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Nutritional evaluation and GC–MS analysis of bioactive compounds present in methanol extracts of dried fruit pericarp of garcinia pedunculata Roxb

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ABSTRACT

This study was conducted to assess the nutritional and phytochemical properties of methanol extracts derived from the dried fruit pericarp of *Garcinia pedunculata*. Samples of the plant were obtained from the Bodoland Territorial Region (BTR), Assam, India due to the lack of study findings on Garcinia pedunculata from this region in the existing literature. Nutritional evaluation has revealed that *Garcinia pedunculata* is a notable source of various nutrients including fibre (15.67 ± 0.05 g/100g), protein (3.97 ± 0.06 g/100g), carbohydrates (80.10 ± 2.48 g/100g) and ascorbic acid (98.16 ± 4.46 mg/100g). Furthermore, the results of the gas chromatography coupled with mass spectrometry analysis (GC-MS) of the methanol extract revealed a diverse range of chemical compounds with both high and low molecular weight. GC-MS analysis showed bioactive compounds like cyclopentanecarboxylicacid, 2-oxo-, ethyl ester with a peak area of 23.60%followed by 1,3- dioxepane, 2-pentadecyl- with a peak area of 22.39%followed by N-[Carboxymethyl]maleamic acid with a peak area of 10.37%and butanedioic acid,3-hydroxy-2,2-dimethyl, dimethyl ester, (R) with a peak area of 10.91%. The extracts exhibit significant amount of various naturally occurring bioactive compounds. Therefore, the existence of potential bioactive compounds and nutritional constituents can be suitably exploited for future studies.

Contribution/Originality: *Garcinia pedunculata* is an indigenous and underutilized fruit found in the BTR, Assam, India. It has been considered a significant source of nutritional and bioactive constituents. Therefore, this study will provide the screening of major bioactive compounds using advanced GC-MS techniques and the exploration of nutritional potential.

1. INTRODUCTION

Garcinia pedunculata Roxb. ex. Buch.-Ham., a member of the Clusiaceae family is a large evergreen dioecious tree recognized for its medicinal benefits distributed in the north eastern region of India. It is called "Borthekera" in Assamese and "Taika" in Bodo. In Assam, this plant is commonly used in cooking and for preparing a refreshing juice which is believed to alleviate symptoms such as headache, fatigue, nausea, vomiting and difficulties in concentration. It is a customary practice among villagers to consume this juice to mitigate or prevent the after-effects of alcohol consumption. Additionally, it is reputed to possess unique properties that aid in weight loss due to its anti-hypolipidemic characteristics. G. pedunculata is slightly unknown and hardly seen these days despite its medicinal significance. Extensive research on Garcinia spp. has revealed that various parts of the plant contain substantial quantities of bioactive compounds, primarily Hydroxycitric acid (HCA), xanthones and flavonoids.

These compounds exhibit noteworthy pharmacological properties, including anti-atherosclerosis, antibacterial, anti-hypolipidemic, anticancer, antihypertensive and antimalarial effects (Maheshwari, 1964). Among these 17 species reported from Assam (Brahma, Islary, & Ray, 2022), the new species *Garcinia sibeswarii* (Clusiaceae) was identified (Shameer, Sarma, Mohanan, & Begum, 2021) and *G. assamica* (Clusiaceae) by Sarma, Shameer, and Mohanan (2016) at Baksa District (Sarma et al., 2016). The current study evaluated the nutritional qualities and analysed the phytochemical composition of polyphenol-rich extracts from dried fruit arils of G. pedunculata Roxb. which is located in the BTR region of Assam(see Figure 1).

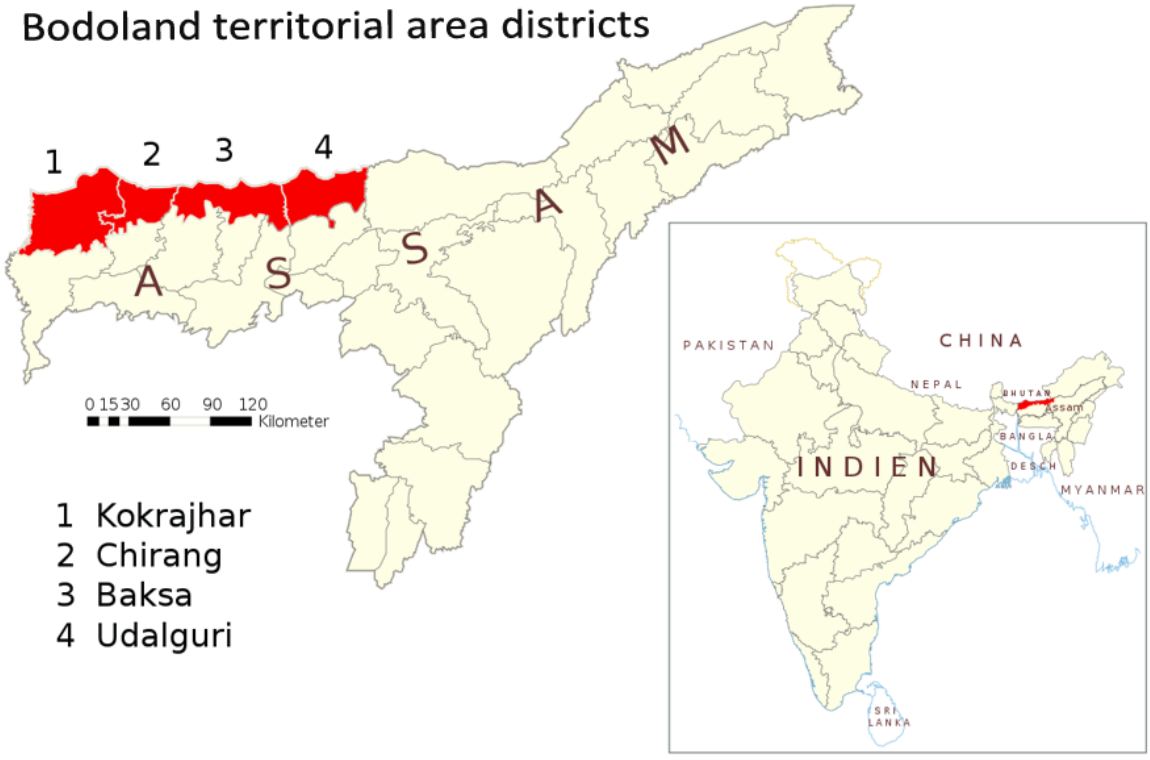

Figure 1. Bodoland territorial region of Assam.

Source: Political map of India.

1.1. Taxonomy and Morphology

Kingdom: Plantae.

Family: Clusiaceae.

Genus: Garcinia.

Species: *Garcinia pedunculata.*

Binomial name: *Garcinia pedunculata* Roxb. ex Buch.-Ham.

G. pedunculata species typically consist of evergreen dioecious trees characterized by distinct male and female flowering plants. These trees produce short, spreading, pendulous branches. Their leaves are simple, have smooth margins are petiolate and are mostly oval, elliptic or oblong in shape. The leaves have obtuse or slightly pointed tips and are distinguished by prominent midribs and lateral veins (Baruah & Borthakur, 2012; Gupta et al., 2018). In terms of leaf anatomy, they exhibit dorsoventrally characteristic including a thin cuticle covering the upper epidermis and an absence of trichomes. Additionally, there are numerous secretory cells and a limited number of vascular system strands. The mesophyll layer is composed of compact layers of palisade parenchyma cells in the laminar region while spongy parenchymatous cells surround it. The transverse section of the leaf's midrib reveals a bicollateral vascular bundle enclosed by patches of sclerenchymatous fibers. The petiole has a thin epidermis covered in a thick layer of cuticle and a centrally located ring-shaped vascular bundle made up of phloem, protoxylem and metaxylem (Gupta et al., 2018). The male flowers are pedicellate, bracteate, tetramerous and

characterized by four thick, fleshy, ovate, brownish-green sepals and four oblong, lanceolate, green petals. Stamens with sessile anthers are clustered together in a capitate structure. Female flowers have a pair of sepals and petals each as well as pedicels and bracts. They feature a centrally positioned, nearly spherical, 8-10 loculated ovary with a sessile, papillate stigma (Baruah & Borthakur, 2012).The fruit produced by this species is a large, globose berry. It is green when unripe and yellow when ripe, possessing a leathery rind and juicy, acidic pulp. There are four to eight reniform seeds enclosed in fleshy arils inside the fruit (Baruah & Borthakur, 2012; Gogoi, Das, & Barua, 2016; Gupta et al., 2018; Maheshwari, 1964). There is some variation in the reported flowering and fruiting seasons of this species. According to Boruah and Borthakur, these plants flower year-round, with the fruiting season limited to January to April (Baruah & Borthakur, 2012). However, another study by Gogoi and Das (2016) suggests a flowering period from September to December and a fruiting period from December to April (Gogoi et al., 2016). One of the earliest reports by Maheshwari mentioned flowering from September to April and fruiting from December to June (Maheshwari, 1964). These discrepancies may arise from differences in study durations, environmental conditions and geographical locations. Several distinctive morpho-anatomic features are associated with this plant, including the presence of paracytic stomata in leaves, a bicollateral vascular bundle in the midrib and a ring-shaped phloem in the stem region. These features as reported by Gupta et al. (2018) are considered crucial for accurate plant species identification (Gupta et al., 2018).

1.2. Distribution and Conservation Status of Garcinia Pedunculata in India

Garcinia species are typically found in the semi-green and evergreen forests of tropical regions (Maheshwari, 1964). Specifically, *G. pedunculata* has been identified in the evergreen forests of Northeastern states as well as in the woodlands of West Bengal and the Andaman and Nicobar Islands in India. These plants thrive in a humid and shaded environment, receiving moderate rainfall ranging from approximately 2000 to 3000 mm and are usually found at altitudes between 300 and 600 meters above sea level (Maheshwari, 1964; Parthasarathy et al., 2011). *G. pedunculata* plants can be observed growing under semi-wild conditions within forests and occasionally even in human settlements. However, their distribution is not uniform and is mainly confined to specific regions in the wild (Dutta, 2017). A study employing Geographic Information System ArcGIS software to map the distribution of *Garcinia* species in their habitats in Southern India revealed a declining trend in their numbers in the wild. Additionally, this study noted that *Garcinia* species were relatively scarce in Northeastern states (Parthasarathy et al., 2011). In a study conducted by Baruah and Borthakur (2012) *G. pedunculata* was classified as a critically endangered species (Baruah & Borthakur, 2012). This critical status is attributed to several factors including limited awareness about the plant, a lack of well-established propagation techniques, dependence on natural seed propagation, deteriorating environmental conditions, deforestation and various human-induced activities. G. pedunculata is almost extinct as a result of these causes' fast decrease in population. Furthermore, Dutta (2017) has proposed the integration of *G. pedunculata* into afforestation programs of the State Forest Department or other agro-forestry initiatives. These programmes' cultivation of G. pedunculata might be extremely important for the species' conservation efforts in addition to improving rural communities' economic standing (Dutta, 2017).

1.3. Ethanobotanical uses of G. pedunculata in Assam

G. pedunculata has long been consumed by people in both its raw and dried forms. The fruit is spherical, measuring between 8 and 12 cm in diameter and it contains a fleshy, edible aril. As the fruit ripens, it changes from green to yellow. When the fruit is completely ripe, it is customarily eaten raw or cooked, usually with fish. When the fruit is still raw, it is used to make pickles. Additionally, it can be preserved through drying and subsequently used to make refreshing beverages. The fruit is known for its effectiveness in treating dysentery and jaundice. Some people also use the wood from the tree to make furniture, including tables, chairs, and beds as well as the traditional "dhaki" rice husking tools. According to literature reviews, G. pedunculata is a good source of naturally occurring

antioxidants. This is mainly because of its high ascorbic acid and phenolic and flavonoid content (Mudoi, Deka, & Devi, 2012). The aged dried fruits are particularly beneficial for addressing dysentery and serve as an excellent source of antioxidants. Furthermore, Pedunxanthons A-C have been extracted from the tree's bark and the plant is also recognized for its substantial hydroxycitric acid (HCA) content (Gogoi et al., 2016). In addition to its culinary and medicinal uses, *G. pedunculata* finds application in pickle production and curry preparation. Its wood is valued as timber. This plant is predominantly found in the Upper Brahmaputra valley, including Kamrup Metro (M), Kamrup Rural (R), Nalbari, Barpeta, Dhemaji, and Lakhimpur regions (Baruah & Borthakur, 2012; Dutta, 2017; Gogoi et al., 2016; Gogoi, Tsering, Tag, & Veer, 2012; Sarma et al., 2016; Sarma & Devi, 2015).

2. METHODOLOGY

2.1. Preparation of a Garcinia Fruit Sample

Fresh and matured *Garcinia* fruits have been gathered from various locations within the BTR region (see Figure 2). Some were collected directly from the trees and others were obtained from local marketplaces. These fruits were carefully sorted, thoroughly washed and subsequently sun dried for 3 days. The fruit pericarp was sliced into thin pieces and left out in the sun to dry. Once dried, these dehydrated *Garcinia* was placed in an airtight container for future use.

A. *G. pedunculata* collected from Chirang District, Assam, India.

B. *G. pedunculata* collected from Baksa District,Assam,India.

C. *G. pedunculata* collected from Kokrajhar District, Assam, India

Figure 2. *Garcinia* species collected from various districts of the Bodoland territorial region of Assam, India.

2.2. Proximate Analysis

2.2.1. Moisture Content Determination

The estimation of moisture content is a common procedure in food analysis. Moisture is typically lost by heating the food at a temperature slightly higher than the boiling point of water allowing it to dehydrate overnight using a desiccating agent or through vacuum heating. The moisture content was determined by using a hot air oven at 100°C ± 5°C until the sample reached a constant weight (AOAC, 2000).

2.2.2. Ash Content Determination

The total ash content was measured using a muffle furnace set at 550 °C until a consistent weight was attained. This procedure entails continuous heating leading to the substance charring and enabling the assessment of mineral content (AOAC, 2000).

2.2.3. Total Carbohydrate Content Determination by the Anthrone Method

Initially, carbohydrates underwent hydrolysis into sugars through dilute hydrochloric acid. Glucose underwent further hydrolysis to produce hydroxymethyl furfural in an acidic and warm environment. This compound formed a complex with the anthrone reagent resulting in a green coloration and exhibiting an absorption peak at 630 nm (AOAC, 2000).

2.2.4. Ascorbic Acid Determination

The determination of ascorbic acid was carried out using the iodine titration method (AOAC, 2000).

2.2.5. Crude Fat Extraction

Crude fat was obtained using a Soxhlet extractor apparatus with n-hexane at a temperature of 60 ± 5°C for 6-8 hours (AOAC, 2000).

2.2.6. Crude Fibre Determination

The term "crude fibre" in agricultural and food analysis refers to the organic residue (mostly cellulose) that remains after samples are treated with acids and alkalis in order to systematically eliminate other carbohydrates and proteins. The crude fiber obtained through this method includes hemicelluloses and nitrogenous substances but is suitable for relatively accurate and comparable results (IS 10226).

2.2.7. Protein Content Determination

The IS 7219 method was employed to ascertain the protein content. This procedure converts nitrogenous substances into ammonium sulphate by oxidizing the sample in the presence of sulfuric acid. Mercury acted as a catalyst while alkali sulfate functioned as a boiling-point enhancer. Ammonia was extracted and quantitatively distilled into a determined volume of sulfuric or standard hydrochloric acid by adding excess alkali. Any unneutralized acid left after the ammonia reaction was titrated back using standard alkali (IS 7219).

2.2.8. Reducing Sugar Content Determination

The dinitrosalicylic acid (DNS) method was employed to measure the reducing sugar content. When reducing sugars were present, DNS was reduced to 3-Amino-5-nitrosalicylic acid, displaying an orange-red color that was measured at 510nm in Indian Standard (IS 15279).

2.2.9. Vitamin C (Ascorbic Acid) Determination

Stabilizing chemicals such as 20% metaphosphoric acid were used to crush the sample in order to determine the amount of ascorbic acid present in fruits and vegetables. Ascorbic acid reduced 2.6-dichlorophenol indophenol to a colorless state, a reaction specific to ascorbic acid within a pH range of 1 to 3.5. The dye appeared blue in alkaline solutions and pink in acidic ones Food Safety and Standards Authority of India (FSSAI Lab Manual).

2.2.10. Statistical Analysis

All assays were conducted in triplicate and the results were expressed as the mean ± standard deviation (SD).

2.3. Extraction of Crude Extract

The garcinia fruit, once dried, underwent a fine grinding process using a mixer grinder. Subsequently, the dehydrated and grind samples underwent a specific progressive extraction process using polarity-increasing solvents such as methanol. The resulting extract was then concentrated into dried form using a rotary vacuum evaporator , specifically the Equitro Xtemp, Roteva model (Gonelimali et al., 2018).

2.4. GC-MS Analysis

The provided sample underwent extraction with methanol and was then analyzed using gas chromatography-mass spectrometry or mass spectrometry to identify various compounds. The *garcinia* which had been oven-dried and powdered was selectively and sequentially extracted using increasingly polar solvents specifically methanol through percolation. The resulting extract was then subjected to gas chromatography-mass spectrometry following the method outlined by Casuga, Castillo, and Corpuz (2016) with some modifications (Casuga et al., 2016).

2.4.1. GC-MS Programme

The analysis was carried out using a Scion 436-GC Bruker which was equipped with a retention time Rtx-5MS column (5% Diphenyl / 95% Dimethyl polysiloxane), measuring 30m x 0.25mm ID x 0.25µm df. Mass spectrometric detection was employed using the Xcaliber software. Pure helium gas (99.995%) was employed as the carrier gas at a flow rate of 1 mL/min. For injection, 1 µl of a 1% solution of the sample extracts, diluted with appropriate solvents was used. The oven temperature was programmed to initiate at 110°C, held for 3.50 minutes, then ramped up to 200°C at a rate of 10°C/min with no hold, subsequently increased to 280°C at a rate of 5°C/min and maintained for 12 minutes. The injector temperature was set at 280°C. The total runtime for the gas chromatography was 40.50 minutes.

The National Institute of Standards and Technology NIST Version-2011 library was used. The inlet line temperature was set to 290°C and the source temperature was maintained at 250°C. Electron energy was set at 70 eV and mass scanning (m/z) ranged from 50 to 500 amu. A solvent delay of 0 to 3.5 minutes was implemented. The total running time for MS was 40.50 minutes. The relative quantity of chemical compounds present in the *G. pedunculata* extract was expressed as a percentage based on the peak area produced in the chromatogram.

3. RESULTS AND DISCUSION

3.1. Nutritional Analysis

Proximate analysis provides essential information for identifying, classifying and determining the nutritional quality of food materials. Table 1 presents the proximate analysis of *G. pedunculata* which revealed high levels of fiber (15.67 ± 0.05 g/100g), protein (3.97 ± 0.06 g/100g), carbohydrates (80.10 ± 2.48 g/100g), and ascorbic acid (98.16 ± 4.46 mg/100g). Another study conducted by Islam, Hoque, Asif-ul-Alam, and Monalisa (2015) confirmed the high fiber and vitamin C content (142.83±2.03 mg/100g) in *G. pedunculata* making it a significant source of these nutrients. The Recommended Dietary Allowance (RDA) for vitamin C is 60 mg per day and *G. pedunculata* surpasses this requirement indicating its potential in preventing vitamin C deficiency, such as scurvy even in diets lacking this vitamin. Gupta et al. (2018) supported the results demonstrating that G. pedunculata had an ash content 2.95% and a moisture content of 18.6%. These values along with extractive values serve as reliable indicators for detecting adulteration aiding in the accurate identification of plant materials. Hossain, Dey, and Joy (2021) recently found that samples of G. pedunculata that were dried at various temperatures showed differences in the amount of ascorbic acid. The sun-dried sample retained significant ascorbic acid content, further establishing its status as a valuable source of vitamin C despite the fact that drying at higher temperature resulted in a drop in vitamin C levels.

3.2. Screening of Bioactive Compounds

Gas chromatography-mass spectrometry was employed to qualitatively assess the various biologically active compounds within crude extracts of *G. pedunculata*. Table 2 presents the bioactive compounds screened from the methanol extracts of *G. pedunculata*. Figure 3 illustrates the Chromatogram graph of *G. pedunculata*. The results revealed a range of high- and low- molecular weight chemical entities, each with varying quantities in the extracts. These chemical compounds bear significance in biological and pharmacological contexts. Bioactive compounds found were cyclopentanecarboxylic acid, 2-oxo, ethyl ester with a peak area of 23.60%followed by 1,3- dioxepane, 2-pentadecyl with a peak area of 22.39%followed by N-[Carboxymethyl]maleamic acid with a peak area of 10.37%and Butanedioic acid, 3-hydroxy-2,2-dimethyl, dimethyl ester, (R) with a peak area of 10.91% Other noteworthy substances were discovered such as oleic acid which is categorized as a fatty acid. Oils containing oleic acid are often used as substitutes for saturated fats in dietary practices. This chemical has the potential to improve heart function by lowering cholesterol and decreasing inflammation. Octadecanoic acid, a C18 straight-chain saturated fatty acid is prevalent in numerous animal and vegetable lipids. Apart from its dietary applications, it finds utility in soap hardening, plastic softening and the production of cosmetics, candles and plastics. Methyl stearate was observed to reduce body weight in subchronic feeding studies conducted on rats with no other significant effects noted. 9-Octadecenoic acid, functioning as a human metabolite serves as a long-chain monounsaturated fatty acid and a nitro fatty acid. Stigmasterol, an essential plant sterol, demonstrates the capability to impede the proliferation of various cancerous cells by hindering their promotion and apoptosis. This inhibitory mechanism may arise from the activation of caspase enzymes, integral components of cellular regulatory networks governing cell death.

According to Rao, Sarma, Venkataraman, and Yemul (1974), two compounds were isolated from the acetone extract of the heartwood of *G. pedunculata* a benzophenone specifically 2,4,6,3-,5-pentahydroxy-benzophenone with

a melting point of 135°C crystallized as colorless needles and a xanthone, namely 1,3,5,7-tetrahydroxyxanthone with a melting point of 228°C. These compounds garnered special interest due to their unusual hydroxyl substitution patterns in their structures. According to Sahu, Das, and Chatterjee (1989), a novel compound named Pedunculol with a molecular formula of C38H52O6, melting at 125°C, and exhibiting [M]+m/z 604 was isolated from the methanolic extract of *G. pedunculata* dried pericarp (Sahu et al., 1989). It manifested as pale yellow solid crystals. Jayaprakasha, Jena, and Sakariah (2003) developed an enhanced liquid chromatographic method that facilitated the identification of organic acid composition in *G. pedunculata*. Hydroxycitric acid emerged as the predominant organic acid, accompanied by hydroxycitric acid lactone, ascorbic acid and oxalic acid (Jayaprakasha et al., 2003). A comprehensive chemical analysis of the petroleum ether extract from *G. pedunculata* bark unveiled the presence of three new xanthones: Pedunxanthone A (melting point 215-216°C, [M]+m/z 342.121, C19H18O6) in the form of bright yellow needles, Pedunxanthone B (melting point 123-124°C, [M]+m/z 396.1579, C23H24O6) as dark yellow needles, and Pedunxanthone C (melting point 174-175°C, [M]+m/z 408.1572, C24H24O6) crystallized as yellow needles (Vo et al., 2012). Chemical profiling of Garcinia pedunculata's pericarp through chloroform extraction revealed three novel tetraoxygenated xanthones: Pedunxanthone D (C29H34O6, [M+Na]+ m/z 501.2259), Pedunxanthone E (C29H34O7, [M+Na]+ m/z 517.2210) and Pedunxanthone F (C29H34O7, [M+Na]+ m/z 495.2392). The identification and structural elucidation of these compounds were accomplished through various techniques including column chromatography, thin-layer chromatography, Nuclear Magnetic Resonance 13C-NMR, 1H-NMR, mass spectroscopy, IR spectroscopy and X-ray crystallography. Most of these compounds belong to the categories of xanthones, polyisoprenylated xanthones, biflavones, triterpenoids, benzophenones and tetraoxygenated xanthones (Jayaprakasha et al., 2003; Rao et al., 1974; Sahu et al., 1989; Vo et al., 2012). A comprehensive chemical profiling of this species remains an ongoing endeavor despite these findings (Bhattacharjee & Devi, 2021).

Table 1. Nutritional profiling of Garcinia pedunculata.

Sample	Nutritional parameters	Results
Garcinia pedunculata	Moisture	12.41 ± 0.26 (g/100g)
	Total ash	3.05 ± 0.01 (g/100g)
	Crude fiber	15.67 ± 0.05 (g/100g)
	Crude fat	0.47 ± 0.02 (g/100g)
	Crude protein	3.97 ± 0.06 (g/100g)
	Carbohydrate	80.10 ± 2.48 (g/100g)
	Reducing sugar	2.90 ± 0.02 (g/100g)
	Ascorbic acid	98.16 ± 4.46 (mg/l00g)

Table 2. GC-MS analysis: Compounds identified in the Methanolic extract of Garcinia pedunculata dehydrated powder.

No	RT	Name of the compound	Molecular formulae	Molecular weight	Peak area %
1.	4.28	3-pentenoic acid, 3-ethyl-, methyl ester	C8H14O2	142	8.87
2.	5.54	But-2-enedioic acid, dimethyl ester	C6H8O4	144	6.97
3.	6.44	Cyclopentane carboxylic acid, 2-oxo-, ethyl ester	C8H12O3	156	23.60
4.	7.16	1,3-Dioxepane, 2-pentadecyl-	C20H40O2	312	22.39
5.	8.67	N-[Carboxymethyl]maleamic acid	C6H7NO5	173	10.37
6.	9.08	Pyrrolizin-1,7-dione-6-carboxylic acid, methyl(ester)	C9H11NO4	197	0.31
7.	10.59	Butanedioic acid, 3-hydroxy-2,2-dimethyl-, dimethyl ester, (R)-	C8H14O5	190	10.91
8.	10.74	Butanoic acid, 4-[2-(1,1-dimethylethyl)-5-oxo-1,3-dioxolan-4-yl]-, methyl ester	C12H20O5	244	1.38
9.	14.84	9-Hexadecenoic acid, methyl ester, (Z)-	C17H32O2	268	0.25
10.	15.12	Hexadecanoic acid, methyl ester	C17H34O2	270	2.79

No	RT	Name of the compound	Molecular formulae	Molecular weight	Peak area %
11.	15.72	n-Hexadecanoic acid	C16H32O2	256	2.06
12.	17.44	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	C19H34O2	294	1.36
13.	17.53	9-Octadecenoic acid, methyl ester, (E)-	C19H36O2	296	3.76
14.	17.62	10-Octadecenoic acid, methyl ester	C19H36O2	296	0.32
15.	17.75	13-Octadecenoic acid, methyl ester	C19H36O2	296	0.21
16.	17.90	Methyl stearate	C19H38O2	298	0.35
17.	18.10	9,12-octadecadienoic acid (Z,Z)-	C18H32O2	280	0.83
18.	18.20	Oleic acid	C18H34O2	282	2.74
19.	18.52	Octadecanoic acid	C18H36O2	284	0.29
20.	35.81	Stigmasterol	C29H48O	412	0.23

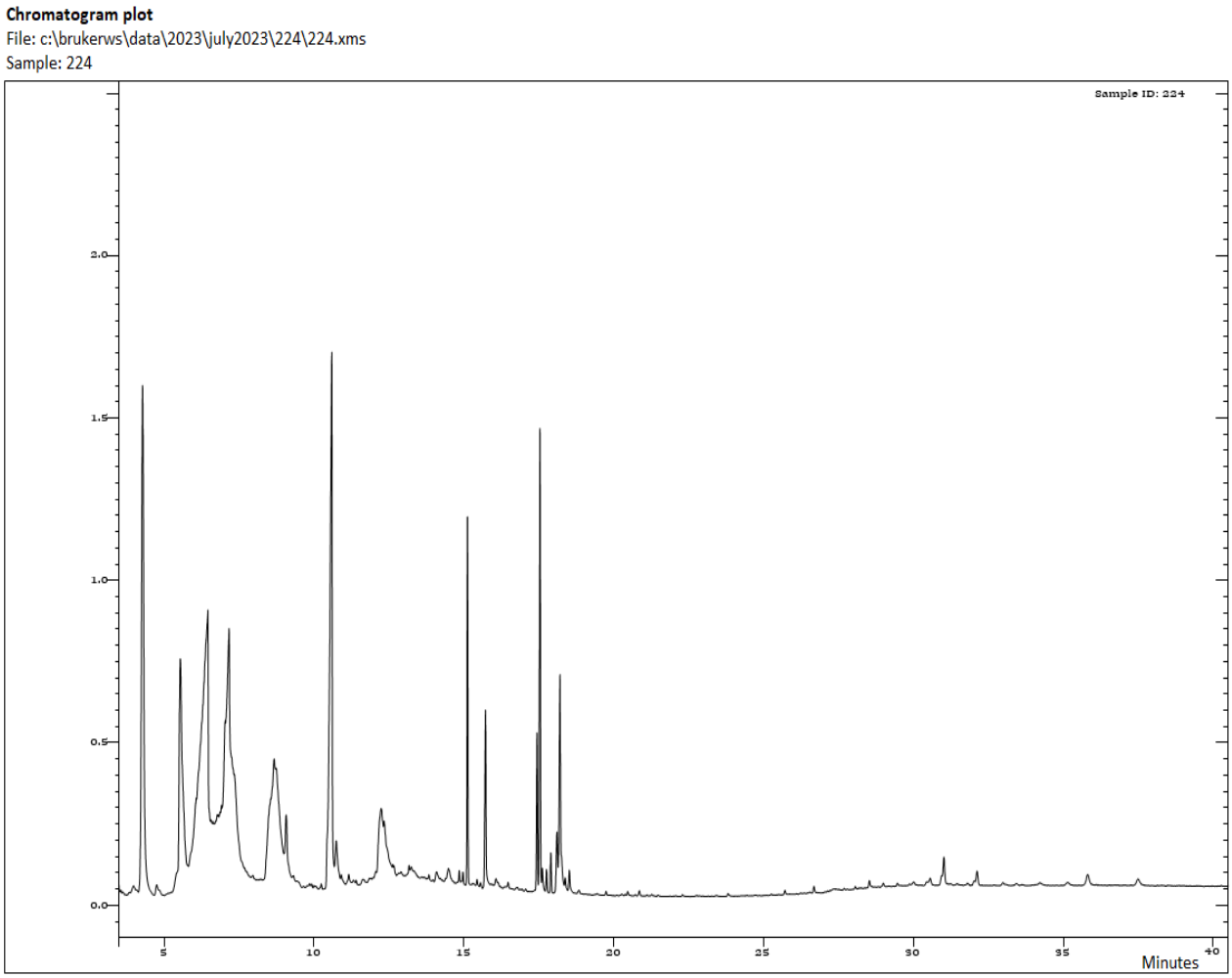

Figure 3. GCMS/MS chromatogram.

4. CONCLUSION

The methanolic extracts have been spectroscopically analyzed to identify and characterize the major bioactive compounds.

Consequently, the discovery of diverse biologically active compounds within the extracts from *G. pedunculata* leaves necessitates further exploration in the realms of biological and pharmacological research. A nutritional analysis revealed that these leaves are rich in fiber, protein and ascorbic acid. In a nutshell, the findings obtained from this study have the potential to significantly contribute to the establishment of pharmacopoeia standards and the prevention of adulteration of *G. pedunculata* leaves and fruit. Furthermore, this investigation will provide

valuable insights for researchers seeking to elucidate the pharmacological activities and potential modes of action associated with this plant.

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Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Conceptualization, J. B., A. I. and S. R.; methodology J.B.; supervision, A. I. and S. R. All authors have read and agreed to the published version of the manuscript.

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