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Research Article

PHYTOCHEMICAL INVESTIGATION OF *Flacourtia jangomas* STEMS

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ABSTRACT

*Flacourtia jangomas has been recognized as a potential medicinal plant in the traditional medicine systems of tropical countries in East and Southeast Asia. This study was conducted to explore the phytochemical constituents of F. jangomas native to Vietnam. Four compounds were isolated from F. jangomas stems, namely β-sitosterol (**1**), 4-hydroxybenzaldehyde (**2**), oleanolic acid (**3**), and methyl ferulate (**4**). The structures of these compounds were characterized by interpreting NMR data and comparing the results with previously reported data.*

***Keywords*:** Salicaceae*; Flacourtia jangomas*; terpenoids

1. Introduction

The genus *Flacourtia* belongs to the Salicaceae family and was formerly classified under the Flacourtiaceae family (Mabberley, 2008). This genus comprises approximately 23 species and is widely distributed across tropical and subtropical regions of Africa and Asia (Zhang et al., 2020). Among these species, *Flacourtia jangomas* (Lour.) Raeusch, commonly known as Indian plum, is a fruit-bearing plant native to the lowland regions of Southeast and East Asia. It is a small deciduous tree that typically reaches 6–10 meters (occasionally up to 14 meters) in height and is characterized by a dense, spreading crown. Its distinctive trunk features rough bark that ranges from pale brown to copper-red and peels into thin, lenticellate layers. The foliage consists of simple, alternately arranged leaves that are ovate to ovate-lanceolate with serrated margins. The fruits are edible and are best consumed fresh when fully ripe during summer (Vo, 1997). Various parts of the plant have long been used in folk medicine. The leaves are known for their antidiarrhoeal and stomachic properties and are used to treat chronic bronchitis, while the fruit is used for liver-related conditions. In addition, both the bark and fruit possess antibilious effects, and an infusion of the bark is

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commonly used as a gargle (Khare, 2008). The plant extracts have exhibited antioxidant activity (Aklima et al., 2014; Neeharika Dubey & Pandey, 2013), antibacterial activity (Parvin et al., 2011), antidiabetic activity in streptozotocin-induced models (Singh & Singh, 2010), and α-amylase inhibitory activity (Aklima et al., 2014).

Previous phytochemical investigations of this species have identified several major classes of secondary metabolites, including flavonoids, coumarins, limonoids, diterpenes, steroids, and other phenolic compounds (Ahmad et al.,1984; Dinda et al., 1989; Pandey & Dubey, 2014).

However, research on the phytochemical composition and bioactive properties of *F. jangomas*, particularly in Vietnam, remains scarce. Because chemical composition is often influenced by geographical and environmental factors, Vietnamese specimens require systematic characterization. Therefore, this study aimed to systematically investigate the chemical composition of *F. jangomas* stems collected in Vietnam by isolating and identifying their constituent compounds. Using a combination of chromatographic separation techniques and spectroscopic analyses, four known compounds were successfully isolated and structurally characterized: *β*-sitosterol, 4-hydroxybenzaldehyde, oleanolic acid, and methyl ferulate from *F. jangomas* stems. Their structures were determined using NMR spectroscopy and compared with published data. These findings not only contribute to the expansion of the phytochemical database for *F. jangomas* but also provide a scientific basis for its potential utilization in the development of pharmaceutical and natural products.

2. Experimental

2.1. General experimental procedures

NMR spectra were recorded on a Bruker Avance spectrometer at frequencies of 500 MHz for ^{1}H and 125 MHz for ^{13}C. Chemical shifts (ppm) were referenced to the residual solvent peaks of $CDCl_3$ ($\delta_H = 7.26$, $\delta_C = 77.2$) and acetone-d_6 ($\delta_H = 2.05$, $\delta_C = 29.8$). Purification via column chromatography employed silica gel 60 (40-63 μm, Merck). Thin-layer chromatography (TLC) was performed using silica gel 60 F_{254} plates, and compounds were visualized by treating the plates with a 20% H_2SO_4 solution and subsequent heating.

2.2. Extraction and isolation

To prepare the crude extract, 8.0 kg of ground *F. jangomas* powder was soaked in MeOH (2 × 20 L) at room temperature over three days. Following filtration, the solution was concentrated using rotary evaporation under reduced pressure to obtain a crude extract (600.9 g). Fractionation of the crude extract was performed by liquid–liquid extraction with *n*-hexane and EtOAc to afford *n*-hexane (H), *n*-hexane–EtOAc (1:1) (HEa), and EtOAc (Ea) extracts. The HEa extract was subjected to open silica gel column chromatography (CC) with an *n*-hexane–EtOAc (4:1, v/v) mobile phase, yielding 12 fractions (**N1**–**N12**).

From fraction **N5** (52.5 g), a solid precipitate was rinsed with acetone to yield compound **1** (1.1 g). Compound **4** (2.9 mg) was isolated from fraction **N7** (51.5 g) via

sequential silica gel CC using the solvent system *n*-hexane–acetone–CH_2Cl_2–EtOAc–H_2O (8:1:1:1:0.0001, v/v/v/v/v) and then *n*-hexane–EtOAc (3:1, v/v). Similarly, fraction **N8** (32.0 g) was subjected to two chromatographic steps using an isocratic elution system of *n*-hexane–acetone–CH_2Cl_2–EtOAc–H_2O (8:1:1:1:0.0001, v/v/v/v/v), followed by CH_2Cl_2–EtOAc–acetone–MeOH–H_2O (130:100:100:1:0.2, v/v/v/v/v) to obtain **2** (2.2 mg) and **3** (10.3 mg), respectively.

2.3. Spectroscopic data

Table 1. *^1H (500 MHz) and ^{13}C NMR (125 MHz) spectroscopic data of **1** and **3** (δ in ppm, J in Hz)*

position	**β-sitosterol (1)**[a]		position	**Oleanolic acid (3)**[b]	
	δ_H	δ_C, type		δ_H	δ_C, type
1		37.4, CH_2	1		39.5, CH_2
2		31.9, CH_2	2		26.3, CH_2
3	3.52, m	72.0, CH	3	3.18, m	78.6, CH
4		42.4, CH_2	4		39.4, C
5		140.9, C	5		56.2, CH
6	5.35, dd, 7.5, 2.0	121.9, CH	6		17.6, CH_2
7		31.9, CH_2	7		33.4, CH_2
8		32.0, CH	8		39.5, C
9		50.3, CH	9		48.6, CH
10		36.6, C	10		37.8, C
11		21.2, CH_2	11		23.8, CH_2
12		39.9, CH_2	12	5.26, t, 3.5	123.1, CH
13		42.4, C	13		145.0, C
14		56.9, CH	14		42.5, C
15		24.4, CH_2	15		28.1, CH_2
16		28.4, CH_2	16		23.9, CH_2
17		56.2, CH	17		46.8, C
18	0.68, s	12.1, CH_3	18	2.91, m	42.3, CH
19	1.00, s	20.0, CH_3	19		40.2, CH_2
20		36.3, CH	20		31.3, C
21	0.92, d, 7.0	18.9, CH_3	21		33.7, CH_2
22		34.1, CH_2	22		34.5, CH_2
23		26.2, CH_2	23	1.00, s	28.7, CH_3
24		46.0, CH	24	0.95, s	16.3, CH_3
25		29.3, CH	25	0.79, s	15.8, CH_3
26	0.81, d, 7.0	19.2, CH_3	26	0.96, s	19.1, CH_3
27	0.83, d, 6.5	19.5, CH_3	27	1.19, s	24.1, CH_3
28		23.2, CH_2	28		178.9, C
29	0.85, t, 7.0	12.0, CH_3	29	0.82, s	33.4, CH_3
30			30	0.93, s	23.8, CH_3

[a]*recorded in $CDCl_3$* ; [b]*recorded in* acetone-d_6

Table 2. *^{1}H (500 MHz) spectroscopic data of **2** and **4** (δ in ppm, J in Hz)*

position	*4-hydroxybenzaldehyde (2)*[b]	position	*Methyl ferulate (4)*[b]
	δ_H		δ_H
2	7.80, d, 8.5	2	6.40, d, 15.5
3	7.01, d, 8.5	3	7.60, d, 16.0
4		2′	7.30, d, 2.0
5	7.01, d, 8.5	5′	6.86, d, 8.0
6	7.80, d, 8.5	6′	7.15, dd, 8.0, 2.0
-CHO	9.84, s	1-OCH_3	3.72, s
		3′-OCH_3	3.92, s

[b]*recorded in* acetone-d_6

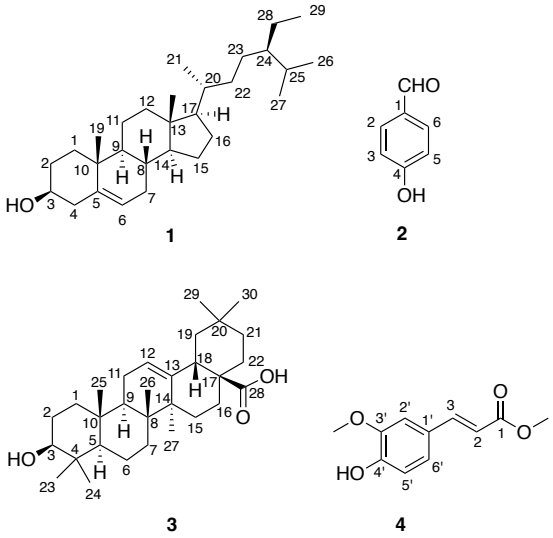

Figure 1. *Chemical structures of isolated compounds **1**–**4***

3. Results and discussion

Compound **1** was obtained as a white crystalline solid. The ^{1}H NMR data displayed signals for six methyl groups at δ_H 1.00 (3H, s), 0.92 (3H, d, *J*= 7.0 Hz), 0.85 (3H, t, *J*= 7.0 Hz), 0.83 (3H, d, *J*= 6.5 Hz), 0.81 (3H, d, *J*= 7.0 Hz), 0.68 (3H, s), one oxygenated methine proton at δ_H 3.52 (1H, m), one olefinic proton at δ_H 5.35 (1H, dd, *J*= 7.5, 2.0 Hz) and two methylene protons at δ_H 2.23 (1H, m), 2.29 (1H, m). The ^{13}C NMR spectrum revealed the presence of 29 carbons, including two olefinic carbons (δ_C 140.9, 121.9), one oxygenated methine (δ_C 72.0), and the aliphatic carbons in the range 12.0–56.9 ppm. The spectroscopic data indicated that **1** has a phytosterol skeleton. Comparison of the ^{1}H and ^{13}C NMR data for **1** with those reported for β-sitosterol (Cayme & Ragasa, 2004) showed close agreement. Therefore, compound **1** was identified as β-sitosterol.

Compound **2** was obtained as a brown crystalline solid. The ^{1}H NMR spectrum revealed one aldehyde proton at δ_H 9.84 (1H, s, -CHO) and a 1,4-disubstituted benzene ring [δ_H 7.80 (2H, d, J = 8.5 Hz, H-2, 6), 7.01 (2H, d, J = 8.5 Hz, H-3, 5)]. These results, together with published data for 4-hydroxybenzaldehyde (Hoque et al., 2020; Pham et al., 2020), confirmed **2** as 4-hydroxybenzaldehyde.

Compound **3** was obtained as a white crystalline solid. The ^{1}H NMR spectrum of **3** revealed one olefinic proton at δ_H 5.26 (1H, t, J = 3.5 Hz), one oxygenated methine at δ_H 3.54 (1H, br s), a deshielded methine at δ_H 3.18 (1H, m), seven singlet methyls at δ_H 1.19, 1.00, 0.96, 0.95, 0.93, 0.82, and 0.79, along with a high-intensity signal in the range 0.9–2.3 ppm. The ^{13}C NMR spectrum of **3** displayed signals for 30 carbons, including one carboxylic carbon at δ_C 178.9, two olefinic carbons at δ_C 145.0 and 123.1, and one oxygenated methine at δ_C 78.6. The data indicated that **3** is a triterpene with an oleanane skeleton. The spectral data for **3** were compared with published data (Seebacher, Simic, Weis, Saf, & Kunert, 2003; Silva et al., 2008), confirming that the structure of **3** was oleanolic acid.

Compound **4** was purified as a white crystalline solid. The ^{1}H NMR spectrum showed signals for two methoxy groups (δ_H 3.92 and 3.72) and two olefinic protons at δ_H 7.60 (1H, *d*, J = 16.0 Hz) and 6.40 (1H, d, J = 15.5 Hz). The large vicinal coupling constants confirmed the *trans* configuration of the α,β-unsaturated double bond, while the downfield shift of the signal at 7.60 is characteristic of a β-proton conjugated to a carbonyl group. In the downfield region, three aromatic protons belonging to an ABX pattern [δ_H 7.30 (1H, d, J = 2.0 Hz), 7.15 (1H, dd, J = 8.0, 2.0 Hz), and 6.86 (1H, d, J = 8.0 Hz)] were observed. Comparison of the NMR data for compound **4** with the reported spectral data for methyl ferulate (Ramadan et al., 2024) showed close agreement. Therefore, compound **4** was identified as methyl ferulate. This is the first report of the isolation of this compound from the genus *Flacourtia*.

The isolation and structural elucidation of compounds **1–4** from *Flacourtia jangomas* stems, including *β*-sitosterol (**1**), 4-hydroxybenzaldehyde (**2**), oleanolic acid (**3**), and methyl ferulate (**4**), expand the phytochemical profile of the Vietnamese species and support previous qualitative screening results. The presence of **1** and **3** is noteworthy due to their established pharmacological activities; specifically, the anti-inflammatory and hepatoprotective properties of *β*-sitosterol (**1**) and oleanolic acid (**3**) align with the traditional use of *F. jangomas* for rheumatism and its reported anti-diabetic potential (Babu & Jayaraman, 2020; Verma, Raghuvanshi, & Singh, 2024). Furthermore, the identification of phenolic derivatives **2** and **4** is consistent with the high antioxidant and radical-scavenging activities previously observed in this species (Chen et al., 2021; Ramadan et al., 2024). While 4-hydroxybenzaldehyde (**2**) is a known antimicrobial and cytotoxic agent, the discovery of methyl ferulate (**4**) is particularly significant, as it represents the first report of this phenylpropanoid within the genus *Flacourtia*. This finding enhances the chemotaxonomic understanding of the species and suggests that these metabolites, individually or

synergistically, support the plant's diverse bioactivities. Overall, these results provide a basis for understanding the ethnobotanical applications of *F. jangomas* and highlight its potential as a source of bioactive aromatic compounds and triterpenoids.

4. Conclusions

Phytochemical investigation of *F. jangomas* stems led to the isolation of four compounds, including *β*-sitosterol (**1**), 4-hydroxybenzaldehyde (**2**), oleanolic acid (**3**), and methyl ferulate (**4**). The chemical structures of these compounds were successfully elucidated by nuclear magnetic resonance (NMR) spectroscopic analysis and comparison with previously published data. To the best of our knowledge, this is the first report describing the presence of these four compounds in *F. jangomas*.

❖ ***Conflict of Interest:*** *Authors have no conflict of interest to declare.*

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REFERENCES

Ahmad, J., Wizarat, K., Shamsuddin, K., Zaman, A., & Connolly, J. D. (1984). Jangomolide, a novel limonoid from *Flacourtia jangomas*. *Phytochemistry, 23*(6), 1269–1270.

Aklima, J., Mojumder, S., & Sikdar, D. (2014). Total phenolic content, reducing power, antioxidative and anti-amylase activities of five Bangladeshi fruits. *Int. Food Res. J., 21*(1), 119.

Babu, S., & Jayaraman, S. (2020). An update on β-sitosterol: A potential herbal nutraceutical for diabetic management. *Biomed. Pharmacother., 131*, 110702.

Cayme, J.-M. C., & Ragasa, C. Y. (2004). Structure elucidation of β-stigmasterol and β-sitosterol from *Sesbania grandifora* [Linn.] Pers. and β-carotene from *Heliotropium indicum* Linn. by NMR spectroscopy. *Kimika, 20*(1), 5–12.

Chen, K.-Y., Chen, Y.-J., Cheng, C.-J., Jhan, K.-Y., Chiu, C.-H., & Wang, L.-C. (2021). 3-Hydroxybenzaldehyde and 4-Hydroxybenzaldehyde enhance survival of mouse astrocytes treated with Angiostrongylus cantonensis young adults excretory/secretory products. *Biomed. J., 44*(6), S258–S266.

Dinda, B., Banerjee, J., Pal, J., & Mahanti, A. (1989). Chemical composition of *Flacourtia jangomas* fruits. *J. Food Sci. Technol., 26*(6), 334–336.

Hoque, N., Sohrab, M. H., Afroz, F., Rony, S. R., Sharmin, S., Moni, F., Hasan, C. M., & Rana, M. S. (2020). Cytotoxic metabolites from *Thysanolaena maxima* Roxb. available in Bangladesh. *Clinical Phytoscience, 6*(1), 89.

Khare, C. P. (2008). *Indian medicinal plants: an illustrated dictionary*: Springer Science & Business Media.

Mabberley, D. J. (2008). Mabberley's plant-book. *A portable dictionary of plants, their classifications and uses, 3*.

Neeharika Dubey, N. D., & Pandey, V. (2013). Ferric reducing power of solvent extracts of fruits of *Flacourtia jangomas* (Lour.) Raeusch. *Life sciences leaflets*, *44*, 66–71.

Pandey, V., & Dubey, N. (2014). Nutraceutical, pharmaceutical and industrial value of coffee plum: *Flacourtia jangomas* (Lour.) Raeusch. *Everyman's Sci, 49*, 98–104.

Parvin, S., Kader, A., Sarkar, G. C., & Hosain, S. B. (2011). In-vitro studies of antibacterial and cytotoxic properties of *Flacourtia jangomas*. *Int. J. Pharm. Sci. Res., 2*(11), 2786.

Ramadan, A. M. A. A., Zidan, S. A. H., Shehata, R. M., El-Sheikh, H. H., Ameen, F., Stephenson, S. L., & Al-Bedak, O. A.-H. M. (2024). Antioxidant, antibacterial, and molecular docking of methyl ferulate and oleic acid produced by *Aspergillus pseudodeflectus* AUMC 15761 utilizing wheat bran. *Scientific Reports, 14*(1), 3183.

Seebacher, W., Simic, N., Weis, R., Saf, R., & Kunert, O. (2003). Complete assignments of ^{1}H and ^{13}C NMR resonances of oleanolic acid, 18α-oleanolic acid, ursolic acid and their 11-oxo derivatives. *Magn. Reson. Chem., 41*(8), 636–638.

Silva, M. G. V., Vieira, Í. G., Mendes, F. N., Albuquerque, I. L., Dos Santos, R. N., Silva, F. O., & Morais, S. M. (2008). Variation of ursolic acid content in eight *Ocimum* species from northeastern Brazil. *Molecules, 13*(10), 2482–2487.

Singh, A. K., & Singh, J. (2010). Evaluation of anti-diabetic potential of leaves and stem of *Flacourtia jangomas* in streptozotocin-induced diabetic rats. *Indian J. Pharmacol., 42*(5), 301–305.

Pham, T. N. T., Nguyen, T. Q., Nguyen, V. H., Quach, T. H., Cao, V. D., Nguyen, T. T., Nguyen, T. D. T., & Le, T. D. (2020). Chemical constituents of the stem of *Coccinia grandis*. *IOP Conference Series: Materials Science and Engineering*, *736*, 022080.

Verma, N., Raghuvanshi, D. S., & Singh, R. V. (2024). Recent advances in the chemistry and biology of oleanolic acid and its derivatives. *Eur. J. Med. Chem., 276*, 116619.

Vo, V. C. (1997). *Từ điển cây thuốc Việt Nam* [Dictionary of Vietnamese medicinal plants]. Medical Publishing House.

Zhang, Y., Kong, J., Zhang, J.-H., Wang, L., Zhang, W., Liu, B., & Jiang, Y. Y. (2020). Chemical constituents and pharmacological activities of family Flacourtiaceae: A class of important phytomedicine. *Am. J. Chin. Med., 48*(02), 287–328.

NGHIÊN CỨU HOÁ THỰC VẬT CỦA THÂN LOÀI *Flacourtia jangomas*

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TÓM TẮT

*Flacourtia jangomas từ lâu đã được xem là một nguồn dược liệu tiềm năng trong y học cổ truyền tại khu vực nhiệt đới Đông Á và Đông Nam Á. Trong nghiên cứu này, chúng tôi tập trung vào việc đánh giá các thành phần hóa học của loài F. jangomas phân bố tại Việt Nam. Kết quả thực nghiệm cho thấy sự hiện diện của bốn hợp chất β-sitosterol (**1**), 4-hydroxybenzaldehyde (**2**), oleanolic acid (**3**), và methyl ferulate (**4**). Cấu trúc hóa học của các hợp chất này được xác định thông qua việc phân tích dữ liệu phổ và so sánh với các tài liệu tham khảo trước đây.*

Từ khóa: Salicaceae*; Flacourtia jangomas*; terpenoids