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Advance in Biological Research, 2025, 6(1), 14-24
https://www.hillpublisher.com/journals/abr/
ISSN Online: 2635-0319

Bioactive Compounds in Goron Tula (*Azanza garckeana*) Fruit Pulp: Elucidation and Identification Using Gas Chromatography Mass Spectrometry/Fourier Transform Infrared Spectroscopy

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How to cite this paper: N. C. Oganezi, U. C. Ebere, I. O. Nwokocha. (2025). Bioactive Compounds in Goron Tula (*Azanza garckeana*) Fruit Pulp: Elucidation and Identification Using Gas Chromatography Mass Spectrometry/Fourier Transform Infrared Spectroscopy. *Advance in Biological Research*, 6(1), 14-24.
DOI: 10.26855/abr.2025.06.002

Received: July 30, 2025
Accepted: August 27, 2025
Published: September 24, 2025

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Abstract

Goron tula (*Azanza garckeana*) fruit pulp is a wild edible fruit that is consumed for food and its medicinal value. This study investigated the bioactive compounds in Goron tula fruit pulp using Gas Chromatography-Mass Spectrometry (GC-MS) and Fourier Transform Infrared Spectroscopy (FTIR). Two solvent extracts (methanol and dichloromethane/methanol 1:1, v/v) were analysed, revealing 39 and 35 compounds, respectively. The most abundant compounds in the methanol extract were succinic acid,4-chloro-3-methylphenyl-2-methoxyphenyl ester (19.02%), 9-octadecenoic acid (Z)-2,3-dihydroxypropyl ester (common name: glyceryl monooleate, 16.85%), and 2,6-Lutidine-3,5-dichloro-4-cyclohexythio (11.52%). The most abundant compounds in the dichloromethane/methanol extract were n-hexadecanoic acid (25.11%), cyclotrisiloxane, hexamethyl (13.73%), and 16-pregnenolone (a steroidal hormone, 11.30%). This research gives the first report of 16-pregnenolone in Goron tula. Compounds which were common to both extracts were hexadecane, 9-Eicosene, nonadecane, cis-vacennic acid, and n-hexadecanoic acid. FTIR confirmed functional groups (amines, carboxylic acids, alkanes, etc.), supporting the presence of bioactive compounds with potential nutritional, therapeutic, and pharmacological applications. The study concludes that Goron tula fruit pulp is a valuable source of bioactive compounds, supporting its traditional medicinal uses (e.g., fertility enhancement, antimicrobial effects).

Keywords

Goron tula; Fruit pulp; Gas chromatography; Mass spectrometry; Functional groups; Bioactive

1. Introduction

Fruits are important components in a healthy diet and are also associated with improved health conditions and with fewer outcomes of developing diseases [1]. There are increasing observations that suggest that some compounds naturally present in fruits are linked to these biological effects in health [2]. This is attributed to the presence of nutrients such as vitamins, mineral salts, and phytochemicals, which are bioactive. These bioactive molecules belong to various classes of compounds that have found usefulness as having nutraceutical and functional roles. Bioactive compounds can be defined as nutrients and non-nutrients contained in the food matrix that can elicit physiological effects beyond their classical nutritional

properties [3]. These compounds have emerged as the main food compounds that are linked to healthy status and disease prevention [3].

Indigenous plant species native to Africa have several uses as well as a long and rich ethno-medicinal history with well-known native applications in different African countries [4]. Indigenous fruits play useful roles in food security, human well-being and nutrition, and the economy of rural inhabitants [5]. One of such indigenous fruit trees growing in some parts of Africa is goron tula, i.e., *Azanza garckeana.* It belongs to the Malvaceae family, and it is a wild edible fruit [6]. It is a deciduous shrub which grows up to a height of 3-13m and a diameter up to 25cm [7]. It grows in various parts of Africa such as in West Africa, namely Benin, Nigeria, and is restricted to East and Southern Africa, such as Botswana, Kenya, Malawi, Mozambique, Namibia, South Africa, Tanzania, Zambia, Sudan, and Zimbabwe [6]. The leaves and fruit are used for food and medicine, but the most popular are the fruits, which are consumed both as food and medicine [6]. It goes by various names such as 'snot apple', 'Morojioa', 'African chewing gum', 'Jakjak', 'Azanza', and some more commonly, 'Goron tula' [6]. Goron tula fruit is 2.5-4cm in diameter, distinctly divided into five segments with fleshy, gummy pulp, and contains seeds inside each segment [8-9]. The fleshy, gummy pulp is quite fibrous.

Traditionally, this fruit is reported to be used as food and medicine to manage a number of human diseases and ailments such as chest pain, cough, infertility, liver problems, menstruation problems, and sexually transmitted infections [10]. Goron tula tends to serve as a functional food and nutraceutical because of the numerous health benefits it proffers. This stems from the fact that it contains bioactive compounds that proffer such health benefits. The elucidation and quantification of bioactive compounds in plants and animal food sources give insight into the relevance of such items as potential sources of raw materials for the extraction of bioactive compounds, which serve as medicine or form part of functional foods and nutraceuticals required to solve medical problems or promote good health.

Gas chromatography/Mass spectrometry technique is one analytical tool that is widely used in the identification and discovery of new bioactive compounds, hence providing a wealth of information about the therapeutic potentials of plants [11]. Fourier transform infrared spectroscopy (FTIR) has been shown to be a valuable tool for the characterization and identification of compounds or functional groups present in an unknown mixture of plant extracts [12]. Extraction is a crucial first step in the analysis of medicinal plants, and the selection of the solvent system largely depends on the specific nature of the bioactive compound being targeted [13]. Bioactive compounds range from polar to non-polar compounds, and the extraction solvent plays a very important role in the extraction efficiency of bioactive compounds from the plant material [14]. The extraction of hydrophilic compounds utilizes polar solvents such as methanol, ethanol, or ethyl acetate, while more lipophilic compounds are best extracted using dichloromethane or a mixture of dichloromethane/methanol (mixture (v/v, 1:1) [13]. It is in view of this that research was conducted to identify the bioactive compounds present in Goron tula (i.e., *A. garckeana*) fruit pulp using gas chromatography/mass spectrometry and Fourier transform infrared spectroscopy, respectively.

2. Methods

2.1 Collection and Preparation of Samples

Mature Goron tula (*Azanza garckeana*) fruits were sourced from Kogi State, Nigeria. The fruits were washed and cut open to remove the seeds before the fibrous, gummy fruit pulp was pulverized in a porcelain mortar.

2.2 Extraction of Bioactive Compounds

Bioactive compounds were extracted using methanol and dichloromethane/methanol (1:1, v/v) solvents by methods described by [13]. Ten (10) grams of the pulverized pulp were dispensed into two different conical flasks, and the solvents were added to the samples in the conical flasks, respectively. They were allowed to stand for 24h at room temperature. After which, each sample mixture was filtered through Whatman filter paper No.1. Each sample extract was concentrated by heating over a boiling water bath to remove excess solvent. Hence, two extracts of *Azanza garckeana* fruit pulp were obtained. These extracts were subjected to gas chromatography/mass spectrometry (GC/MS) analysis for the separation and identification of compounds. Fourier transform infrared spectroscopy (FTIR) was used to confirm the functional groups of the bioactive compounds present in each extract.

2.3 Gas Chromatography/Mass Spectrometry (GC/MS) Analysis

GC/MS analysis of bioactive compounds from the two extracts was done using Agilent Technologies Gas Chromatography Systems (GC-7890A) and Mass Spectrometer (MS-5975C model) (Agilent Technologies, Santa Clara, CA, USA). The

gas chromatogram was equipped with HP-5MS column (30mm x 0.25mm x 250 µm film thickness). Helium gas (99.99%) was used as carrier gas with a flow rate of 1ml/min. The initial column temperature was set at 50°C to 150°C with an increasing rate of 3°C/min and a hold time of 10 minutes. Finally, the temperature was increased to 300°C with a hold time of 10°C/min. 3µl of each sample extract was injected in a splitless mode into the gas chromatogram using a Hamilton syringe. The injector temperature was 250°C while the Mass Spectrometer ion source was 200°C with an interface temperature of 280°C, and recorded over a scan range of 70-200m/z for the methanol extract and 40-650m/z for the dichloromethane/methanol extract. Electron impact ionization energy was 70ev. The total run time of the GC-MS for the methanol extract was 39 and 38 minutes for the dichloromethane/methanol extract. The relative abundance of chemical compounds present in each extract was expressed as a percentage based on peak area normalization produced on the chromatogram. Compounds were identified by Mass Spectrometry. This was done by comparing retention indices and mass fragmentation patterns of the compounds with those stored in the computer library software of the National Institute of Standards Technology (NIST/EPA/NIH, Mass Spectral Library, Version 2.0). Quantitative determinations were made by relating peaks to TIC areas of the GC-MS.

2.4 Fourier Transform Infrared Spectroscopy (FTIR)

FTIR of each extract was analysed by the method described by [15]. One (1) ml of each sample extract was mixed with 0.5ml nujol and mounted on a salt pellet of sodium chloride. Each sample extract was placed in the FTIR spectrometer chamber (Cary 630, Agilent Technologies, USA), respectively. Analysis was done in a scan range of 4000-600 cm^{-1} at a resolution of 4cm. During measurement, FTIR spectra were obtained at frequency regions of 4,000-600 cm^{-1}, at 32 scans and at 4 cm^{-1} resolution. FTIR spectra were displayed as transmitter values

3. Results

Table 1 shows results on gas chromatography/mass spectrometry of bioactive compounds in the methanol extract of Goron tula fruit pulp, while Table 2 shows results on Fourier transform infrared spectroscopy (FTIR) elucidating the functional groups/class of compounds in the methanol extract. Results indicated the presence of 39 compounds in the methanol extract. The major compounds found in the dichloromethane/methanol (1:1, v/v) extract were thirty-five. These represent the lipophylic fraction of compounds present in Goron tula fruit pulp, and they are shown in Table 3. Table 4 shows results on Fourier transform infrared spectroscopy (FTIR) elucidating the functional groups/class of compounds in the dichloromethane/methanol extract.

4. Discussion

4.1 Bioactive Compounds in the Methanol Extract of Goron tula fruit pulp

The most abundant compounds were succinic acid, 4-chloro-3-methylphenyl-2-methoxy phenyl ester, 9-octadecenoic acid (Z)-2,3-dihydroxypropyl ester (i.e., glyceryl monooleate), and 2,6-lutidine-3,5-dichloro-4-cyclohexythio. These had relative abundance of 19.02, 16.85, and 11.52% respectively. [16] identified the presence of four compounds, namely 4-(E)-3-hydroxyl-1-propenyl, Di-n-octylphthalate, benzonitrile, and phenol-2,4-bis (1,1-dimethyethyl) in the methanol extract of goron tula fruit pulp. The variation between our findings with those of [16] could be due to the extraction process, geographical/agronomic factors of the location where the plant was grown, or gas chromatography/mass spectrometry libraries used for the identification of the bioactive compounds. Other compounds found in appreciable quantities were pyrrolidine, 1-methyl-3,2-spiro-benzo-1,3-dioxolane, cis-vaccenic acid, 9-octadecenoic acid, and hexadecane. These had relative abundance of 7.46, 5.82, 5.34, and 3.73% respectively. Eicosene compounds were also present, as well as squalene. All these compounds, amongst others, have well-documented biological activities. Succinic acid, 4-chloro-3-methyl phenyl-2-methoxyphenyl ester, is a derivative of the parent compound, succinic acid. There is no well-documented biological activity. Succinic acid and sodium succinate are flavour enhancers for beverages, and it is also used in pharmaceutical products as anticarcinogenic and insulinotropic agents, sequestrants, neutralizing agents, and antimicrobial agents [17]. 9-octadecenoic acid (Z)-2,3-dihydroxypropyl ester (common name: glyceryl monooleate) is an amphiphilic lipid that plays a crucial role in drug delivery systems due to its potential to self-assemble in water, and it generates a variety of well-defined thermodynamically stable liquid crystal structures [18]. Glyceryl monooleate is non-toxic, biodegradable, biocompatible, and can maintain the internal nanostructure of bulk systems as well as keep it intact, hence, can retain significantly large amounts of drugs [19]. It is a promising carrier agent for applications in the drug delivery field [20]. Goron tula's glyceryl monooleate (16.85%) can also be a promising drug cellular vehicle in biological systems. 2,6-lutidine-3.5-dichloro-4-cyclohexylthio is a derivative of 2,6-lutidine. 2,6-Lutidine is a natural heterocyclic aromatic organic compound

and has been evaluated for use as a food additive owing to its nutty aroma. When present in solution at very low concentrations, it is a pyridine derivative [21].

Pyrrolidine-1-methyl-3, 2-spiro-benzo-1, 3-dioxolane is a pyrrolidine derivative. Pyrrolidine is a potential therapeutic agent that can find usefulness in the food and drug industry and has been reported to exhibit a wide range of activities [22]. Such activities include antimicrobial, which encompasses antifungal [23], antiviral [24], anticancer, anti-inflammatory, anticonvulsant, cholinesterase inhibition, and carbonic anhydrase inhibition [22], antitumoral [25], as well as antioxidant activity [26]. Cis-vaccenic acid is the cis-isomer of vaccenic acid. Substantial quantities of cis-vaccenic have been discovered in avocado oil in a concentration of 5.5-7.5% and it is considered to be used as an aid for detecting adulteration of this seed oil [27]. Vaccenic acid is considered a functional ingredient as a result of being a precursor to the endogenous synthesis of rumenic acid (i.e., conjugated linoleic acid by lactic acid bacteria in humans [28]. Hexadecane is reported to have activities such as being antibacterial and antioxidant [29]. Eicosene derivatives, namely 9-Eicosene and 5-Eicosene, were present in the methanol extract of Gonron tula fruit pulp. 9-Eicosene has antimicrobial and cytotoxic properties [30] while 5-Eicosene is reported to have antimicrobial activity [29].

Table 1. Results on bioactive compounds from the Methanol extract of Goron tula (*Azanza garckeana*) fruit pulp

Peak S/N	Retention time (min)	Name of Compound	Relative Abundance (%)	Molecular Formula	Molecular Weight
1	6.862	Cyclooctane-1,2-diethyl	0.26	$C_{12}H_{24}$	168.32
2	7.001	Tetradecane	0.85	$C_{14}N_{30}$	198.39
3	8.490	Phenol, 2,6-bis (1,1-dimethyl ethyl)	0.50	$C_{14}H_{22}O$	206.32
4	8.611	Hexadecane	0.59	$C_{16}H_{34}$	226.44
5	9.559	Dodecanoic acid	1.60	$C_{12}H_{24}O_2$	200.32
6	9.736	Dodecanoic acid	0.24	$C_{12}H_{24}O_2$	200.32
7	10.026	1-Tridecene	0.55	$C_{13}H_{26}$	182.35
8	10.127	Cyclooctane, 1,2-diethyl	0.42	$C_{12}H_{24}$	168.32
9	10.189	Hexadecane	1.93	$C_{16}H_{34}$	226.44
10	10.888	1-Hexacosanol	0.26	$C_{26}H_{54}O$	382.71
11	10.992	Tetradecane, 1-fluoro	0.35	$C_{14}H_{29}F$	216.38
12	11.713	Heptadecane	0.86	$C_{17}H_{36}$	240.47
13	11.846	2,6,10-Trimethyl tridecane	0.46	$C_{16}H_{34}$	226.44
14	11.919	Tetracosane	0.38	$C_{24}H_{50}$	338.65
15	12.529	Tetradecanoic acid	2.54	$C_{14}H_{28}O_2$	228.37
16	13.022	9-Eicosene (E)	1.21	$C_{20}H_{40}$	280.53
17	13.168	Hexadecane	1.21	$C_{16}H_{34}$	226.44
18	13.333	Hexadecane, 1-Chloro	0.28	$C_{16}H_{33}Cl$	260.89
19	13.912	Dodecane, 5-cyclohexyl	0.28	$C_{18}H_{36}$	252.48
20	14.565	Nonadecane	0.29	$C_{19}H_{40}$	268.52
21	14.712	1,2-Benzene dicarboxylic acid, Butyl-2-ethyl hexyl ester	0.78	$C_{20}H_{30}O_4$	334.40
22	15.316	n-Hexadecanoic acid	4.63	$C_{16}H_{32}O_2$	256.42
23	15.772	5-Eicosene (E)	4.27	$C_{20}H_{40}$	280.53
24	15.897	Nonadecane	0.36	$C_{19}H_{40}$	268.52
25	17.474	9-Octadecenoic acid	5.34	$C_{18}H_{34}O_2$	282.5
26	17.643	2-Chloropropionic acid, hexadecyl ester	1.17	$C_{13}H_{25}ClO_2$	248.79
27	17.841	Cis-Vaccenic acid	0.51	$C_{18}H_{34}O_2$	282.50
28	17.873	Oleic acid	0.44	$C_{18}H_{34}O_2$	282.47
29	17.953	Heptadecyl heptafluoro butyrate	0.54	$C_{21}H_{35}F_7O_2$	452.49
30	18.293	1-Docosene	2.29	$C_{22}H_{44}$	308.59
31	18.402	Tritetracontane	0.58	$C_{43}H_{88}$	605.20
32	18.521	9-Eicosene	0.21	$C_{20}H_{40}$	280.50
33	19.082	Octadecane, 1-(ethenyloxyl)	0.16	$C_{20}H_{40}O$	296.53
34	19.196	Decane, 3-cyclohexyl	0.42	$C_{16}H_{32}$	224.43
35	19.579	Carbonic acid, eicosyl vinyl ester	0.22	$C_{23}H_{44}O_3$	368.60
36	20.608	1-Octadecene	0.98	$C_{18}H_{36}$	252.50
37	20.707	Tritetracontane	0.20	$C_{43}H_{88}$	605.20
38	21.786	Bis (2-ethylhexyl) phthalate	0.70	$C_{24}H_{38}O_4$	390.56
39	24.863	Squalene	1.08	$C_{30}H_{50}$	410.73

Table 1 Continued

Peak S/N	Retention time (min)	Name of Compound	Relative Abundance (%)	Molecular Formula	Molecular Weight
40	31.324	Pyrrolidine, 1-methyl-3,2'-spiro-benzo-1,3-dioxolane	7.46	$C_{11}H_{13}O_2N$	191.10
41	32.097	Propanamide, N-(3-methoxyphenyl)-2,2-dimethyl	0.69	$C_{12}H_{17}NO_2$	207.27
42	32.200	Pentanamide, 4,4-dimethyl-N-(4-nitrophenyl)-3-oxo	1.02	$C_{13}H_{16}N_2O_4$	264.28
43	32.352	Cis-Vaccenic acid	2.62	$C_{18}H_{34}O_2$	282.50
44	32.556	Cis-Vaccenic acid	2.69	$C_{18}H_{34}O_2$	282.50
45	32.948	Succinic acid, 4-chloro-3-methylphenyl-2-methoxy phenyl ester	19.02	$C_{18}H_{17}ClO_5$	348.78
46	32.978	2,6-Lutidine,3,5-dichloro-4-cyclohexythio	11.52	$C_{19}H_{31}Cl_{12}O_2N_5$	376
47	36.635	Cis-9-Tetradecenoic acid, propyl ester	1.17	$C_{17}H_{32}O_2$	268.40
48	37.248	9-Octadecenoic acid (Z)-2,3-dihydroxy propyl ester	16.85	$C_{21}H_{40}O_4$	356.54

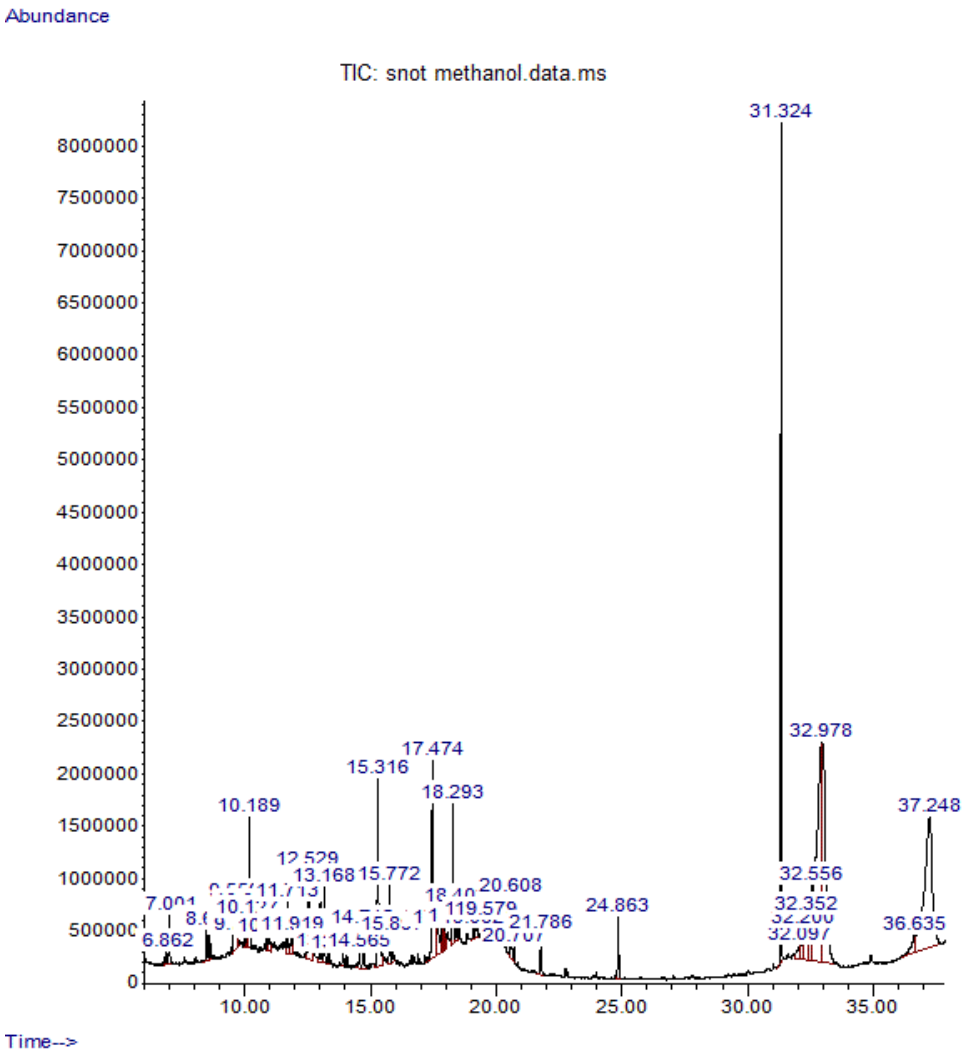

Figure 1. Gas Chromatograph of Methanol Extract of Goron tula (*Azanza garckeana*) fruit pulp.

4.2 Fourier transform infrared spectroscopy (FTIR) analysis of methanol extract from goron tula (*Azanza gackeana*) fruit pulp

Fourier transform infrared spectroscopy (FTIR) analysis of the methanol extract of goron tula fruit pulp is shown in Table 2 and Figure 2, respectively. FTIR spectra of the methanol extract unravelled twelve peaks indicating various functional groups. It revealed the presence of phenols, carboxylic acids, cyclic alkene, aromatic amine, aromatic compounds, alkane, fluoro compounds, and olefinic alkene. All these functional groups are components of compounds that eliminate the presence of alkaloids, flavonoids, steroids, fatty acids, alkanes, alkenes, and aromatic compounds. Each of these compounds has profound biological activities with the associated health benefits, respectively.

Table 2. Fourier Transform Infrared Spectroscopy (FTIR) result of methanol extract of Goron tula (*Azanza gackeana*) fruit pulp

S/No	Band Position/Wave Number (¯cm)	Functional Group/ Mode of Vibration	Functional Group Assignment	Group Frequency
1	3836.32	O-H Stretch	O-H in hydroxy compounds, alcohols, and phenols	3584-3700
2	3483.247	N-H Stretch	Aromatic primary amine	3460-3510
			Heterocyclic Amine	3430-3490
3	3248.996	O-H Stretch	Hydrogen-bonded alcohols, Phenols	3200-3400
4	2982.456	C-H Stretch	Alkane	2840-3000
5	2887.627	C-H Stretch	Alkane	2840-3000
6	2612.895	O-H Stretch	Carboxylic acids	2500-3300
7	2537.852	O-H Stretch	Carboxylic acids	2500-3300
8	2031.726	N=C=S Stretch	Isothiocyanate	1990-2140
9	1848.523	C-H Bend	Aromatic compound	1650-2000
10	1624.511	C=C Stretch	Cyclic alkene	1566-1650
11	1395.624	C-F Stretch	Fluoro Compound	1000-1400
12	901.1483	Vinyl C-H out of plane bend	Olefinic Alkene	890-915

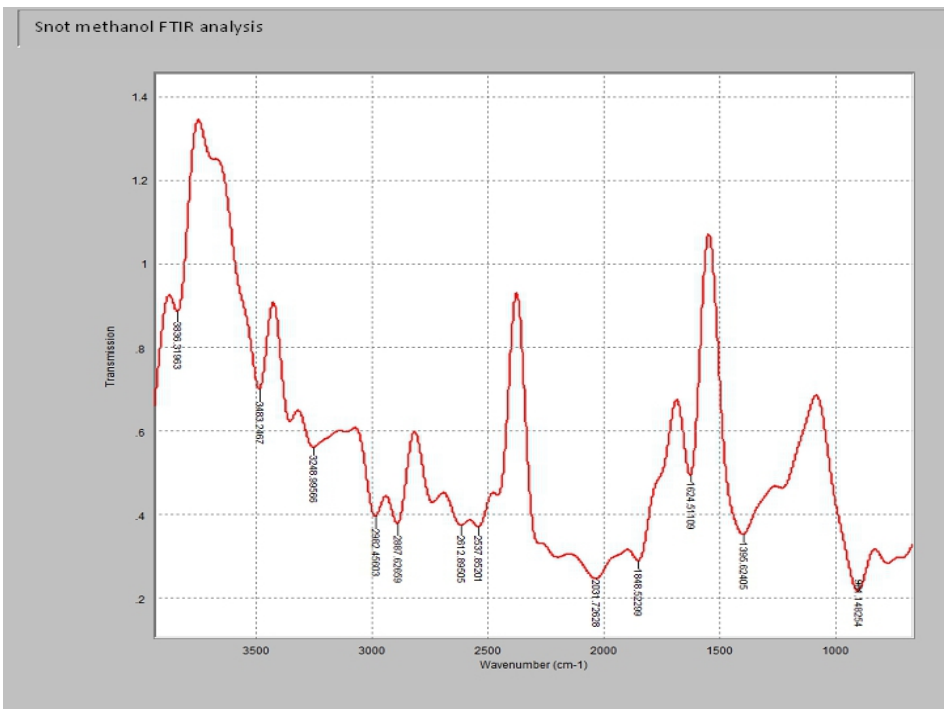

Figure 2. Fourier Transform Infrared (FTIR) Spectrograph of Methanol extract of Goron tula (*Azanza gackeana*) fruit pulp.

Bioactive Compounds in Dichloromethane/methanol extract of Goron tula fruit pulp: These include n-hexadecanoic acid, cyclotrisiloxane, hexamethyl, and 16-pregnenolone. These had relative abundance of 25.11, 13.73, and 11.30% respectively. Other compounds found in significant amounts were tetradecanoic acid, 1-Docosene, cis-vaccenic acid, and 3-(3,4-dimethoxy cinnamoyl)-4-hydroxy-6-methyl-2H-pyran-2-one. These had relative abundance of 5.69, 6.51, 4.15, and 5.59% respectively. 3-(3,4-Dimethoxy cinnamoxyl)-4-hydroxy-6-methyl-2H-pyran-2-one is a flavonoid compound. N-Acetoacetyl-deacetyl colchicine was present with a relative abundance of 1.52%. This compound is a derivative of cholchicum alkaloid. Colchicine and its many derivatives have cytotoxic activity [31]. [32] reported that N-Acetoacetyl-deacetyl colchicine has antitubulin activity and is cytotoxic. Cyclotrisiloxane, hexamethyl, is reported to have anticancer activity [33]. 16-Pregnenolone is a derivative of pregnenolone, which is an animal steroid hormone. Pregnenolone is a precursor for the synthesis of dihydroepiandrosterone (DHEA), progesterone, testosterone, estradiol, cortisol, etc. Recent findings have reported the ability of plants to convert these steroids into animal steroid hormones such as phytoecolysteroids, estrogens, progesterone, and androgenic substances of the testosterone type, including testosterone precursors and derivatives, but they are hormonally inactive [34]. Mammalian steroid hormones are part of the metabolic profile of plants, and these influence the physiological processes of plants as they are considered to be a type of 'supporting regulators' for plant metabolism [35,36]. Pregnenolone and its derivatives are reported to play crucial roles such as enhancing memory and learning, reversing depressive disorders, modulating cognitive functions, aiding neuroprotection and neuro-regeneration, can suppressing the secretion of tumour necrosis factor α and interleukin-6 mediation through TLR_2 and TLR_4 [37]. [38] reported that the methanol extract of goron tula fruit elicited the best response in spermiogram, hormonal concentrations and antioxidant activities in New Zealand white Rabbit bucks when compared with the other extracts, namely n-Hexane, ethylacetate, and aqueous extract. Therefore, the presence of 16-pregnenolone in Goron tula fruit pulp (11.30%) contributes to its use for the treatment of infertility, as pregnenolone is a precursor to progesterone and testosterone, etc.

The compounds found in appreciable quantities, such as n-Hexadecanoic acid, are reported to possess anti-inflammatory, antioxidant, anticancer, hypocholesterolemic activities [39] as well as nematicide, pesticide, lubricant, and anti-androgenic activities [40]. 9-octadecenoic acid is reported to have antimicrobial activities [40], anti-inflammatory, antiandrogenic, cancer preventive, dermatitigenic, hypochelesterolemic, 5-Alpha reductase inhibitor, anemiagenic, insectifuge, and flavor properties [41]. Hexadecane is shown to possess antifungal and antibacterial activities [42]. Compounds which were common to both extracts were hexadecane, 9-Eicosene, nonadecane, Cis-vaccenic acid, and n-hexadecanoic acid.

Table 3. Results on bioactive compounds from Dichloromethane/Methanol extract of Goron tula (Azanza garckeana) fruit pulp

Peak S/N	Retention time (min)	Name of Compound	Relative Abundance (%)	Molecular formula	Molecular weight
1	7.00	Tetradecane	0.88	$C_{14}H_{20}$	198.39
2	8.481	2,4-Di-tert-butylphenol	0.46	$C_{14}H_{22}O$	206.32
3	8.611	Pentadecane	0.35	$C_{15}H_{32}$	212.41
4	9.592	Dodecanoic acid	1.87	$C_{12}H_{24}O_2$	200.32
5	10.022	3-Chloropropionic acid- heptadecyl ester	0.34	$C_{20}H_{39}ClO_2$	346.98
6	10.185	Hexadecane	1.11	$C_{16}H_{34}$	226.44
7	11.706	Heptadecane	0.50	$C_{17}H_{36}$	240.47
8	12.556	Tetradecanoic acid	5.07	$C_{14}H_{28}O_2$	228.37
9	12.742	Tetradecanoic acid	0.62	$C_{14}H_{28}O_2$	228.37
10	13.017	9-Eicosene	2.24	$C_{20}H_{40}$	280.53
11	13.165	Octadecane	2.18	$C_{18}H_{38}$	254.49
12	13.331	1-Octadecane sulphonyl chloride	0.49	$C_{18}H_{37}ClO_2S$	353.003
13	13.920	9-Heptadecanone	0.94	$C_{17}H_{34}O$	254.45
14	14.062	7,9-Di-tert-butyl-1-oxaspiro (4,5) deca-6,9-diene-2,8-dione	0.65	$C_{17}H_{24}O_3$	276.4
15	14.559	Nonadecane	0.74	$C_{19}H_{40}$	268.52
16	14.707	Dibutyl phthalate	2.03	$C_{16}H_{22}O_4$	278.34
17	15.106	Aspidospermidin-17-ol, 1- acetyl -19,21-epoxy-15,16-dimethoxy	0.47	$C_{23}H_{30}N_2O_5$	414.50
18	15.320	n-Hexadecanoic acid	23.43	$C_{16}H_{32}O_2$	256.43
19	15.504	n-Hexadecanoic acid	1.68	$C_{16}H_{32}O_2$	256.43
20	15.616	tert-Hexadecanethiol	1.70	$C_{16}H_{34}S$	258.51
21	15.764	1-Docosene	5.64	$C_{22}H_{44}$	308.59

Table 3 Continued

Peak S/N	Retention time (min)	Name of Compound	Relative Abundance (%)	Molecular formula	Molecular weight
22	15.890	Heptadecane	1.14	$C_{17}H_{36}$	240.47
23	17.367	9,12-Octadecadienoic acid (Z, Z)	0.61	$C_{18}H_{32}O$	280.45
24	17.475	cis-Vaccenic acid	4.15	$C_{18}H_{34}O_2$	282.46
25	17.621	9,12-Octadecadienoic acid, ethyl ester	0.97	$C_{20}H_{36}O$	308.49
26	18.285	1-Docosene	0.87	$C_{22}H_{44}$	308.59
27	20.604	Pentadeca fluorooctanoic acid, octadecyl ester	0.47	$C_{26}H_{37}F_{15}O_2$	665.5
28	21.780	Diisooctyl phthalate	0.72	$C_{24}H_{38}O_4$	390.6
29	22.752	17-Pentatriacontene	0.16	$C_{35}H_{70}$	490.93
30	24.856	Squalene	1.13	$C_{30}H_{50}$	410.73
31	27.785	Ergosterol	1.22	$C_{28}H_{44}O$	396.65
32	30.006	N-Acetoacetyl-deacetyl-colchicine	1.52		
33	30.417	Thymol, TMS derivative	2.27	$C_{13}H_{22}OSi$	222.40
34	31.052	Cyclotrisiloxane, hexamethyl	13.73	$C_6H_{18}O_3Si_3$	222.46
35	31.095	Silicic acid, diethyl bis (trimethyl silyl) ester	1.82	$C_{10}H_{28}O_4Si_3$	296.48
36	31.288	16-Pregnenolone	11.30	$C_{21}H_{32}O_2$	316.50
37	31.350	3-(3,4-Dimethoxycinnamoyl)-4- hydroxy-6-methyl-2H-pyran-2-one	5.59	$C_{17}H_{16}O_6$	316.30

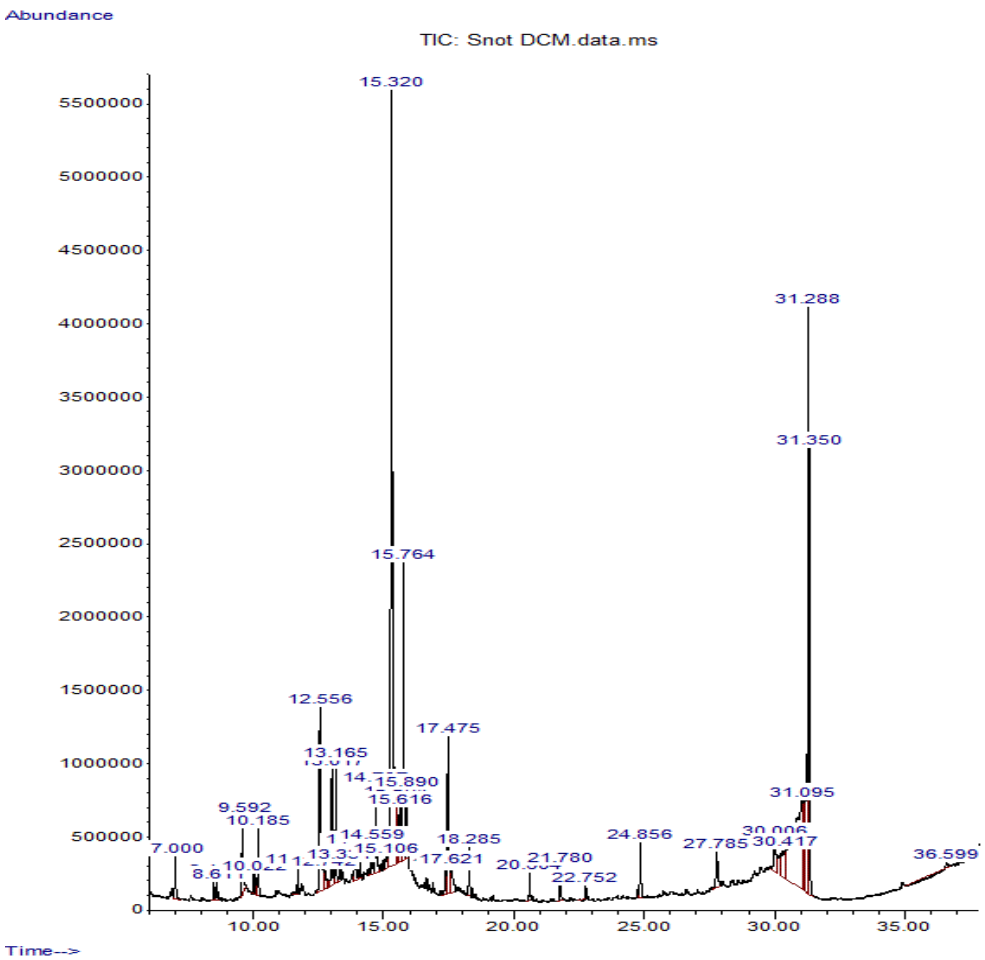

Figure 3. Gas Chromatograph of Dichloromethane/Methanol Extract of Goron tula (*Azanza garckeana*) fruit pulp.

4.3 Fourier Transform Infrared Spectroscopy (FTIR) result on the dichloromethane/methanol (1:1, v/v) extract of Goron tula (*Azanza gackeana*) fruit pulp

Fourier Transform Infrared Spectroscopy (FTIR) result on the dichloromethane/methanol (1:1, v/v) extract of Goron tula (*Azanza gackeana*) fruit pulp is shown in Table 4 and Figure 4, respectively. FTIR spectra of the dichloromethane/methanol extract unravelled eleven peaks indicating various functional groups. It revealed the presence of phenols, carboxylic acids, cyclic alkene, aromatic amine, aromatic compounds, alkane, fluoro compounds, organic sulphates, silicone compounds, olefinic alkene. All these functional groups are components of compounds that delineate the presence of alkaloids, flavonoids, steroids, fatty acids, alkanes, alkenes, and aromatic compounds. Each of these compounds has profound biological activities with the associated health benefits, respectively.

Table 4. Fourier Transform Infrared Spectroscopy (FTIR) result on the dichloromethane/methanol extract of Goron tula (*Azanza gackeana*) fruit pulp

S/No	Band Position/ Wave Number (¯cm)	Functional Group/ Mode of Vibration	Functional Group Assignment	Group Frequency
1	3806.712	O-H Stretch	O-H in alcohols, phenols,	>3800
2	3405.701	N-H Stretch	Primary amine	3400-3500
		O-H Stretch	Alcohol (Intermolecular bonded)	3200-3550
3	3251.968	N-H Stretch	Aliphatic primary amine	3250-3330
4	2900.787	C-H Stretch	Alkane	2840-3000
5	2510.058	O-H Stretch	Carboxylic acid	2500-3300
6	2155.761	-	Unknown	-
7	1942.025	C=C=C Medium	Allene	1900-2000
8	1668.661	C–H Bend	Aromatic Compound	1650-2000
		C–C Stretch	Alkene	1668-1678
		C–O Stretch	Conjugated ketone	1666-1685
9	1372.283	O–H Bend	Phenol	1310-1390
		S–O	Organic sulphates	1370-1420
		C–F	Fluoro Compounds	1000-1400
10	1311.281	O–H Bend	Phenol	1310-1390
		S–O	Dialkyl/Aryl sulfones	1300-1335
11	881.5816	Si–OH	Silicone compounds	810-950
		C-H	Alkenes	675-995

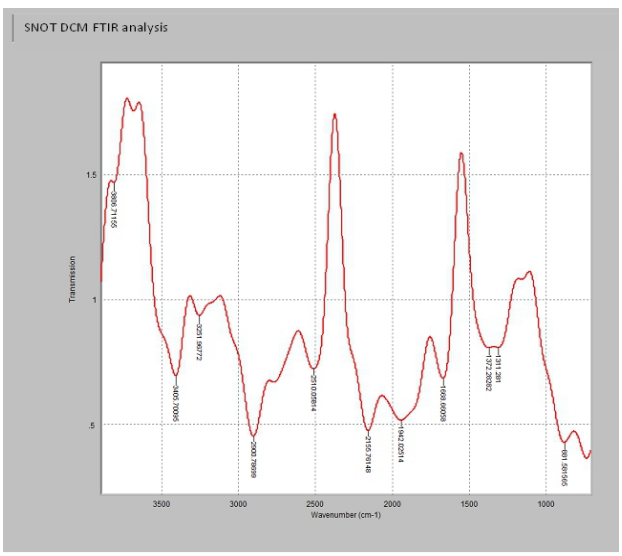

Figure 4. Fourier Transform Infrared (FTIR) Spectrograph of Dichloromethane/Methanol extract of Goron tula (*Azanza gackeana*) fruit pulp.

5. Conclusion

In this study, results indicated the presence of beneficial bioactive compounds in goron tula (i.e., *Azenza garckeana*) fruit pulp. The polarity of solvents used for extraction resulted in variations in the class and relative abundance of bioactive compounds. Dichloromethane/methanol extract of goron tula fruit pulp revealed the presence of steroidal animal hormone in the form of 16-pregnenolone for the first time. The presence of 16-pregnenolone is quite interesting and proves the efficacy of goron tula fruit pulp in folklore, as it is used for improving fertility, and it can be postulated that its presence, as well as other bioactive compounds, are capable of enhancing sex hormones in humans when consumed. Goron tula's glyceryl monooleate is a promising drug delivery vehicle. Goron tula fruit pulp is useful and should be exploited for its nutritional and therapeutic value, as well as being a pharmaceutically important substrate/raw material that can be exploited in the preparation of nutraceuticals and processed into various forms, such as food bars.

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