and alkenes; and C-O in esters. All this suggests the presence of compounds such as fatty acids, fatty alcohols, waxes, fats and terpenes. The acetone and toluene/ethanol extracts show strong absorption bands at 3,340 and 3,320 cm⁻¹, characteristic of the O-H elongation vibrations of aromatic structures. In addition, we observe absorption peaks at 2,915 and 2,913 cm⁻¹, respectively, corresponding to CH bonds in the carbon chains of terpenes, waxes, fats, and other compounds. Also, a signal at 1,670 and 1,675 cm⁻¹, indicative of C=C bonds in terpenes, aromatic compounds, and

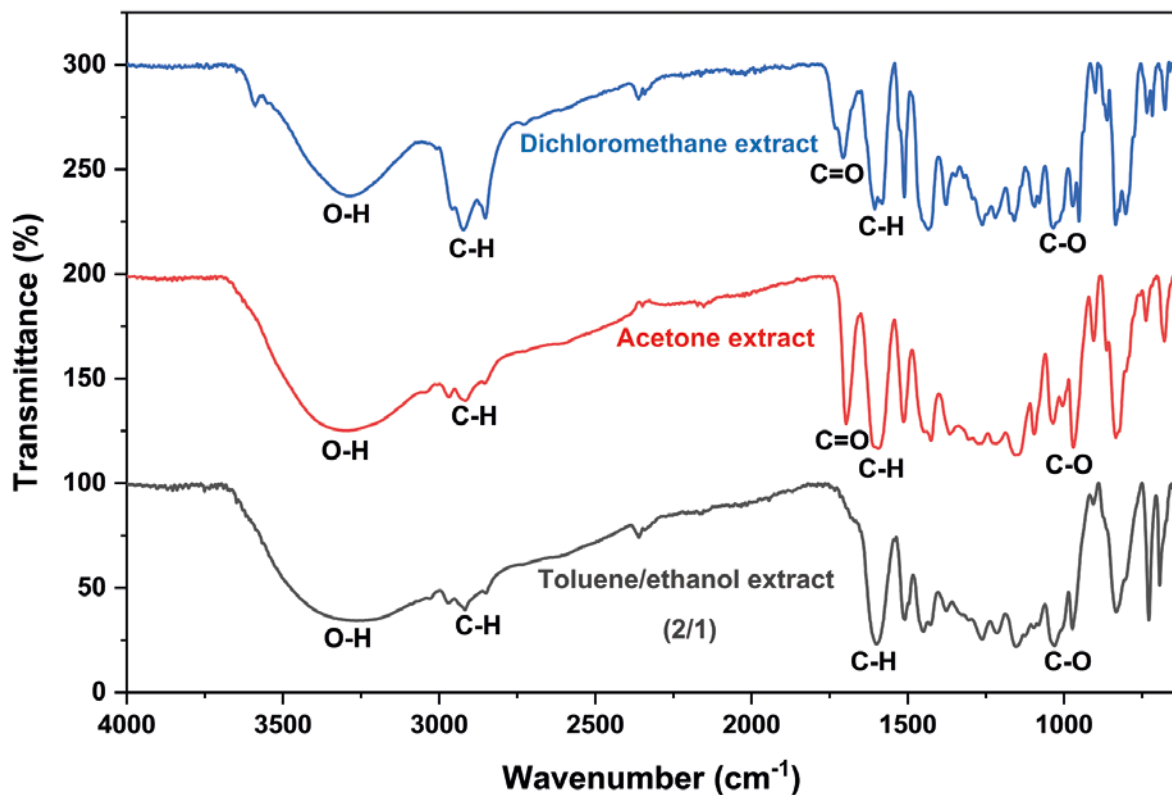


Figure 6.
 Analysis of infrared spectra of white iroko sawdust (*Milicia excelsa*) extracts.
 N.B. : The y-axis does not allow the intensity values at each wavelength to be measured. The graph only allows one to assess the extent to which the peaks are broadened as a function of wavelength.

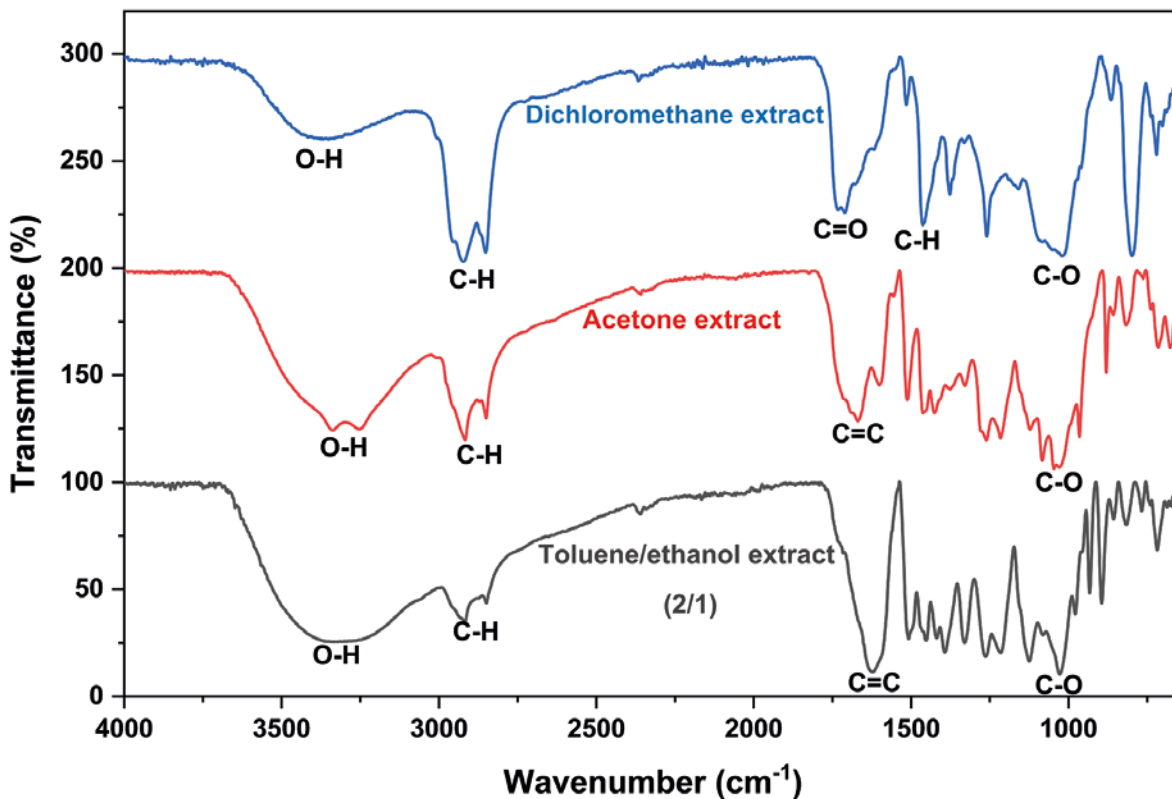


Figure 7.
 Analysis of infrared spectra of samba sawdust (*Triplochiton scleroxylon*) extracts.
 N.B. : The y-axis does not allow the intensity values at each wavelength to be measured. The graph only allows one to assess the extent to which the peaks are broadened as a function of wavelength.

Table VII.
Compounds identified in white iroko (*Milicia excelsa*) heartwood extracts.

Solvent	Retention time (min)	Molecule name	Composition (%)	Formula
Dichloromethane	9.94	p-hydroxybenzaldehyde	0.52	C ₇ H ₆ O ₂
	10.87	p-Hydroxybenzoic acid	2.90	C ₇ H ₆ O ₃
	15.50	2,4-Dihydroxybenzaldehyde	6.15	C ₇ H ₆ O ₃
	16.57	Palmitic acid	1.67	C ₁₆ H ₃₂ O ₂
	17.14	Oleic acid	0.45	C ₁₈ H ₃₆ O
	17.85	Stearic acid	1.14	C ₁₈ H ₃₆ O ₂
	18.46	/	7.54	/
	19.01	Lauric diethanoamide	1.46	C ₁₆ H ₃₃ NO ₃
	19.13	/	2.14	/
	24.34	3,4-dihydroxyphenylglycol	10.04	C ₈ H ₁₀ O ₄
	27.90	Stigmast-5-ene	2.61	C ₂₉ H ₅₀
	29.27	/	9.72	/
Acetone	31.66	Chlorophorine	53.66	C ₂₄ H ₂₈ O ₄
	11.28	Erythritol	0.28	C ₄ H ₁₀ O ₄
	13.70	Xylitol	0.42	C ₅ H ₁₂ O ₅
	15.35	2,5-dihydroxybenzoic acid	0.40	C ₇ H ₆ O ₄
	17.23 ; 17.68	Oleic acid	2.13 ; 2.79	C ₁₈ H ₃₄ O ₂
	17.83	Stearic acid	0.70	C ₁₈ H ₃₆ O ₂
	19.46	/	0.68	/
	20.88	Resveratrol	4.13	C ₁₄ H ₁₂ O ₃
	21.39	/	0.67	/
	21.98	Oxyresveratrol	18.97	C ₁₄ H ₁₂ O ₄
	22.62	/	8.49	/
	30.07	/	5.88	/
Toluene/Ethanol	32.94 ; 36.96	Chlorophorine	35.97 ; 11.94	C ₂₄ H ₂₈ O ₄
	35.52	/	6.51	/
	11.34	Erythritol	3.69	C ₄ H ₁₀ O ₄
	11.88	/	0.24	/
	12.75	L-Rhamnose	0.47	C ₆ H ₁₂ O ₅
	12.98	p-Hydroxybenzoic acid	1.01	C ₇ H ₆ O ₃
	13.49	/	1.79	/
	13.74	Xylitol	21.49	C ₅ H ₁₂ O ₅
	14.73	Arabinose	2.15	C ₅ H ₁₀ O ₅
	15.58	D-Mannitol	2.14	C ₆ H ₁₄ O ₆
	15.64	/	3.65	/
	16.27	Palmitic acid	7.31	C ₁₆ H ₃₂ O ₂
	18.46	/	1.20	/
	19.51	/	0.74	/
	20.78	D-Trehalose	1.18	C ₁₂ H ₂₂ O ₁₁
	21.75	Oxyresveratrol	9.09	C ₁₄ H ₁₂ O ₄
	22.41	/	3.96	/
	27.88	/	1.39	/
	29.23	/	4.69	/
	31.33 ; 35.16	Chlorophorine	23.02 ; 6.42	C ₂₄ H ₂₈ O ₄
	34.27	/	4.48	/

*(/): Unidentified compounds

other compounds. Finally, signals at 1,021 and 1,022 cm⁻¹ are assigned to C-O bonding in esters, tannins, lignans, flavonoids, waxes, and many other compounds. Table VIII presents dichloromethane extract (22.65% of acid and fatty alcohols; 69.12% of triterpenes), acetone extract (48.82% of sugars; 40.19% of triterpenes), and toluene-ethanol extract (none).

Discussion

Extractive content

Successive solvent extractions highlight the differential solubility of wood metabolites and enable the targeted isolation of bioactive compounds for detailed analysis. Nonpolar solvents, such as dichloromethane, selectively extract lipophilic constituents, including terpenoids, fatty acids, sterols, and waxes, while polar solvents like acetone solubilise phenolic compounds, notably simple phenols, flavonoids, and condensed tannins.

Gmelina exhibits high extractive yields (10.32%), with substantial contributions from both dichloromethane (4.02%) and acetone (3.14%) fractions, reflecting dual enrichment for lipophilic and moderately polar metabolites. This compositional pattern suggests a multifunctional chemical defence system capable of both fungistatic activity and leaching resistance, supporting its potential durability (Gao et al., 2024).

In contrast, acacia exhibits markedly low total extractive content (1.75%), with minimal recovery in both the dichloromethane and acetone fractions, indicating limited investment in chemical defences. Such low extractive abundance is generally associated with reduced intrinsic decay resistance and implies a greater reliance on structural or ecological defence mechanisms, in agreement with recent comparative analyses (Kirker et al., 2024).

Intermediate species, including mahogany and white iroko, demonstrate acetone-dominated profiles (71–73% total extractives), highlighting the prominence of phenolic compounds that likely underpin their antifungal and antioxidant activities (Gao et al., 2024). Across all species, aqueous fractions remain minor (<0.40%), as expected for heartwood dominated by hydrophobic and moderately polar secondary metabolites. While hot-water extracts may contain hydrolysable tannins and low-molecular-weight phenols with specific bioactivities, their contribution to overall heartwood protection is minimal (Zhao et al., 2022).

Macromolecular composition

The compositional analysis of the heartwood from six Ivorian species reveals pronounced interspecific variability, underscoring the critical role of chemical specificity in biorefinery valorisation. Cellulose (29.65–42.01%) and lignin (21.54–28.49%) contents frequently deviate from the typical ranges reported for hardwoods (40–50% cellulose, 20–30% hemicelluloses, and 18–25% lignin), as originally described by Sjöström (1993).

Such deviations may be attributed to the species-dependent accumulation of extractives in the

heartwood. These compounds, by interfering with conventional analytical protocols, are known to artificially inflate Klason lignin values and distort polysaccharide quantification, as recently highlighted by Sapouna et al. (2023).

Consistent with its well-documented profile, acacia is distinguished by high cellulose and relatively low lignin content, features that are particularly suitable for enzymatic saccharification. This trend was confirmed by Almeida et al. (2022) in *Acacia dealbata*, which reported approximately 47% cellulose and 17% Klason lignin. Conversely, the elevated lignin content of *G. arborea* is consistent with earlier findings by Oluwadare et al. (2016), suggesting strong potential for the valorisation of lignin-derived aromatics. Furthermore, the exceptionally high holocellulose levels recorded in *M. excelsa* (white iroko) and *T. scleroxylon* (samba), which correspond to hemicellulose proportions approaching 45%, position these species as highly promising candidates for the development of innovative hemicellulose-based bioproducts, an emerging strategic pathway emphasised by Chen et al. (2024).

Chemical profile of acacia

The chemical composition of *A. mangium* heartwood extracts highlights a remarkable diversity of bioactive compounds whose distribution is strongly influenced by solvent polarity. Dichloromethane extracts are particularly enriched in lipophilic constituents such as fatty acids (palmitic and oleic acids), long-chain alcohols, sterols (campesterol, stigmasterol, and γ -sitosterone), and triterpenes (lupeol). It confirms earlier reports of abundant non-polar metabolites in the *Acacia dealbata* (Rodrigues et al., 2021).

In contrast, the acetone fraction was dominated by polar sugars and sugar alcohols, including D-pinitol, D-glucitol, and L-rhamnose, complemented by smaller amounts of sterols and triterpenes, consistent with the solvent's intermediate polarity. The toluene/ethanol extract further underscored the wood's chemical complexity by yielding nitrogen-containing heterocycles (e.g., 2,4,6-trimethylpyridine), organic acids, inositols, and several unidentified compounds.

Collectively, these findings confirm that *A. mangium* heartwood is a source of diverse natural products exhibiting documented antimicrobial and antioxidant activ-

Table VIII.

Compounds identified in samba (*Triplochiton scleroxylon*) heartwood extracts.

Solvent	Retention time (min)	Molecule name	Composition (%)	Formula
Dichloromethane	13.22	Lauric acid	4.20	C ₁₂ H ₂₄ O ₂
	15.07	Myristic acid	2.22	C ₁₄ H ₂₈ O ₂
	15.85	Pentadecanoic acid	1.17	C ₁₅ H ₃₀ O ₂
	15.93	Palmitic alcohol	1.98	C ₁₆ H ₃₄ O
	16.02	No synonym	3.83	C ₂₀ H ₃₀ O ₄
	16.56	Palmitic acid	5.81	C ₁₆ H ₃₂ O ₂
	17.13	Oleic alcohol	4.16	C ₁₈ H ₃₆ O
	17.29	Stearic alcohol	0.97	C ₁₈ H ₃₈ O
	17.66	Linoleic acid	2.14	C ₁₈ H ₃₂ O ₂
	18.65	/	1.53	/
	24.91	/	2.89	/
	27.10	Stigmasterol	12.32	C ₂₉ H ₄₈ O
	27.89	γ -Sitosterol	43.86	C ₂₉ H ₅₀ O
	29.75	γ -Sitostenone	12.94	C ₂₉ H ₄₈ O
Acetone	11.35	Erythritol	4.24	C ₄ H ₁₀ O ₄
	14.68	D-(-)-Fructopyranose	22.97	C ₆ H ₁₂ O ₆
	15.33	β -D-allopyranose	5.35	C ₆ H ₁₂ O ₆
	15.61	α -D-mannopyranose	13.66	C ₆ H ₁₂ O ₆
	16.79	Myo-Inositol	2.60	C ₆ H ₁₂ O ₆
	24.94	/	2.73	/
	26.82	/	2.83	/
	27.13	Stigmasterol	7.41	C ₂₉ H ₄₈ O
	27.91	Stigmast-5-ene	24.99	C ₂₉ H ₅₀
	29.82	γ -Sitostenone	3.79	C ₂₉ H ₄₈ O
	30.18	Lupeol	4.00	C ₃₀ H ₅₀ O
	32.08	/	5.43	/
Toluene/Ethanol		Unidentified compounds		

*(/): Unidentified compounds

ities (Prayogo et al., 2021). This duality of metabolites (lipophilic sterols, triterpenes, and fatty acids on one hand, and polar sugars and polyols on the other) positions the species as a promising source of bioactive agents for applications in wood preservation, pharmaceuticals, and agrochemicals. The predominance of sterols and triterpenes, such as lupeol, alongside functional sugars, such as D-pinitol, highlights opportunities for both industrial extraction and biotechnological exploitation, reinforcing their relevance to sustainable biomaterials development.

The FTIR spectra corroborate these GC-MS results by confirming, at the functional-group level, the presence of the identified compounds. Broad O–H absorption bands between 3,400–3,200 cm^{-1} are consistent with hydroxylated molecules such as sugar alcohols, sterols, and triterpenes, while the C–H stretching signals at 2,916–2,850 cm^{-1} , particularly evident in the dichloromethane fraction, reflect the abundance of aliphatic fatty acids and alcohols. Strong absorptions in the ranges 1,750–1,700 cm^{-1} and 1,300–1,000 cm^{-1} further confirm carbonyl and C–O bonds, in line with the occurrence of carboxylic acids and polyols revealed by GC-MS. Notably, the dichloromethane extract exhibited the highest number of FTIR absorption bands, mirroring its chemically diverse composition rich in sterols, terpenoids, and fatty acids, whereas the acetone and toluene/ethanol fractions presented comparatively simpler spectra dominated by sugar-derived functionalities. Together, the complementary insights from GC-MS and FTIR underscore the solvent-dependent selectivity of extraction and highlight the structural diversity of *A. mangium* metabolites, thereby reinforcing their potential for high-value bio-based applications.

Chemical profile of mahogany

The compositional pattern enriched in lipophilic terpenoids/sterols in the apolar fraction, catechins and galloylated flavanols in the polar fractions, and sugar alcohols/inositols in the intermediate fractions aligns with previous phytochemical and bioactivity reports on *Khaya* species. Several studies report high tannin/phenolic content and associated antioxidant/antimicrobial activities for *K. ivorensis* heartwood and bark, and the isolation of limonoids/terpenoids from *Khaya* stems has been documented, supporting the presence of terpenoid and limonoid families in Meliaceae heartwood (Bikoro et al., 2021).



Photo 6.
Acacia (*Acacia mangium*) trunk.
Photo H. A. A. Ouattara.

In addition, investigations into *Khaya* bark/wood have demonstrated termiticidal and antimicrobial activities that correlate with high phenolic (tannin/catechin) contents and with lipophilic extractives implicated in natural durability (Adedeji et al., 2018). Indeed, recent work on limonoids and triterpenoids of the genus *Khaya* confirms the presence of chemical families (limonoids, mexicanolides, triterpenes) with antimicrobial and antifungal activities, reinforcing the hypothesis that the protective action of wood stems from a synergistic combination of hydrophilic phenols and lipophilic extractives (Olatunji et al., 2021).

FTIR complementarity strengthens these GC-MS assignments: the broad O–H stretching band (3,313–3,300 cm^{-1}) observed in acetone and toluene/EtOH fractions is fully consistent with the high content of polyphenols (catechins and galloylated catechins) and

polyols (inositol, erythritol) detected by GC-MS. The intense aliphatic C–H bands ($2,930\text{--}2,850\text{ cm}^{-1}$) and the carbonyl/C=O absorptions ($1,737$ and $1,180\text{ cm}^{-1}$, with a weaker C=O at $1,730\text{ cm}^{-1}$) observed in the dichloromethane spectrum corroborate the presence of abundant fatty acids, long-chain alcohols, and sterol/triterpene skeletons reported by GC-MS. When FTIR shows numerous distinct bands in the DCM fraction while acetone/toluene-EtOH spectra are dominated by broad OH/C–O features, this mirrors the chemical diversity of the apolar fraction (many distinct terpenoid/sterol signatures) versus the carbohydrate/phenolic dominance of polar fractions. Taken together, GC-MS and FTIR provide mutually reinforcing evidence of a tannin- and catechin-rich polar profile that likely explains the antioxidant and antimicrobial activity, as well as a lipophilic profile rich in fatty acids and sterols/triterpenes that may contribute to wood durability and bioactivity.

Chemical profile of dabema

GC-MS analysis of *P. africanum* wood reveals a chemical richness marked by the simultaneous presence of primary (sugars, polyols, fatty acids) and secondary (sterols, triterpenes) metabolites, suggesting high metabolic activity and diversified defence mechanisms. This chemical composition could reflect both the species' ecological adaptation and its potential for use in various fields, notably pharmacology and industrial valorisation.

Polyols and simple sugars, dominant in the acetone and toluene/ethanol extracts, are evidence of high physiological activity. The detection of D-pinitol in high quantities in several solvents (>20%) is particularly noteworthy. This compound, widely documented for its antidiabetic, antioxidant, and cytoprotective properties (Pandi et al., 2022), could play a key role in osmotic metabolism and water stress in wood.

Similarly, the significant presence of inositol, a central precursor in phosphoinositide signalling, confirms the high metabolic activity and membrane stability of lignified tissue. Simple sugars (glucose, fructose, mannose) and sucrose are involved in energy storage and transport, characteristics of reserve tissues.

The fatty acids identified, notably palmitic and oleic acids, are major membrane constituents that confer rigidity, selective permeability, and resistance to abiotic and biotic stressors. Their abundance in the dichloromethane extract suggests an important structural involvement. Previous studies have shown that these lipids may also play a role in signalling and defence against pathogens (Lim et al., 2017).

The presence of sterols and triterpenes confirms the potential of *P. africanum* wood as a source of bioactive compounds. α -spinasterol and stigmast-7-en-3-ol, identified at notable concentrations, are known for their antimicrobial and anti-inflammatory activities (Ghosh et al., 2025). Lupeol, although often observed in the bark or leaves of medicinal plants, is found here in wood, which may reflect an atypical defensive accumulation in the heartwood. These compounds may protect wood against lignivorous microorganisms and insects, thereby conferring natural durability.

However, the detection of cypermethrin, a synthetic insecticide, in some extracts raises questions. Although its presence may result from environmental contamination (e.g., phytosanitary application near the tree), absorption or physico-chemical interaction with wood compounds cannot be ruled out. This result calls for increased vigilance in the sampling and analysis of wood from anthropised environments, particularly in tropical zones. Overall, these results reinforce the interest of *P. africanum* wood as a natural bioactive matrix, both for its potential biological properties and for its chemical stability. Its use could be envisaged in pharmaceutical and cosmetic applications or as a source of functional biomolecules, provided that we gain a better understanding of the origin and stability of the identified compounds.

FTIR spectroscopy provided complementary structural insights into these chemical groups. The dichloromethane extract exhibited strong absorption bands at $2,915$; $2,848$; $1,710$; and $1,463\text{ cm}^{-1}$, characteristic of aliphatic CH_2/CH_3 and carbonyl groups, consistent with the presence of fatty acids and long-chain alcohols identified by GC-MS. In contrast, the acetone and toluene/ethanol extracts exhibited intense O–H stretching bands at $3,325\text{--}3,350\text{ cm}^{-1}$, confirming the prevalence of polyols and sugars, while absorptions at $1,006\text{--}1,020\text{ cm}^{-1}$ reflected C–O bonds typical of carbohydrate structures. Additional signals at $1,620\text{--}1,610\text{ cm}^{-1}$ (C=C stretching) and $1,729\text{--}1,737\text{ cm}^{-1}$ (C=O stretching) indicated aromatic and ester/carboxyl functionalities, consistent with the presence of phenolics, sterols, and triterpenes. Taken together, the FTIR spectra corroborate the GC-MS chemical profile, highlighting the partitioning of lipophilic compounds into apolar extracts and carbohydrate-rich metabolites into polar fractions, thereby reinforcing the view of *P. africanum* as a reservoir of structurally diverse and bioactive natural products.

Chemical profile of gmelina

Comparative analysis of *G. arborea* wood extracts obtained with solvents of increasing polarity (dichloromethane, acetone, toluene/ethanol) highlighted the diversity of extractive compounds and their solvent-specific affinities. As an apolar solvent, dichloromethane enabled selective extraction of lipophilic compounds, including long-chain fatty acids and alcohols such as montanyl alcohol (33.35%), ceryl alcohol, and palmitic and oleic acids. These compounds are well known for their emollient, antibacterial and anti-inflammatory properties (Safou-Tchiam, 2023).

Acetone, with intermediate to polar polarity, has shown effectiveness in extracting simple sugars (glucose, mannose, rhamnose) and organic acids (succinic acid, veratric acid), as well as gmelinol, a lignan widely found in acetone extracts at levels of up to 39.62%. Gmelinol is reported to have antioxidant and antifungal activities, particularly against crop pathogens (Kawamura & Ohara, 2005). Veratric acid, meanwhile, is a methoxylated derivative of benzoic acid, possessing antioxidant, hepatoprotective and antimicrobial properties (Woodward et al., 2019).



Photo 7.
Gmelina (*Gmelina arborea*) trunk.
Photo H. A. A. Ouattara.

The mixed-polarity toluene/ethanol mixture enabled simultaneous extraction of hydrophilic and hydrophobic compounds. It was used to extract fatty acid esters, such as ethyl caprate (27.74%) and ethyl stearate, which are known for their antimicrobial properties and use as bioactive excipients (Firoozbahr et al., 2023). The concomitant presence of sugars and polyols (glucose, galactose, inositol, glucosamine) also testifies to its ability to extract polar metabolites. In particular, the compounds gmelinol and veratric acid were detected in all three solvents, suggesting their high representativeness in wood and their potential for broad-spectrum extraction. This ubiquity indicates a possible involvement in wood's natural chemical defence mechanisms against biotic and abiotic stresses (Farhat et al., 2013).

These results highlight the importance of solvent choice in optimising the targeted extraction of bioactive compounds. The sequential or combined use of solvents of varying polarity would enable the full valorisation of the biomolecules present in lignocellulosic matrices for phytosanitary, cosmetic, and pharmaceutical applications (Goudenhoofft et al., 2017).

The distinct FTIR signature of the dichloromethane extract, characterised by strong aliphatic C-H stretches and a prominent carbonyl band, spectroscopically confirms the GC-MS result that this apolar solvent selectively isolated long-chain fatty acids and alcohols. Conversely, the intense,

broad hydroxyl absorptions in the spectra of the acetone and toluene/ethanol extracts directly evidence successful extraction of polar, hydrogen-bonding species, including sugars, polyols, and phenolic compounds such as gmelinol and veratric acid, as identified by GC-MS. The consistent presence of carbonyl and C-O stretches across all extracts offers further spectroscopic support for the ubiquitous detection of key bioactive compounds bearing these functional groups. In synergy, the techniques demonstrate that solvent polarity governs extraction efficiency by targeting specific functional motifs, with FTIR defining the broad chemical classes present and GC-MS elucidating the precise molecular identities within those classes.

Chemical profile of white iroko

GC-MS analysis reveals a diverse molecular composition of white iroko wood extracts, strongly influenced by solvent polarity. Dichloromethane, an

apolar to weakly polar solvent, was used to extract most lipophilic and aromatic compounds. Chlorophorin predominated (53.66%), a xanthone with well-documented antifungal and antioxidant activity (Huang et al., 2021). Other phenolic compounds, such as 3,4-dihydroxyphenylglycol (10.04%), 2,4-dihydroxybenzaldehyde, and p-hydroxybenzoic acid, have also been identified. These molecules possess antiradical and antimicrobial activities and are involved in plant chemical defences (Alves et al., 2013). Fatty acids (palmitic, stearic) and lipophilic compounds such as stigmast-5-ene, a sterol with anti-inflammatory action (Moreau et al., 2002), complete the profile.

Acetone, an intermediate polar solvent, extracted a wider range of polar metabolites. Among them, polyols (erythritol, xylitol), hydroxylated acids (2,5-dihydroxybenzoic acid), and, above all, stilbenes such as resveratrol (4.13%) and oxyresveratrol (18.97%) were detected. The latter are known for their powerful antioxidant, antiviral and anti-tyrosinase activities, giving them cosmetic and therapeutic interest (Lee et al., 2015). Chlorophorin is also found in acetone extracts in high proportions (up to 35.97%), confirming its solubility in a wide range of solvents.

The toluene/ethanol mixture, with modulated polarity, enables the simultaneous extraction of sugars, polyols and phenolic compounds. There was a very high presence of xylitol (21.49%), a natural sweetener with oral antimicrobial and prebiotic effects (Mäkinen, 2010), as well as other

sugars such as arabinose, mannitol and trehalose, which play a role in water and heat stress tolerance in plants (El Sayed et al., 2014). Oxyresveratrol (9.09%) was again detected, as was chlorophorin (up to 23.02%), underscoring the mixture's ability to extract both hydrophilic and lipophilic compounds efficiently.

Cross-sectionally, chlorophorin is the primary chemical marker in the extracts, with contents ranging from 11 to 54% across solvents. Its dominant presence reflects its importance in wood defence. Furthermore, hydroxylated phenolic molecules and stilbenes detected across all solvents are associated with antioxidant, antifungal, and anti-inflammatory activities (Guo et al., 2021).

FTIR spectra corroborate these compositional findings by confirming the presence of hydroxyl, carbonyl, and ester groups associated with phenolic acids, aldehydes, and polyols identified by GC-MS. Broad absorption bands at $3,300\text{ cm}^{-1}$ in all extracts reflect O–H stretching vibrations typical of aromatic phenols, in line with the high levels of chlorophorin, resveratrol, and oxyresveratrol. The peaks at $1,715\text{--}1,702\text{ cm}^{-1}$ are consistent with C=O stretching vibrations of carboxylic acids and aldehydes, such as p-hydroxybenzoic acid and 2,4-dihydroxybenzaldehyde. Similarly, the CH_2 and CH_3 stretching vibrations observed at $2,920\text{--}2,926\text{ cm}^{-1}$ correspond well with the fatty acids detected in GC-MS (palmitic, oleic, and stearic acids), while absorptions at $1,050\text{--}1,022\text{ cm}^{-1}$ confirm the presence of C–O bonds characteristic of sugar alcohols (xylitol, erythritol) and esters. Taken together, the complementary results of GC-MS and FTIR demonstrate that the extractives of *M. excelsa* are dominated by polyphenolic metabolites and lipophilic acids, directly supporting its reputation as one of the most naturally durable tropical hardwoods (Kirker et al., 2024).

Chemical profile of samba

Analysis of Samba extracts from three solvents of increasing polarity reveals a clear solvent effect on the selectivity of extracted compounds. Dichloromethane, a low-polarity solvent, enabled the extraction of many lipids, fatty alcohols and plant sterols, while acetone, a polar solvent, favoured the extraction of sugars and triterpenes. No compounds were identified in the toluene/ethanol extract, suggesting either inefficient extraction or insufficient compound concentration for detection.



Photo 8.
Cut trunk of white iroko wood (*Milicia excelsa*).
Photo H. A. A. Ouattara.

The composition of the dichloromethane extract is dominated by plant sterols, notably γ -sitosterol (43.86%), γ -sitostenone (12.94%) and stigmasterol (12.32%), compounds widely known for their hypocholesterolemic, anti-inflammatory and anticancer properties (Woyengo et al., 2009). In addition, several saturated and unsaturated fatty acids have been identified, including lauric, myristic, palmitic, pentadecanoic, linoleic, and oleic acids, with antimicrobial, emollient, and anti-inflammatory properties (Kabara et al., 1972; Safou-Tchiama, 2023). The abundance of fatty alcohols, such as palmitic, oleic, and stearic, confirms the lipidic nature of the profile.

The acetone extract is rich in oses and polyols: D-fructopyranose (22.97%), α -mannopyranose (13.66%), β -allopypyranose, and erythritol. These compounds are associated with energy reserve functions and osmotic protection against abiotic stress (El Sayed et al., 2014). Inositol, detected at 2.60%, is a cyclic metabolite involved in cell signalling pathways and plant growth. The lipophilic acetone fraction also contains sterols (stigmasterol: 7.41%; stigmast-5-ene: 24.99%), and γ -sitostenone, as well as lupeol (4.00%), a pentacyclic triterpene with strong anti-inflammatory, antimicrobial, and hepatoprotective potential (Oliveira et al., 2007). These compounds are often associated with phytoprotective action against pathogens.

Several factors could explain the absence of identified compounds in the toluene/ethanol extract: inefficiency of the solvent in extracting the main chemical families pres-

ent in the analysed wood, insufficient extractive compound content, or interference during chromatographic analysis. A reassessment of polarity, solvent ratio or extraction time could be considered to optimise this mixture. The results show a marked complementarity between solvents: dichloromethane is ideal for targeting lipids and phytosterols, while acetone extracts bioactive sugars, inositol, and triterpenes more effectively. These profiles confirm the value of polarity-selective extraction, with a view to upgrading tropical woods for cosmetic, nutraceutical, or phytosanitary applications.

The FTIR data corroborate the functional-group assignments from GC-MS. Strong aliphatic C-H stretching bands at 2,922–2,913 cm^{-1} in the DCM spectrum are fully consistent with the abundance of long-chain fatty acids and alcohols identified by GC-MS. The carbonyl absorption near 1,710 cm^{-1} supports the presence of free or esterified carboxylic acids (palmitic, stearic, lauric acids) observed in the apolar extract. The C-O stretching features at 1,020 cm^{-1} likewise corroborate the presence of ester and alcohol functionalities reported in the DCM fraction. For the acetone extract, the pronounced O-H stretching bands at 3,340–3,320 cm^{-1} and the strong C-O absorptions around 1,021 cm^{-1} match the high content of mono- and oligosaccharides and polyols (fructose, mannose, allose, erythritol, myo-inositol) found by GC-MS; these FTIR bands are typical of carbohydrate-rich fractions. FTIR signals attributable to C=C stretching (1,670–1,675 cm^{-1}) and CH deformation (1,460 cm^{-1}) also agree with the presence of sterol/triterpene skeletons (stigmast-5-ene, stigmasterol, lupeol) detected in both DCM and acetone fractions.

Conclusion

The extracts of six tropical woods from Côte d'Ivoire were obtained using solvents of increasing polarity. They contained numerous chemical compounds with valuable properties, such as insecticidal, fungicidal, and antimicrobial activities. These properties make them suitable for applications in various fields, notably cosmetics, pharmaceuticals, and agriculture. This large-scale availability of bioactive compounds underscores the importance of characterising extracts from sawdust of different woods used by industries and carpenters in Côte d'Ivoire. This will enable better use of wood waste across fields and help to reduce environmental pollution from sawdust neglected as waste in Côte d'Ivoire.

Acknowledgements

We thank the Society for the Development of Forests (SODEFOR) and INPROBOIS for supplying plant material. We would also like to thank the Doctoral school of INP-HB and the laboratory for the study and research of wood materials at the University of Lorraine.

Research Ethics

The local institutional review board deemed the study exempt from review.

Conflicts of Interest

The authors state no conflict of interest.

Research Funding

This research was not funded.

Data Availability Statement

The data associated with this article have been deposited in the digital repository Zenodo. They are accessible online via: OUATTARA, H. A. A., & N'GUESSAN, J. L. L. (2026). Experiment of degradation of holocellulose, lignin and extraction by soxhlet method and GC-MS analysis data. Zenodo. <https://doi.org/10.5281/zenodo.18671073> assigned by the platform Creative Commons Attribution 4.0 International. The data are made available in open access, in accordance with open science principles, and may be consulted and downloaded under the conditions specified in the corresponding Zenodo record.

Statement on the Use of Artificial Intelligence Tools

The authors declare that no artificial intelligence tools were used for language editing, translation, literature research, scientific data analysis, or any other stage involved in the preparation of this manuscript. All scientific and writing work was carried out exclusively by the authors.

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