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A comprehensive characterization and therapeutic properties in ripened Noni fruits (*Morinda citrifolia* L.)

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Abstract: In this study, methanolic extracts from fresh ripened noni fruits (NFs) (*Morinda citrifolia*) were analyzed using GC-MS, FTIR, and XRD methods. Comprehensive assessments were carried out by proximate analysis (PA), higher heat value (HHV), bulk density (BD) and swelling index (SI). The qualitative analysis of the ripened NFs extracts in various solvents, including distilled water, chloroform, dimethyl sulfoxide (DMSO), dimethyl formamide, and methanol, revealed positive results for starch, terpenoids, saponin, and cardiac glycosides. The percentages of volatile matter, ash content and fixed carbon in PA are 78.799±0.592, 7.18±0.044 and 14.02±0.553, respectively. To use biomass as energy, PA is essential that burns in a gaseous state (volatile matter), solid-state (fixed carbon), and inorganic waste material (ash). It is important to consider the HHV of 17.185±0.103 MJ/kg when estimating the potential for energy recovery from the fruit's biomass. Compositional analysis (CA) was used to determine the percentages of the extractive contents (4.497±0.346), cellulose (33.114±0.261), lignin (9.569±0.399), and hemicellulose (17.89±0.608), all of which have substantial antibacterial properties. Our research looked at its BD (0.312±0.001g/cm^3) and SI (1.535±0.022%), resulting in increased susceptibility of the biomass to microbial activity. FTIR and XRD reveal C-O, O-H, N-H, O=C=O, C-H, and O-H linkages with solid lattice spacing. It helps to determine how a substance will interact with biological tissue following implantation. However, no research documents were found in any literature about the oil from noni fruits for the purpose of external pain relief. Advice on using NFs oil for pain treatment comes from our field study of a woman who is 80 years old. In ripened NFs extract, GC-MS analysis identified 100 phytochemicals, including D-limonene, 3-carene, gamma-terpinene, methyl eugenol, caryophyllene, hentriacontane etc. GCMS and virtual screening-cum-molecular docking studies have been done and reported first time to check the documentation and look for caryophyllene that could be used for pain-relieving properties. These compounds have been shown to have antioxidant, antimicrobial, anticancer, inflammation in the brain and oxidative stress-related effects. Our research confirms the bioactive potential of ripened NFs as an alternative medication source.

Introduction

Plants have been used to treat illnesses since the dawn of civilisation. Traditional healers have gained importance recently for historical and cultural reasons, particularly in developing nations with scarce access to healthcare (Sarkar, 2016; Bhattacharjee, 2021). Traditional therapy

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and medications are still widely used to treat a variety of ailments (Sarkar et al., 2016; Banerjee et al., 2014; Sanyal et al., 2018; Kar et al., 2022). The lack of a scientific study of medicinal herbs to verify their usage may result in significant harmful effects (Maiti et al., 2013; Fitzgerald et al., 2020). One of the major sources of bioactive chemicals is thought to be plants and fruits. According to several studies, 80% of residents use medicinal plants as their primary source of healthcare (Maiti et al., 2010; James et al., 2018).

Noni fruits (NFs) (*Morinda citrifolia*, Family: Rubiaceae), which are native to China and India, are now used as a folk remedy (Choi et al., 2021). When NFs are ripened, it has an astringent or bitter flavour and a potent rancid scent resembling butyric acid. It is a significant plant that is utilised in medicine in many nations. This plant is known as Noni, Indian mulberry, Nuna, and Mengkudu (Potterat and Hamburger, 2007). It treats many conditions, including dysentery, heartburn, liver illness, diabetes, high blood pressure, migraines, joint pain, muscle aches, and arthritis. Likewise, it is often used to cure drug addiction. This plant's mature fruit is used to cure tuberculosis and respiratory illnesses (Singh, 2012).

However, research has revealed that NFs are beneficial in fighting bacteria, diabetes, cancer, free radicals, inflammation, and cardiovascular disease (Motshakeri and Ghazali, 2015). Due to the numerous changes and uses of plant structures for various medical purposes, NFs have attracted the interest of researchers in the food and pharmaceutical industries. Its potential as a valuable food source has also been mentioned (Almeida et al., 2019). Few NFs-containing foods are currently available on the market. Therefore, it is crucial to assess the chemical makeup and therapeutic potential. Through the analysis of numerous approaches and the assertion of the traditional view, this study attempted to describe the extract of ripened NFs.

Materials and Methods

A field survey based on questionnaires was used to conduct the research's initial phase. Based on their interest in healthcare medicinal plants, we interested elderly people (50 numbers) solely to facilitate record-keeping on the villagers' traditional knowledge of medicinal plants that treat health disorders in the North 24 Parganas district of West Bengal (Lat. 22.5620º & Long. 88.9125º). The older people assist us by offering the plants and utilising their components. We noted their suggestions on the preparation procedure, quantity/quality, purposes, and use time.

The second part of the study is based on the characterization of plant materials based on information gathered from villagers for the first section. According to this study, when traditional beliefs are seen through the prism of scientific assessments using conventional tools, techniques, and bioactive possibilities, they may correspond to conclusions regarding novel medications in the future. Only 4% of people have been told about the NFs and their multiple medical uses. This work used scientific techniques to examine methanolic extracts from freshly ripened NFs.

Sample collection, size and Extraction

Disease-free NFs sample was collected from the medicinal garden of Acharya Prafulla Chandra College campus (Lat. 22.6972º and Long. 88.4384º), West Bengal, India. After the sample had been made for shed dried completely, it was put through a Wiley Mill and reduced to a powder. This powder was screened using a sieve with a mesh size of 40 µm. The characterization process utilized this particle size.

The NFs powder was soaked overnight in various solvents, such as chloroform, heated distilled water, dimethyl sulfoxide (DMSO), dimethylformamide, and methanol extract. The dry extract was recovered from the filtrate by air drying and heating it over a hot water bath (40℃), and it was then stored in an airtight container pending laboratory tests.

Test for solubility (0.05 g in 10 ml & 0.1 g in 10 ml)

A prepared sample was used to dissolve 0.05 g and 0.1g of the sample with 10 ml separately of the various solvents [viz., Distilled water, Chloroform, Dimethyl sulfoxide (DMSO), Dimethyl formamide and Methanol]. The mixture was then left out overnight. It was heated up after 24 hours. It was then filtered, the filtrate dried in a hot air oven (37°C), and the dilution percentage (%) was determined by measuring the filtrate.

Bulk Density (BD)

The dry weight of a solid per unit volume is known as bulk density (BD). 16.37g of a ripened NFs sample mass that had been screened through a sieve with an aperture size of 850 µm was then poured at a roughly 45º angle into a clean, dry, graduated 50 mL measuring cylinder. We recorded the volume occupied and computed the mean DB (United States Pharmacopoaeia, 2003).

$$DB = M/VB$$ (where M = weight of the sample and VB = mean bulk volume of the sample)

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Swelling Index

The swelling index determined how much plant material could expand when exposed to water and whether or not it contained mucilaginous material. Two readings were collected after adding water to the sample material: the first and second readings three hours later. Transfer 1g of the ripened NFs to a measuring vial with a stopper that holds 25 ml methanol. The cylinder should be filled with water to the 20 ml mark. Allow to stand for up to three hours, then stir gently. Determine the volume of space occupied by the swelling.

Proximate Analysis

The NFs samples' proximate components were determined using the Official Analytical Chemist technique (AOAC, 1990). The micro-Kjeldahl method was used to measure the nitrogen as described by Pearson (1976). By multiplying, the percentage of nitrogen was changed to crude protein. Ash content, fixed carbon content, and volatile matter from the NFs materials were determined using the weight difference method (Das et al., 1997; Haro et al., 1968). The moisture, ash, and volatile matter (VM) concentrations in NFs were proximally analysed in accordance with ASTM D1762 (ASTM D-1762-84, 1989). The fixed C content was found by subtracting moisture, ash, and VM contents from 100. Percentages were used to report on all proximate values. There were three duplicates of each determination.

Higher Heating Value

The higher heating value (HHV) refers to the heating value determined by the calorimeter based on the oven dry weight. Approximately 1g of oven-dried ground sample (-20/+40 mm mesh) was pressed into pellets using a hydraulic pellet press and loaded into an oxygen bomb calorimeter (Parr model 6300). Three NFs samples were combusted to estimate the HHV.

Ultimate Value

NFs' elemental compositions were calculated using a CHNSO elemental analyser as percentages of carbon (C), hydrogen (H), and nitrogen (N) (Eurovector EA3000). The analyser was calibrated by utilising 5 tin capsules filled with a 5L-cystine test. A tin pill containing 0.1 mg of powdered biomass was used. A steady stream of helium gas that had been enhanced with oxygen was used to heat it to 980℃. The elemental makeup of the NFs biomass was estimated by data analysis utilising Callidus® software.

Compositional analysis

Using the fibre plus automatic fibre estimation technique, the polysaccharide fraction of the NFs biomass samples was assessed (Pelican). A crucible containing 0.5–1g of the powdered biomass sample was used to measure the neutral detergent fibre (NDF). At room temperature, sodium sulphite and 100 ml of neutral detergent solution were added to the crucible. At 400℃, the crucible was heated to boiling point and refluxed after 60 minutes. The mixer was filtered, cleaned with acetone and then water. The crucible was dried for 8 hours at 105℃, and the weight was noted. According to Van Soest et al. (1991), the NDF was determined as follows.

$$\text{NDF \%} = \frac{\text{(Wt of crucible + NDF) - Wt. of crucible}}{\text{Wt. of Sample}} \text{ X } 100$$

To analyze acid detergent fiber, a technique similar to the NDF estimate was applied (ADF). An acidic solution was used because the detergent solution was not neutral. The following calculations were made to determine the weight loss:

$$\text{ADF \%} = \frac{\text{(Wt of crucible + ADF) - Wt. of crucible}}{\text{Wt. of Sample}} \text{X } 100$$

The acid detergent lignin (ADL) was produced by placing the ADF in a crucible, adding 72% H_2SO_4, and stirring continuously for three hours. It then went through two water washes and filters. The crucible was heated to 100℃ in the hot air oven for 8 hours while the weight loss was monitored. In order to obtain the ash, the crucible was placed in a muffle furnace heated at 500℃ for 7 minutes. The weight loss was measured. To calculate the proportions of cellulose, hemicellulose, and lignin, the formulas below were used:

Hemicellulose % = NDF% - ADF%

Cellulose % = (Y-L/W) x 100

Lignin% = (L-A/W) x 100

Where, Y = Weight of ADF + crucible,

L = Weight of crucible + Lignin,

A = Weight of crucible + ash,

W = Weight of a sample.

X-ray diffraction (XRD)

XRD examination of the biomass samples was carried out on a Rigaku TT Rax diffractometer using a Cu-Ka radiation source produced at 18 kW and 250 mA at a 2 theta range 10-40^o at a scan speed of 10 min^{-1}.

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The biomass sample's crystalline indices (CrI) were determined as follows (Cao & Tan, 2005).

CrI = 100 x [(I002 – Iamorphous)/I002]

where I002 is the intensity of at 2Θ = 20 for the where I002 is the intensity of at 2Θ = 20 for the crystalline portion (cellulose), and Iamorphous is the peak at 2Θ = 16.6 for the amorphous portion (cellulose, hemicellulose, and lignin).

FTIR analysis

With diffuse reflectance spectroscopy coupled with Fourier transform infrared (FTIR) spectroscopy (Model FTS 3500 GX), the functional groups contained in the biomass were identified (DRS). The 10 gm dry biomass sample was compressed into pellets after being combined with 200 mg KBr. The spectra were gathered between the wave numbers 400 and 4000 cm^{-1} with a scan rate of 40 and a step size of 4 cm^{-1}.

GCMS analysis & Virtual screening-cum-molecular docking study

The GC-MS-QP2010 PLUS (SCHIMADZU-JAPAN) system was used to analyse methanolic extracts from the NFs. The mass spectrometer in this test employed 400 V and a mass range of m/z 50–600 to detect the electron ionization mode. The temperature of the gas chromatography column (DB ms 30 m x 0.25 mm, 025 m) was begun at 50℃ and increased to 280℃ at a rate of 2℃/min. The gas flow rate for this experiment was set at 1.2 ml/min, and the sample injection volume was 1 µl. With the help of the standard data in the NIST library, which was made available by these facilities, the components of these extracts were examined by retention durations and mass fragmentation patterns.

The BIOVIA-DSV software was used to analyse selected docking complexes' protein-ligand-molecular interaction (Swain et al., 2021).

Phytochemical Screening

Through phytochemical screening, a fundamental understanding of the existence of diverse compounds with medicinal advantages can be acquired. Various solvent extracts of NFs were examined for the content of anthraquinone, cardiac glycosides, flavonoids, phenolic compounds, saponin, tannins, terpenoids, and starch using the techniques suggested by Harborne (1973), Brindha et al. (1981), Trease and Evans (1981), and Sofowara (1993).

Anthraquinone (Borntrager's test)

A dry test tube containing 50 mg of extract powder had 5 ml of chloroform added to it before being agitated for 5 minutes. Whatman No. 1 filter paper was used to filter the extract, and an equal volume of 10% ammonia solution was added to the filtrate before being shaken. Anthraquinone is present when the ammoniacal layer (lower layer) turns pink, violet, or red.

Cardiac glycosides (Keller-Kiliani test)

1.25 mg of each extract was properly combined with 0.5 ml of chloroform and left to react. The next step was to gently add 0.5 ml of strong sulfuric acid to create a lower layer. The reddish-brown colour at the interface shows that cardiac glycosides' glycone component, a steroidal ring, is present.

Flavonoids (Shinoda Test)

Dropwise, add concentrated HCl and a few pieces of magnesium ribbon to the extract solution (5 ml). Flavonoids are present when red or orange-red colouring is present.

Phenolic compounds (Ferric Chloride Test)

1-3 drops of ferric chloride solution were added to the NFs crude extract, or 5 mg of the dry extract could be dissolved in 0.5 ml of 1% ferric chloride solution. The development of bluish-black colouring is a sign that phenolic chemicals are present.

Saponin (Frothing test)

A test tube containing 2.5 mg of the NFs extract was carefully shaken with 5 ml of distilled water before the reaction could begin. Warm samples were given if they had foam. The foam was combined with three drops of olive oil and aggressively shaken to create an emulsion, which is a saponin feature.

Tannins (Braymer's Test)

In a test tube, 5 ml of distilled water was used to boil about 2.5 mg of each NFs extract before it was filtered through Whatman's no. 1 filter paper. A favorable outcome was determined by adding two to three drops of 0.1% ferric chloride and looking for a brownish-green or a blue-black precipitate.

Terpenoids (Salkowski test)

In a water bath, 0.5 ml of the NFs dried chloroform extract was evaporated to dryness before being heated for 10 minutes with 3 ml of concentrated sulfuric acid. A layer of reddish-brown colouration at the interface developed, providing evidence that terpenoids were present.

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Screening for Starch

10 ml of a saturated NaCl solution was added to 1 ml of an aqueous NFs extract. When the starch reagent of the sample is heated and added, the result is a blue-purple colour, indicating that starch is present.

Statistical Analysis

The data are expressed using mean and standard deviation (Mean ± SD). The version 17 of SPSS was utilized throughout all of the statistical studies.

Result:

The solubility of an unidentified molecule can be used to make judgements about the size of the compound, its polarity, and whether or not it contains functional groups that are acidic or basic. This NFs powder was separated using a sieve with a mesh size of 40 µm. Solubility tests were carried out using distilled water, chloroform, dimethyl sulfoxide (DMSO), dimethylformamide, and methanol (Table 1).

Table 1. Using distilled water, chloroform, dimethyl sulfoxide (DMSO), dimethylformamide, and methanol as solvents, 40 µm dust of maturing noni fruits (NFs) was used for the solubility test.

Solvents	Sample		
	Original Sample (g)	After Dissolving (g)	% Solubility
Distilled water	0.05	0.018	64
	0.1	0.040	60
Chloroform	0.05	0.022	56
	0.1	0.093	10
Dimethyl sulfoxide (DMSO)	0.05	0.004	92
	0.1	0.083	17
Dimethylformamide	0.05	0.013	74
	0.1	0.044	56
Methanol	0.05	0.013	74
	0.1	0.048	52

A basic concept of the existence of various chemicals with therapeutic benefits can be gained from phytochemical screening. The presence of Anthraquinone, cardiac glycosides, Flavonoids, phenolic compounds, saponin, tannins, terpenoids and Starch was screened in various solvent extracts of NFs using the methods. The ripened fruits of the Nani plant have been shown to contain starch, saponins, flavonoids, terpenes, and cardiac glycosides, all of which have passed tests for presence (Table 2 & Figure 1).

Table 2. Results of the phytochemical analysis of ripened *Morinda citrifolia* L.

Sl. No.	Tests	Sample A
1	Starch	Positive
2	Terpenoids	Positive
3	Tannins	Negative
4	Saponin	Positive
5	Phenolic compounds	Negative
6	Flavonoids	Positive
7	Anthraquinones	Negative
8	Cardiac glycosides	Positive

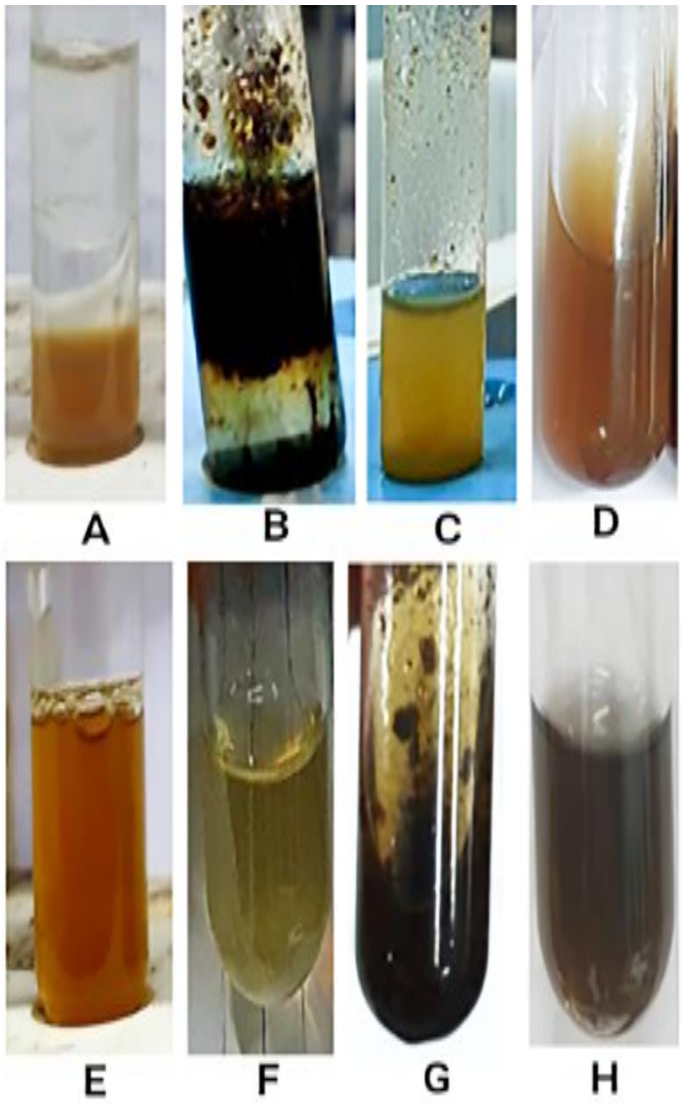

Figure 1. (A) Anthraquinone sample *Morinda citrifolia* L. yield a negative (-) result, (B) Cardiac glycosides test results are positive (+), (C) A positive (+) result was found in the flavonoids test, (D) The phenolic compound test returned a result of not positive (-), (E) The results for saponin were positive (+), (F) Tannin tests revealed a negative (-) result, (G) Test results for terpenoids were positive (+), (H) The presence of starch in NF's sample produced a positive (+) result, which was expressed as a bluish colouration.

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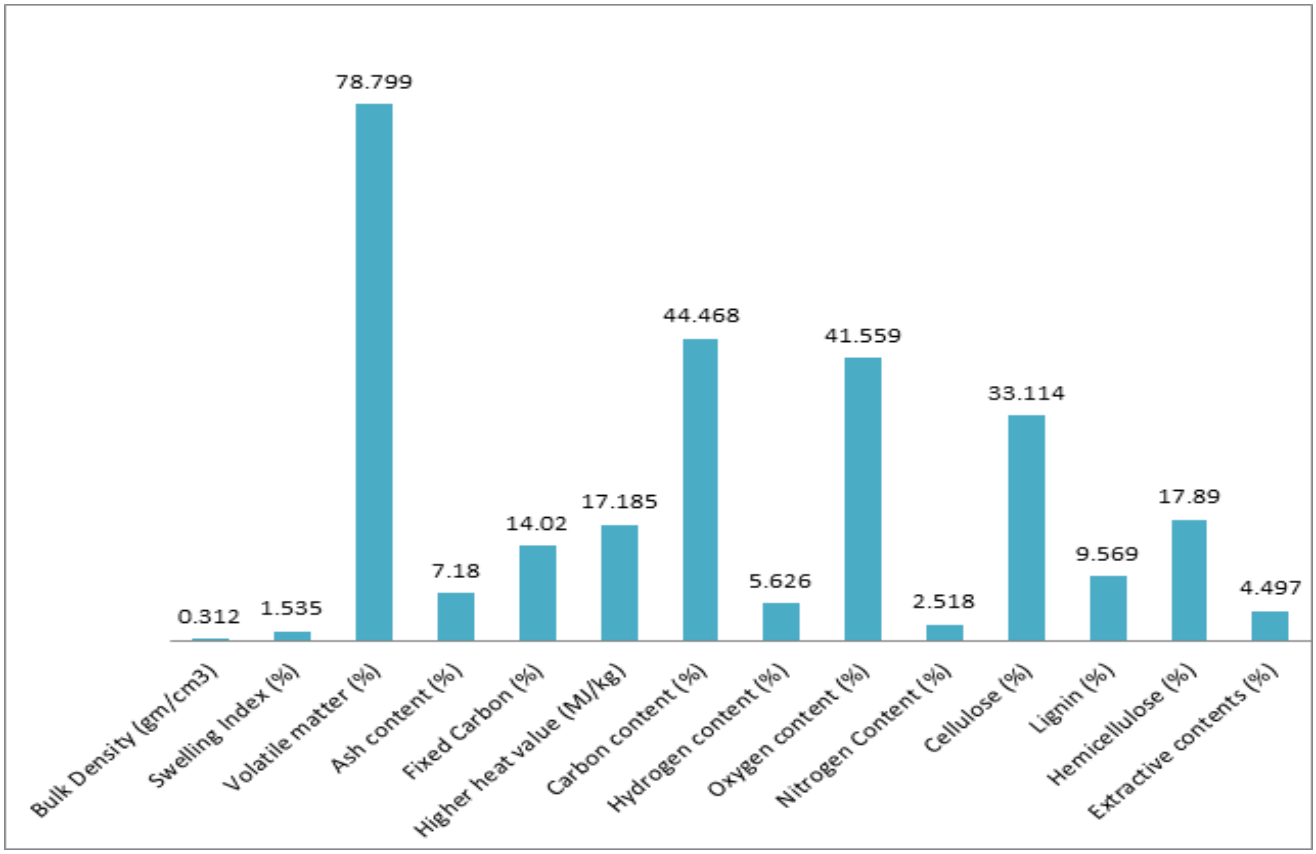

Figure 2. The figure shows the results of bulk density, swelling index, proximate analysis, ultimate analysis and compositional analysis of ripened *Morinda citrifolia* L..

Table 3. Results on bulk density, swelling index, proximate analysis, ultimate analysis and compositional analysis of ripened *Morinda citrifolia* L.

Bulk density gm/cm^3	Swelling index (%)	Proximate analysis			
		Volatile matter (%)	Ash content (%)	Fixed Carbon (%)	Higher heat value (MJ/kg)
0.312±0.001	1.535±0.022	78.799±0.592	7.180±0.044	14.02±0.553	17.185±0.103
Ultimate analysis					
Carbon content (%)	**Hydrogen content (%)**	**Oxygen content (%)**	**Nitrogen Content (%)**		
44.468±0.077	5.626±0.003	41.559±0.091	2.518±0.161		
Compositional analysis					
Cellulose (%)	**Lignin (%)**	**Hemicellulose (%)**	**Extractive contents (%)**		
33.114±0.261	9.569±0.399	17.89±0.608	4.497±0.346		

Bulk density (BD) and higher heating value (HHV)

The biomass' bulk density (BD) indicates how much it can be transported. The lignin content of the biomass and the volatile matter is expected to be higher if the bulk density is higher. After an acquisition, biomass waste is only somewhat valuable. This is a source of energy. Our study focused on its BD (0.312±0.001g/cm^3), which elevated the biomass' sensitivity to microbial activity.

The calorific value of biomass is directly influenced by its bulk density. The higher heating value (HHV) is 17.185±0.103 (MJ/kg) (Table 3 & Figure 2). A substance with a higher bulk density has a higher heating value (HHV) because it has less vacant space, a higher packing ratio, and a higher specific energy yield (Nwaiwu and Ibekwe, 2006).

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Proximate analysis (PA)

Proximate analysis (PA) reveals that volatile matter, ash content, and fixed carbon percentages are78.799±0.592, 7.18±0.044 and 14.02±0.553, respectively (Table 3 & Figure 2). It is necessary to have PA that burns in a gaseous state (volatile matter), in a solid state (fixed carbon), and inorganic waste material in order to use biomass as a source of energy (ash). Since the amount of volatile matter in the biomass employed in this study is larger than 70%, this indicates that there is an increased presence of lignin, which in turn increases the antibacterial quality. According to the results of the analysis of the ash content (7.18±0.044%), the biomass can be utilized successfully as a fuel source. As a result, the wastes have the potential to be employed to demonstrate an improved energy recovery pathway (McKendry, 2002).

Compositional analysis

Compositional analysis was used to determine the percentages of the extractive contents (4.497±0.346), cellulose (33.114±0.261), lignin (9.569±0.399), and hemicellulose (17.89±0.608) (Table 3 & Figure 2), all of which had substantial antibacterial properties and may be utilised for energy recovery (Mothé and de Miranda, 2009).

Swelling index

The swelling index was calculated in order to determine how much plant material could expand when exposed to water and whether or not it contained mucilaginous material. After adding water to the plant material, two readings were taken: the initial reading and the last reading three hours later. It was observed that NFs had a swelling index of 1.535%.

Ultimate analysis

According to the findings of the Ultimate Analysis, the percentage of carbon content is rather significant, which suggests that biomass offers significant energy qualities. The percentage of Carbon content, Hydrogen content, Oxygen content and Nitrogen Content are 44.468±0.077, 5.626±0.003, 41.559±0.091 and 2.518±0.161 respectively (Table 3 & Figure 2). Because the ratio of oxygen, hydrogen, and nitrogen indicates a significant result, it is safe to assume that the phenolic content of the supplied biomass is high. If the phenolic content is high, it is safe to assume that the amount of volatile substances is also high. As a result, biomass possesses superior antibacterial properties and is a more reliable energy source. The atomic ratios of oxygen to carbon and hydrogen to carbon are the primary factors that influence energy recovery efficiency (Milne et al., 1992). The heating value of biomass increases, and greater amounts of energy are recovered when it has a lower oxygen-to-carbon ratio. This is because the energy content of biomass is inversely related to elemental ratios. The given biomass has significant antibacterial capabilities and can be used for energy recovery, as shown by the substantial quantity of lignin, cellulose, hemicellulose, and extractable.

XRD analysis

In the XRD graph, the components of cellulose and hemicellulose can be seen at 2Θ between the values of 20 and 25 (Figure 3). The powder X-ray diffraction (XRD) measurements revealed that distinct lattice expansion could be seen in the highest heated NFs samples. As the temperature climbed, the lines grew thinner and more distinct. A comparison with the XRD database revealed that the XRD lines in these patterns correlate to the lines of naturally occurring crystalline cellulose and hemicellulose components.

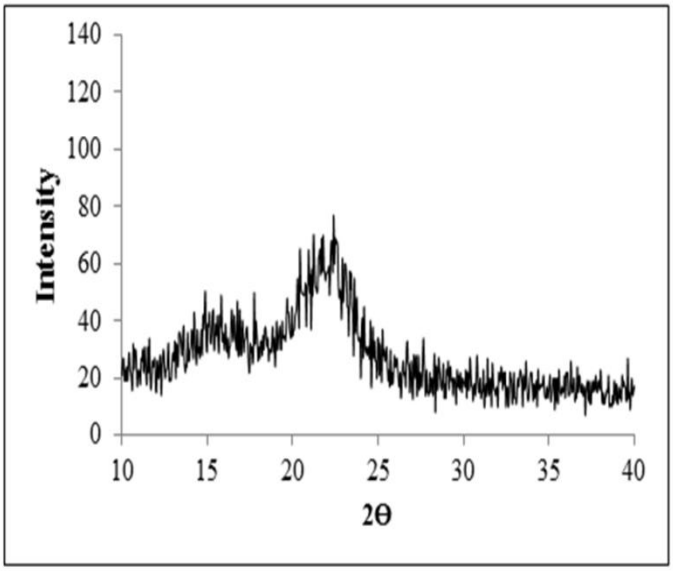

Figure 3. X-ray diffractometry (XRD) peaks of ripened *Morinda citrifolia* L. powder.

FTIR analysis

The plant sample underwent FTIR analysis to identify the present functional groups (Table 4). The results of this study also indicate the existence of a specific bioactive component in the plant matter.

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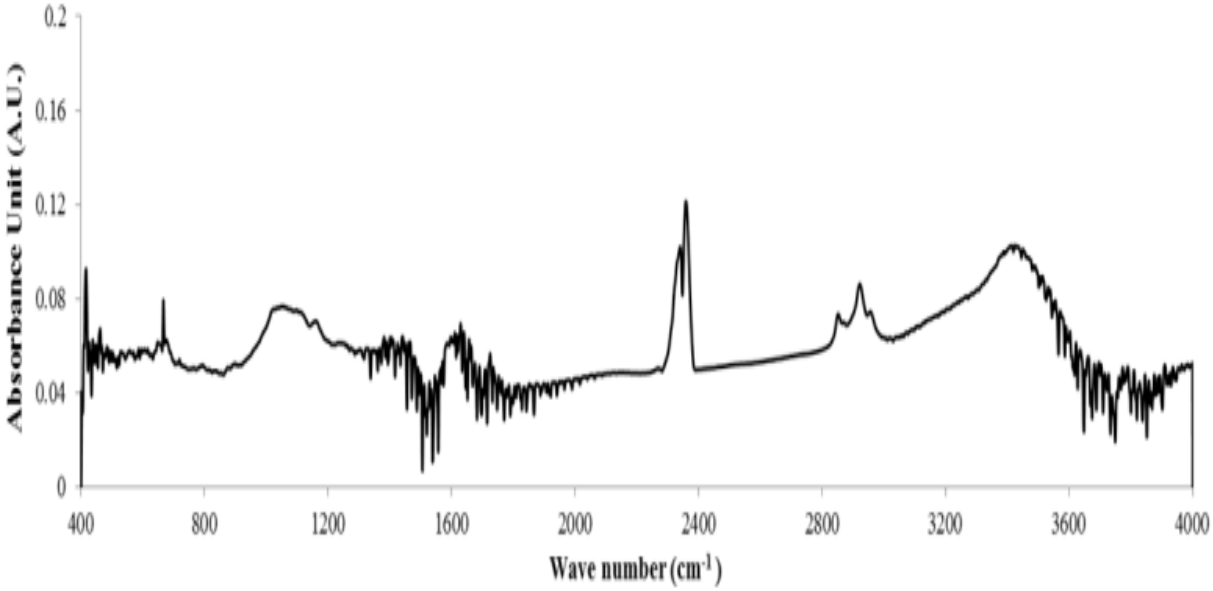

Figure 4. FTIR spectra of ripened *Morinda citrifolia* L. powder extract

Table 3. FTIR spectral peak values and functional groups were obtained for the leaf extract in *Morinda citrifolia* L. methanol solvents.

Peak Position	Peak range	Group	Class
1070	1050-1085	C-O stretching	Primary alcohol
1430	1395-1440	O-H bending	Carboxylic acid
1650	1580-1650	N-H bending	Alkene
2370	2349	O=C=O stretching	Carbon dioxide
2930	2840-3000	C-H stretching	Alkane
3450	3200-3550	O-H stretching	Alcohol/phenol

According to the spectra of the dried NFs, the primary absorption bands in these samples are those that are typical of the organic component and the water that has been retained. The O=C=O stretching is responsible for most of the prominent peaks observed at 2400 cm^{-1}. On the other hand, the wavelengths 1050-1085 cm^{-1}, 1395-1440 cm^{-1}, 1580-1650 cm^{-1}, 2840-3000 cm^{-1}, and 3200-3550 cm^{-1} are attributed to the stretching vibrations of C-O stretching (primary alcohol), O-H bending (carboxylic acid), N-H bending (alkene), C-H stretching (alkane), and O-H stretching (alcohol/phenol), respectively. The results of the thermal analysis demonstrated this. In addition, the values of the peak regions of the hydroxyl OH of hydroxyapatite demonstrated that dehydration happened when the temperature was raised above a certain point. The interpretation was accomplished by utilizing already published material (Prado et al., 2005).

GCMS analysis and Virtual screening-cum-molecular docking study

The GC-MS analysis of the NFs biomasses evaluated in this study was carried out to have a detailed insight regarding the presence of various compounds within the considered biomasses. The detailed methodology adopted for the analysis of GC-MS has been indicated in the methodology section. Various peaks were obtained for the biomass specimen under evaluation which was obtained based on their retention time. The peaks having significant coverage areas were taken into consideration. The standard database of NIST 20 (Data version: NISTv20; Software version: 2.4) was used to arrive conclusion regarding the presence of the various compounds. The obtained data are presented in figures 6 & 7. The chromatograms indicated in the figure confirmed the presence of a wide spectrum of

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compounds. The presence of the various compounds within the NFs biomass under evaluation has been showcased in table 5.

The in-vitro results are generally supported by the virtual screening and molecular docking results, and found preliminary phytoconstituents from GC-MS analyses were active against both fungal and bacterial targets. Sesquiterpenes, or germacrenes, are a subclass of volatile organic hydrocarbons. Although they also serve as insect pheromones, germacrenes are typically generated by various plant species for their antibacterial and insecticidal activities. Germacrene D has antibacterial and antifungal properties and can be applied in conjunction with azoles and aminoglycosides as adjuvant (Sitarek et al., 2017).

According to studies, beta caryophyllene has anti-inflammatory, anticancer, and antioxidant properties. Significantly, cannabinoid receptors, one of the important components of the endocannabinoid system, have been found to be fully selective agonists of beta caryophyllene receptors. Researchers discovered that beta-caryophyllene decreased inflammation in the brain and oxidative stress-related compounds. These anti-inflammatory qualities might also aid in preventing oedema and inflammation of the brain after a stroke to enhance stroke outcomes. Additionally, beta-caryophyllene therapy reduced gut inflammation in mouse studies (Gertsch et al., 2008; Javed et al., 2016; Pieri et al., 2016; Swamy et al., 2016).

Three strains of gram positive bacteria, four strains of gram negative bacteria, three strains of yeast, and four strains of mould cannot grow when 1-epi-cubenol is present (Kabouss et al., 2011). According to Gonzalez et al. (2012), 1-epi-cubenol showed antibacterial activity against two pathogenic fungi and antifungal activity against five pathogenic strains of bacteria. Numerous pharmacological actions of alpha-pinene have been documented, including analgesic, anticancer, antibacterial, antimalarial, anti-inflammatory, and effects that modulate antibiotic resistance. The biological activity that alpha- and beta-pinene phytochemicals exhibit have led to a variety of uses for them, including fungicidal agents, tastes, perfumes, and antiviral and antibacterial agents (da Silva et al., 2012). Additionally, renal and hepatic medications contain - and -pinene as an ingredient (Sybilska et al., 1994). Additionally, due totheir toxic effects on membranes, alpha and beta pinene are utilized as antibacterials (Alma et al., 1994). Additionally, it has been discovered that alpha and beta pinene inhibits leukemia and breast cancer (Zhou et al., 2004). Pinenes have used outside of natural medicine; they have, for instance, shown to be very flexible in the production of polymers (Winnacker and Rieger, 2015; Salehi et al., 2019).

Irinotecan and topotecan, analogues of camptothecin, have been authorized for the treatment of cancer (Li et al., 2017). A pentacyclic quinoline alkaloid with significant cytotoxic activity in numerous cell lines, camptothecin is a naturally occurring substance. The medication has significant drawbacks that hinder full clinical application, including low solubility and hydrolysis under physiological circumstances. Both the active lactone form and the inactive hydrolyzed carboxylate form of camptothecin remain in balance. The DNA topoisomerase I cleavage complex is thought to be the only site of activity where the active lactone interacts. Binding prevents DNA ligation, which causes apoptosis (Venditto and Simanek, 2010). *In-vitro* studies have demonstrated that delta cadinene possesses antioxidant and antibacterial properties (Jang et al., 2016; Kundu et al., 2013).

Figure 4. Noni fruits (NFs) (*Morinda citrifolia*)

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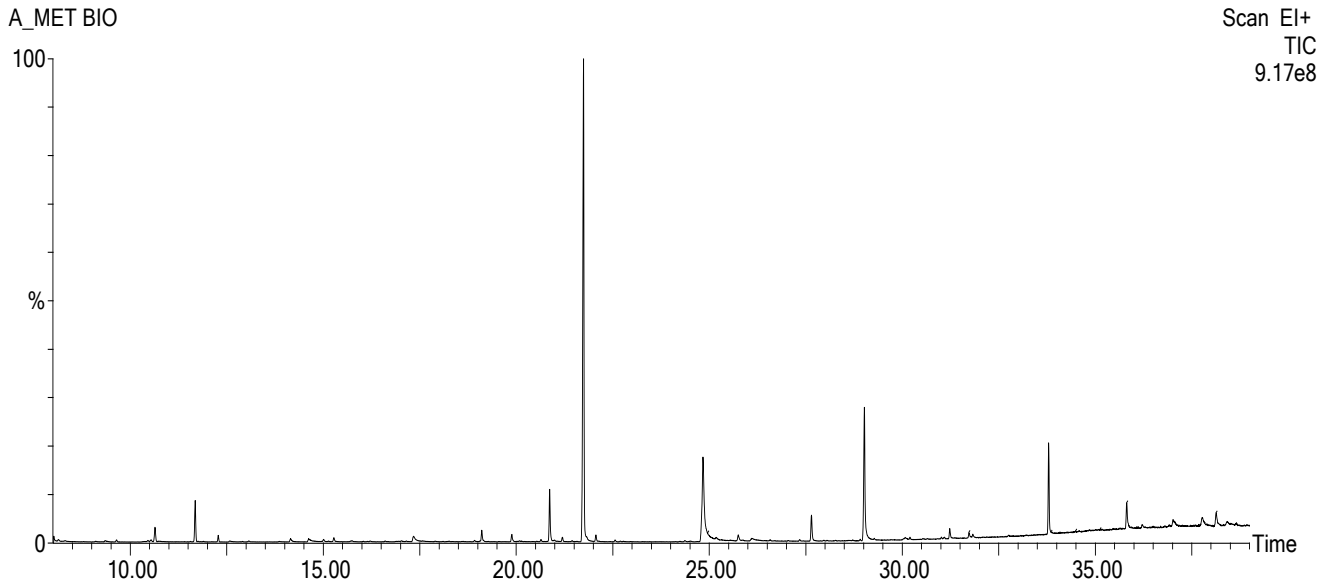

Figure 6. GC-MS study of the ripened fruit of *Morinda citrifolia* using the extract obtained from methanol.

Discussion

The sieve used to screen this NFS powder had a mesh size of 40 µm. This particle size was used in the characterization procedure. Increasing the particle size or homogenizing the form will result in a smaller angle of repose. According to the findings of the phytochemical screening tests, the NFs constituted of components such as starch, terpenoids, saponin, flavonoids, and cardiac glycosides. In India and China, terpenoids make up the biggest phytochemicals that have a history of being used for therapeutic purposes. Anticancer drugs derived from terpenoids are currently being investigated in clinical studies (Thoppil and Bishayee, 2011). Saponins reduce blood lipid levels as well as the risk of cancer and blood glucose response. Inhibiting dental cavities and platelet aggregation, treating hyper-calciuria in people, and acting as an antidote for acute lead poisoning are all possible uses for a high saponin diet. Several saponins, which are among the physiologically active classes of phytochemicals, have been shown to reduce body weight and serum lipid levels (Marrelli et al., 2016). A class of bioactive substances known as flavonoids is often present in foods made from plants. Regular consumption of these foods is linked to a lower risk of numerous chronic illnesses, such as cancer, cardiovascular disease (CVD), and neurological diseases (Panche et al., 2016). While some flavonoids show potential for anti-human immunodeficiency virus capabilities, many flavonoids have been proven to have anti-oxidative activity, free-radical scavenging capacity, coronary heart disease prevention, and anticancer action (Yao et al., 2004). Cardiac glycosides are a special class of secondary metabolites and are regarded as one of the most effective medicinal medications. Cardiac glycosides are either C23 or C24 steroids with a cyclo-pentano-perhydro phenanthrene substitution at the C17 position in the basic nucleus. Cardiac glycosides are drugs used to treat certain irregular heartbeats and heart failure. They belong to one of the medication classes used to treat heart disease and linked disorders (Morsy, 2017). The starch was positive for NFs, which is used for the phytochemical screening tests. Starch is present, which denotes the existence of carbohydrates. A significant class of naturally occurring organic substances known as carbohydrates is vital to the upkeep and nourishment of life in both plants and animals.

NFs with a higher bulk density will be able to hold more water. It is critical that plants get enough moisture in order for them to grow healthily. Bulk and tapped density have an impact on the properties of powder flow. Optimal working conditions were met by phenolic compounds, antioxidant activity, and bulk density with higher aesthetic preference (Charunuch et al., 2008). When the swelling index is larger, the biomass is more amenable to hydroscopy. The capacity of biomass to take up water is significant. As a consequence, biomass is less suitable for the technique of energy recovery and is also more susceptible to the activity of microbes (Kleme et al., 2020).

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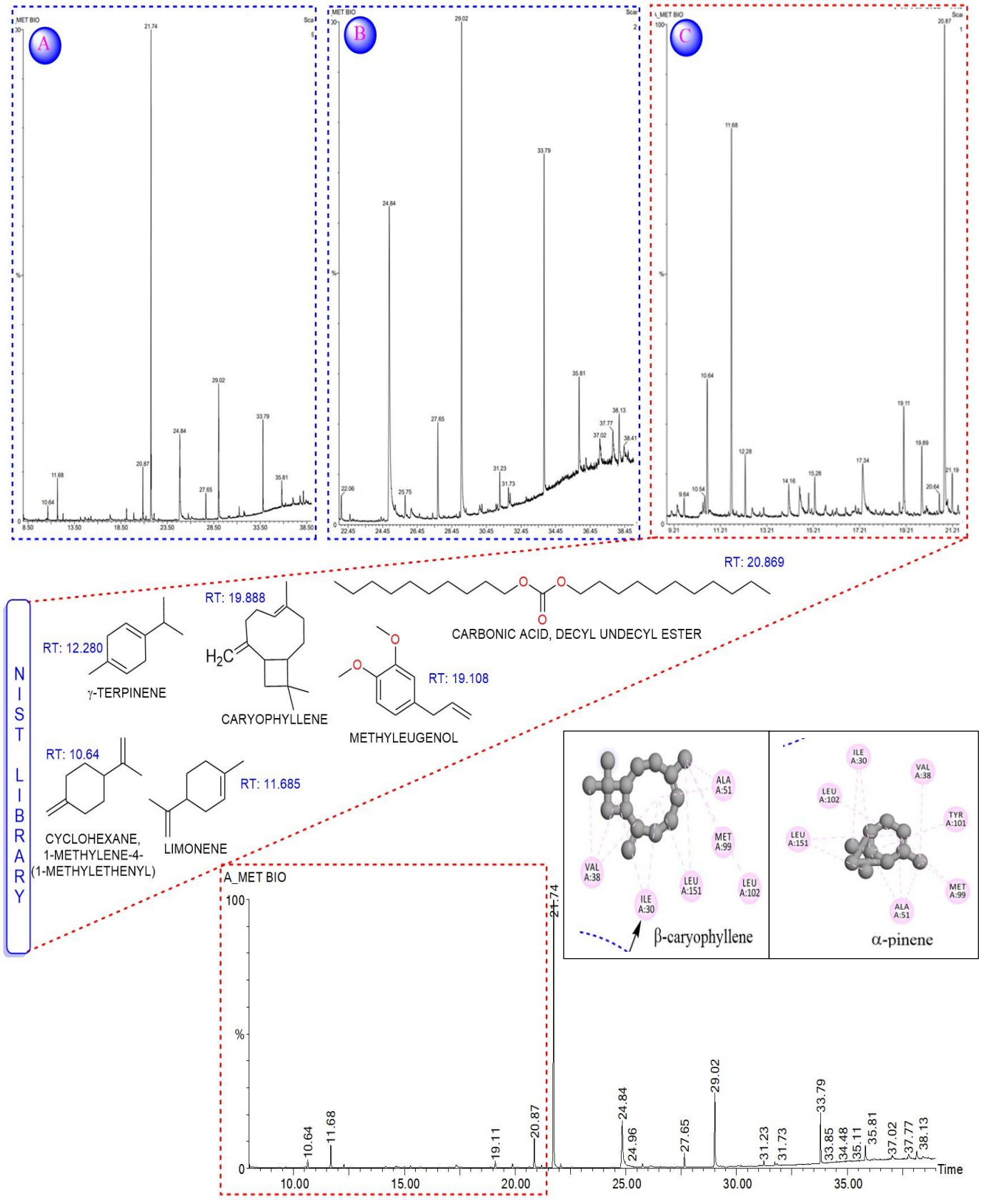

Figure 7. GC-MS analysis of the ripened fruit of *Morinda citrifolia* utilizing the extract derived from methanol as the solvent and beta-caryophyllene & alpha-pinene interactions (protein-ligand) were visualized by BIOVIA-DSV software.

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Table 5. GC-MS study of the methanolic extract of ripened *Morinda citrifolia* fruit.

Sl. No.	RT	Scan	Height	Area	Area %	Norm %	Compound		Mol. Wt.
							Hit	Name	
1	10.644	529	27,420,604	986,470.8	0.944	2.97	Hit-1	Cyclohexane, 1-Methylene-4-(1-Methylethenyl)	136
							Hit-2	Bicyclo[3.1.0]Hexane, 4-Methylene-1-(1-Methylethyl)-	136
							Hit-3	Cyclopenta[C]Pyran-1,3-Dione, 4,4A,5,6-Tetrahydro-4,7-Dimethyl-	136
							Hit-4	3-Carene	136
							Hit-5	Bicyclo[3.1.1]heptane, 6,6-Dimethyl-2-Methylene-, (1S)-	136
							Hit-6	Alpha.-Pinene	136
							Hit-7	Cyclopentene, 3-Isopropenyl-5,5-Dimethyl-	136
							Hit-8	Cyclohexane, 1-Methylene-4-(1-Methylethenyl)-	136
							Hit-9	Tricyclo[2.2.1.0(2,6)]Heptane, 1,7,7-Trimethyl-	136
							Hit-10	Cyclohexene, 4-Methylene-1-(1-Methylethyl)-	136
							Hit-11	Bicyclo[3.1.0]Hex-2-Ene, 4-Methyl-1-(1-Methylethyl)-	136
							Hit-12	(1R)-2,6,6-Trimethylbicyclo[3.1.1]Hept-2-Ene	136
							Hit-13	Beta.-Phellandrene	136
							Hit-14	Cyclohexane, 1-Methylene-4-(1-MethylethenyL)-	136
							Hit-15	Bicyclo[2.2.1]Heptane, 7,7-Dimethyl-2-Methylene-	136
							Hit-16	Beta.-Phellandrene	136
							Hit-17	Bicyclo[3.1.1]Heptane, 6,6-Dimethyl-2-Methylene-, (1S)-	136
							Hit-18	Tricyclo[2.2.1.0(2,6)]Heptane, 1,7,7-TrimethyL-	136
							Hit-19	Tricyclo[2.2.1.0(2,6)]Heptane, 1,3,3-Trimethyl-	136
							Hit-20	Bicyclo[3.1.0]Hexane, 4-Methylene-1-(1-Methylethyl)-	136
2	11.685	737	78,271,360	2,381,861	2.279	7.18	Hit-1	D-Limonene	136
							Hit-2	Limonene	136
							Hit-3	D- Limonene	136
							Hit-4	D- Limonene	136
							Hit-5	D-Limonene	136
							Hit-6	Limonene	136
							Hit-7	Cyclohexene, 1-Methyl-5-(1-	136

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								Methylethenyl)-, (R)-	
							Hit-8	Cyclobutane, 1,2-Bis(1-Methylethenyl)-, Trans-	136
							Hit-9	Limonene	136
							Hit-10	Cyclohexene, 4-Ethenyl-1,4-Dimethyl-	136
							Hit-11	Limonene	136
							Hit-12	Cyclohexene, 1-Methyl-4-(1-Methylethenyl)-, (S)-	136
							Hit-13	Cyclohexene, 1-Methyl-4-(1-Methylethenyl)-, (S)-	136
							Hit-14	1,5-Cyclooctadiene, 1,5-Dimethyl-	136
							Hit-15	Cyclohexene, 1-Methyl-5-(1-Methylethenyl)-	136
							Hit-16	Cyclobutane, 1,3-Diisopropenyl-, Trans	136
							Hit-17	Bicyclo[5.1.0]Octane, 8-Methylene-	136
							Hit-18	Bicyclo[6.1.0]Non-1-Ene	136
							Hit-19	Bicyclo[5.2.0]Non-1-Ene	136
							Hit-20	1,6-Cyclodecadiene	136
3	12.280	856	12,727,778	348,998.5	0.334	1.05	Hit-1	Gamma.-Terpinene	136
							Hit-2	Gamma.-Terpinene	136
							Hit-3	3-Carene	136
							Hit-4	Tricyclo[2.2.1.0(2,6)]Heptane,1,3,3-Trimethyl	136
							Hit-5	Cyclohexene, 4-Methylene-1-(1-Methylethyl)	136
							Hit-6	Gamma.-Terpinene	136
							Hit-7	Bicyclo[3.1.0]Hexane, 4-Methylene-1-(1-Methylethyl	136
							Hit-8	Cyclohexane, 1-Methylene-4-(1-Methylethenyl)	136
							Hit-9	Tricyclo[2.2.1.0(2,6)]Heptane, 1,3,3-Trimethy	136
							Hit-10	Beta.-Phellandrene	136
							Hit-11	Bicyclo[3.1.0]Hex-2-Ene, 4-Methyl-1-(1-Methylethyl)	136
							Hit-12	(+)-3-Carene	136
							Hit-13	3-Carene	136
							Hit-14	(1R)-2,6,6-Trimethylbicyclo[3.1.1]Hept-2-Ene	136
							Hit-	Alpha.-Pinene	136

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							15		
							Hit-16	Bicyclo[3.1.0]hex-2-Ene, 2-Methyl-5-(1-Methylethyl)	136
							Hit-17	Tricyclo[2.2.1.0(2,6)]Heptane, 1,7,7-Trimethyl	136
							Hit-18	Gamma.-Terpinene	136
							Hit-19	Tricyclo[2.2.1.0(2,6)]Heptane, 1,7,7-Trimethyl	136
							Hit-20	3-Carene	136
4	19.108	2221	21,902,950	815,041.9	0.780	2.46	Hit-1	Methyleugenol	178
							Hit-2	Methyleugenol	136
							Hit-3	Benzene, 1,2-Dimethoxy-4-Propenyl-, (Z)-	178
							Hit-4	Methyleugenol	178
							Hit-5	Methyleugenol	178
							Hit-6	2-Allyl-1,4-Dimethoxybenzene	178
							Hit-7	Benzene, 1,2-Dimethoxy-4-(1-Propenyl)-	178
							Hit-8	Methyleugenol	178
							Hit-9	Benzene, 1,2-Dimethoxy-4-(1-Propenyl)-	178
							Hit-10	Benzene, 1,2-Dimethoxy-4-(1-Propenyl)-	178
							Hit-11	Benzenepropanoic Acid, Ethyl Ester	178
							Hit-12	Benzenepropanoic Acid, Ethyl Ester	178
							Hit-13	3H-2-Benzopyran-3-Imine, 1,4-Dihydro-	147
							Hit-14	Benzene, 1,2-Dimethoxy-4-(1-Propenyl)-	178
							Hit-15	Benzenepropanoic Acid, Ethyl Ester	178
							Hit-16	2-Butanone, 3-Bromo-4-hydroxy-1,4-Diphenyl-	318
							Hit-17	Cyanamide, (Dimethyl phenyl phosphoranYlidene)-	178
							Hit-18	Phenol, 2-Methoxy-4-Methyl-6-[Propenyl]-	178
							Hit-19	Benzenemethanol, 2-Methyl-	122
							Hit-20	N,N'-DiphenethylthioUrea	284
5	19.888	2377	13,925,305	520,370.0	0.498	1.57	Hit-1	Caryophyllene	204
							Hit-2	Bicyclo[7.2.0]Undec-4-Ene, 4,11,11-Trimethyl-8-Methylene-,[1R-(1R*,4Z,9S*)]-	204
							Hit-3	Caryophyllene	204
							Hit-4	Bicyclo[7.2.0]Undec-4-Ene, 4,11,11-	204

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									Trimethyl-8-Methylene-,[1R-(1R*,4Z,9S*)]-
								Hit-5	Bicyclo[7.2.0]Undec-4-ENE, 4,11,11-Trimethyl-8-Methylene- 204
								Hit-6	Caryophyllene 204
								Hit-7	Bicyclo[5.2.0]Nonane, 2-Methylene-4,8,8-Trimethyl-4-Vinyl- 204
								Hit-8	Bicyclo[7.2.0]Undec-4-Ene, 4,11,11-Trimethyl-8-Methylene-,[1R-(1R*,4Z,9S*)]- 204
								Hit-9	Bicyclo[5.2.0]Nonane, 4-Methylene-2,8,8-Trimethyl-2-Vinyl- 204
								Hit-10	BICYCLO[7.2.0]UNDEC-4-ENE, 4,11,11-TRIMETHYL-8-METHYLENE-,[1R-(1R*,4Z,9S*)]- 204
								Hit-11	Aromandendrene 204
								Hit-12	Bicyclo[7.2.0]Undec-4-Ene, 4,11,11-Trimethyl-8-Methylene- 204
								Hit-13	(1R,9R,E)-4,11,11-Trimethyl-8-Methylenebicyclo[7.2.0]Undec-4-Ene 204
								Hit-14	11,11-Dimethyl-Spiro[2,9]Dodeca-3,7-Dien 190
								Hit-15	4,5,6,7-Tetrahydroindazole-3-Spirocyclohexane 190
								Hit-16	I-Propyl 7,10,13,16,19-Docosapentaenoate 372
								Hit-17	Alloaromadendrene 204
								Hit-18	10,10-Dimethyl-2,6-Dimethylenebicyclo[7.2.0]Undecane 204
								Hit-19	Aromandendrene 204
								Hit-20	1,11-Hexadecadiyne 218
6	20.869	2573	99,026,968	3,143,340	3.008	9.47	Hit-1	Hentriacontane	436
							Hit-2	Tritetracontane	604
							Hit-3	Heptadecane, 2,6,10,15-Tetramethyl-	296
							Hit-4	Carbonic Acid, DecylUndecyl Ester	356
							Hit-5	Carbonic Acid, Octadecyl Vinyl Ester	340
							Hit-6	Heneicosane	296
							Hit-7	Decane, 3,8-Dimethyl-	170
							Hit-8	Sulfurous Acid, Dodecyl 2-Ethylhexyl Ester	362
							Hit-9	Heneicosane	296
							Hit-10	Eicosane	282
							Hit-	DecylHeptyl Ether	256

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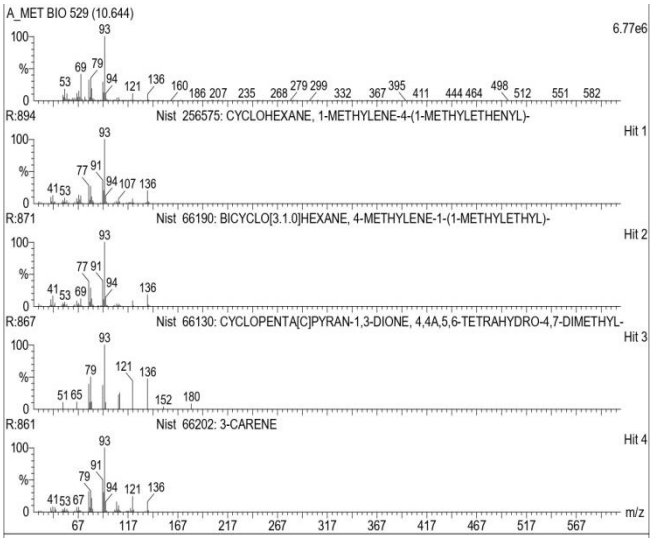
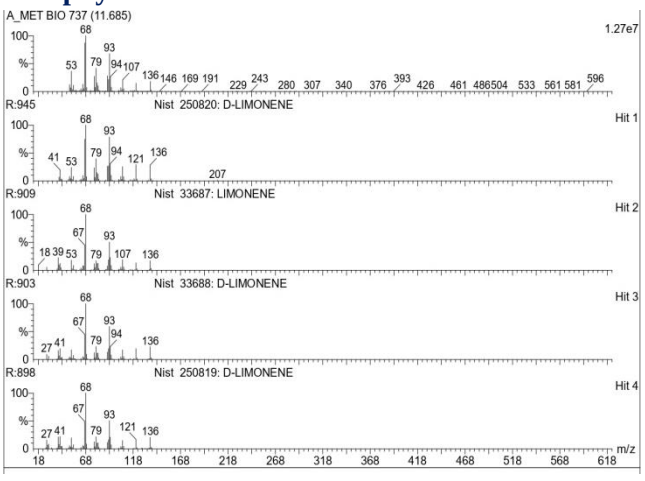
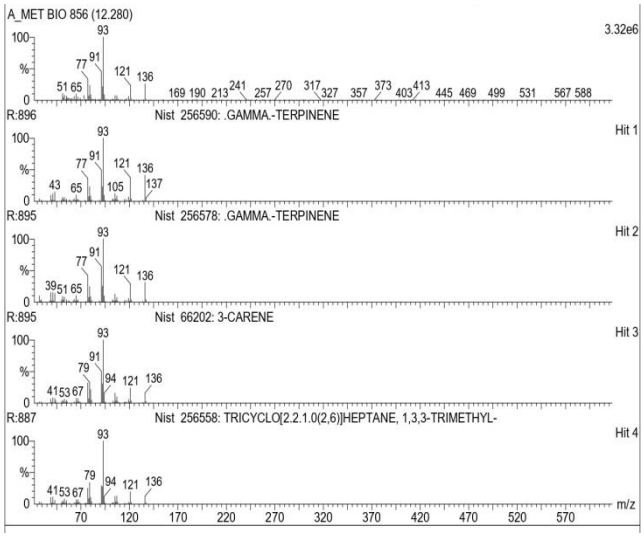
11		
Hit-12	Octadecane	254
Hit-13	Hexacosane	366
Hit-14	Heptadecane	240
Hit-15	2,6,10-Trimethyl Tridecane	226
Hit-16	Tetratetracontane	618
Hit-17	Nonadecane	268
Hit-18	EicosylHeptyl Ether	396
Hit-19	Dodecyl Heptyl Ether	284
Hit-20	Heptadecane, 7-Methyl-	254



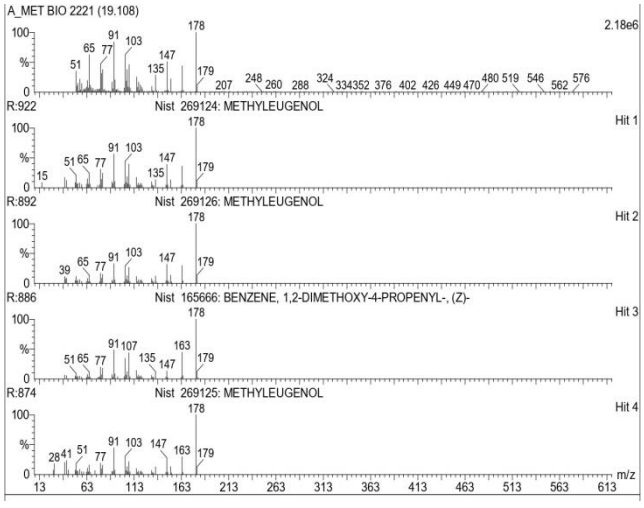
8(a). Retention time (RT, 10.644) and major phytochemicals.



8(b). Retention time (RT, 11.685) and major phytochemicals.



8(c). Retention time (RT, 12.280) and major phytochemicals.



8(d). Retention time (RT, 19.108) and major phytochemicals.

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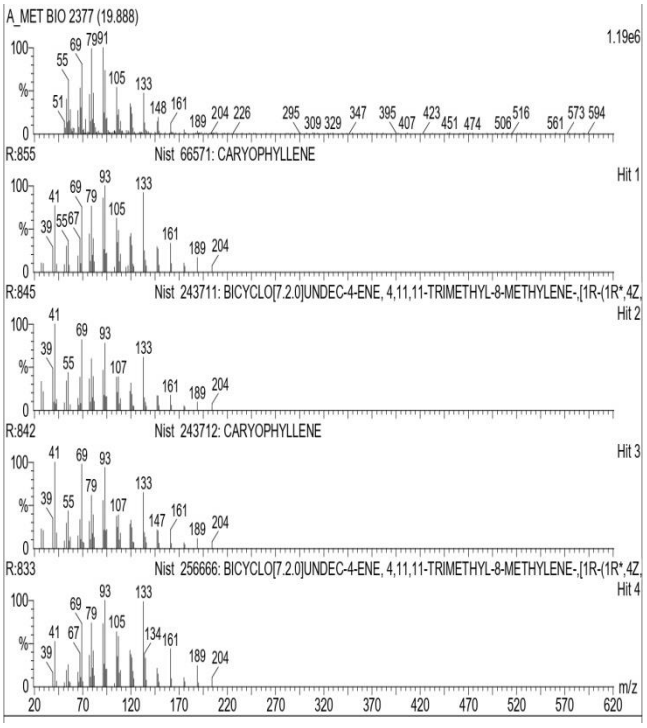
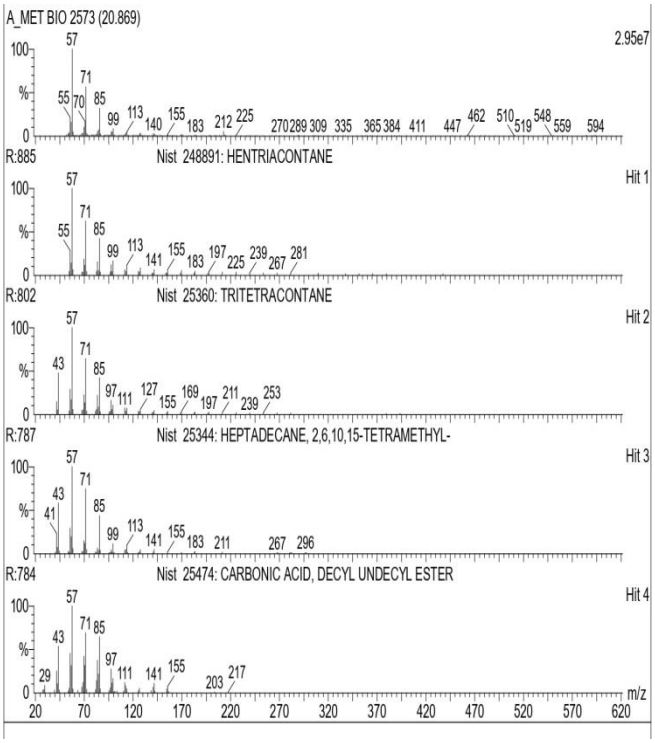


8(e). Retention time (RT, 19.888) and major phytochemicals.



8(f). Retention time (RT, 20.869) and major phytochemicals.

The biomass in this situation has a swelling index of 1.535±0.022% (Table 3 & Figure 2). Since of this, the biomass is more susceptible to the action of antibacterial agents because it contains less moisture. As a direct consequence of this, it can be utilized as a source of energy.

NFs have the potential to be a neutraceutical, an energy drink, and a food supplement, according to proximate analysis. A significant class of naturally occurring organic compounds necessary for maintaining and supporting life in plants and animals and providing raw materials for many industries include volatile matter, ash content, fixed carbon (carbohydrate contents), and greater heat value. The NFs are a good carbohydrate source because they satisfy the RDA requirements. The ash content indicates the quantity of mineral components found in the samples. Mineral content in the NFs was average. In addition to the foregoing, the volatile matter content and proximate analysis both demonstrated importance in delivering health advantages linked to their nutritional composition (McKendry, 2002; Naqbi et al., 2022).

The ultimate evaluation is described as the determination of carbon, hydrogen, nitrogen, and sulfur in a wide variety of organic and inorganic materials, both solid and liquid. This sort of analysis can be performed on both organic and inorganic substances. Since the ratio of oxygen, hydrogen, and nitrogen indicates a significant result, it is reasonable to believe that the given biomass has a high concentration of phenolic compounds due to the significance of the result. It is reasonable to presume that a significant quantity of volatile chemicals is present when there is a high phenolic content. As a consequence, biomass not only has greater antibacterial qualities but also is a more trustworthy energy source. The key criteria that determine the amount of energy that can be salvaged from a lost source are the atomic proportions of oxygen to carbon and hydrogen to carbon (Milne et al., 1992). A greater proportion of carbon to oxygen in the biomass results in a higher heating value, which in turn allows for a greater amount of energy to be recovered. This is due to the fact that the elemental ratios have a negative relationship with the amount of energy contained in biomass.

Lignin, cellulose, extractive contents and hemi-cellulose are the primary components that make up the secondary wall, which develops after the primary wall of the plant cell has finished growing. Only certain types of plant cells have secondary or inferior, walls that provide additional support, protection, or water conductivity. The basic cell wall is made up of a few layers and is regarded as a structure with a fair amount of flexibility. On the other hand, the secondary cell wall is stiffer due to its thicker and more organized cellulose structures. Near the plasma membrane, cellulose fibrils are directly synthesized, whereas the matrix polysaccharides are formed enzymatically by glycosyl transferase processes.

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Cellulose fibrils are the primary structural component of eukaryotic cells. In its fibril state, cellulose comprises a bundle of very fine elementary fibres organized in a matrix together with additional polysaccharides and lignin. The NFs biomass has strong antibacterial capabilities and can be used for energy recovery, as evidenced by the substantial quantity of extractable lignin, cellulose, and hemicellulose. Furthermore, biomass has significant antibacterial capabilities and can be utilized for energy recovery (Mothé and de Miranda, 2009).

Crystallinity, isomorphous substitution, and particle size can all be measured using XRD, an analytical method widely used for analyzing molecular and crystal structures. It is also a qualitative identifier of active compounds, a qualitative resolution of different molecules, and a method that can measure crystallinity. When X-ray radiation is reflected on any particles, it causes a multitude of diffraction peaks to be created. These peaks represent the physicochemical features of the crystalline lattice (Bar et al., 2009). The arrangement of the diffraction peaks is an extremely important factor to consider when determining the properties of these materials.

The components of cellulose and hemicellulose may be observed at 2Θ between the values of 20 and 25 in the XRD graph. These components are located in the middle of the graph. The powder X-ray diffraction (XRD) examinations showed that the NFs samples treated to the greatest possible temperature exhibited a unique lattice expansion. The lines became less thick and more distinguishable as the temperature continued to rise. The XRD lines in these patterns correspond to the lines of naturally occurring crystalline cellulose and hemicellulose components, as was determined by comparison with the XRD database.

FTIR analysis was utilized to determine the identities of the various biomolecules found in NFs. The FTIR spectroscopy analyses showed that the extracts contained a wide variety of functional chemicals, each of which had a distinctive characteristic peak value. The FTIR procedure was carried out on a spectrophotometer system, which identified the characteristic peak values and the functional groups associated with them. The Fourier transform infrared spectroscopy (FTIR) can provide precision, reproducibility, and a strong transmission ratio, in addition to determining whether or not biomolecules are actively coupled to one another. The presence of peaks demonstrates that secondary metabolites of plants, including flavonoids, terpenoids, phenols, glycosides, and tannin function groups, including aldehydes, ketones, carboxylic acid, and so on, are present. The majority of the significant peaks that were identified at 2400 cm^{-1} are due to O=C=O stretching, which was observed in the NFs methanol extract, which showed typical absorption bands. On the other hand, the stretching vibrations of C-O stretching (primary alcohol), O-H bending (carboxylic acid), N-H bending (alkene), C-H stretching (alkane), and O-H stretching (alcohol/phenol) are responsible for the wavelengths 1050-1085 cm^{-1}, 1395-1440 cm^{-1}, 1580-1650 cm^{-1}, 2840-3000 cm^{-1}, and 3200-3550 cm^{-1}, respectively. The presence of a variety of functional groups in the various extracts most likely indicates the existence of carbohydrates, carotene, glycogen, amino acids, amides, starch, calotropin, calotropogenin, phosphates, lipids, glycogen, cellulose and hemicellulose.

The findings of the GC-MS analysis on the methanol extract of *M. citrifolia* fruit are presented in table 5, along with figures 6 and 7. The result part includes a discussion of the most important chemicals, interactions, and the biological validations of those compounds.

Conclusion

M. citrifolia, also known as noni, is a plant with a very high value in many application areas. Currently, the food, chemical, and pharmaceutical industries use *M. citrifolia*. Fruit from *M. citrifolia* L. is not suited for fresh consumption due to its bitter flavour and pronounced rotten flavour. *M. citrifolia* has been employed as a medication for both the general upkeep of good health and the avoidance of several illnesses, including those affecting the skin, brain, GIT, heart, liver, and cancer. A phytochemical investigation was conducted after the ripened NFs extracts solubility test revealed polarity and antipolarity properties as indicator components.

The therapeutic qualities of ripened noni fruits may be considerably influenced by the presence of anthraquinone, cardiac glycosides, flavonoids, phenolic compounds, saponin, tannins, terpenoids, and starch. The risk of cancer, blood glucose response, and blood cholesterol levels are all decreased by saponins. Clinical investigations are now looking into terpenoids-based anticancer medications. Ripened NFs contain more than 100 substances that have biological activity that has been established. Our research has been published for the first time to examine the validity of beta-potential caryophyllene's for pain relief.

The therapeutic qualities of noni fruits may be considerably influenced by the presence of anthraquinone, cardiac glycosides, flavonoids, phenolic compounds, saponin, tannins, terpenoids, and starch.

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Cancer risk, blood glucose response, and blood lipid levels are all decreased by saponins. Clinical investigations are now looking into terpenoids-based anticancer medications. M. Citrifoli contains more than 100 substances that have biological activity that has been established. Our research has been published for the first time to examine the validity of beta-potential caryophyllene's for pain relief. Our extensive field research before the laboratory analysis made it possible for us to do this. Some of the substances that are present in the ripened fruits of *M. citrifoli* include germacrene-D, beta-caryophyllene, 1-epi-cubenol, alpha-pinene, camptothecin, and delta-cadinene. Antioxidant, antibacterial, anticancer, anti-inflammation in the brain and actions related to oxidative stress have all been demonstrated for these substances.

Our investigation confirms the bioactive potential of ripened NFs as a substitute pharmaceutical source. Drugs called cardiac glycosides are used to treat some heart irregularities and heart failure. These meals reduce the risk of many chronic diseases, including cancer, cardiovascular disease (CVD), and neurological disorders. In order to identify the bioactive compounds in this plant that may one day be used to develop biopharmaceuticals against infectious diseases and a source of antioxidants, spectroscopic characterization techniques such as FTIR, XRD, and proximate, ultimate, and compositional analysis have been used to confirm the existence of ripened NFs. The several components of *M. citrifolia* that were found through GC-MS research have been employed as medicines to promote health and treat some ailments. Phytochemicals found in *M. citrifolia* have immune-boosting, antiviral, antifungal, and antibacterial properties. Therefore, this research paper aims to present thorough information on *Morinda citrifolia*, describing both its traditional use and modern developments in the processing and standardization of noni fruit-derived products.

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Conflict of Interest

The authors declare no conflict of interest.

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