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PHYTOCHEMICAL SCREENING AND SPECTROSCOPY ANALYSIS OF JACKFRUIT (*Artocarpus integer* Thumb.) PEEL

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ABSTRACT

Ethanolic and methanolic extracts of Jackfruit peels (Artocarpus integer) were investigated. The phytochemical screening revealed that the presence of alkaloids, flavonoids, carbohydrates, proteins and triterpenoids the active compounds. The Gas Chromatography-Mass Spectroscopic analysis of various extracts like ethanol and methanol identified the presence of various phytochemical compounds and secondary metabolites like Hexadecanoic acid, Squalene, Calophyllolide, Thialisopyine and so on. Nuclear Mass Resonance Spectroscopy showed the presence of Alkyl group and carbon bearing OH group compounds. Atomic Absorption Spectroscopy of peel indicated the presence of major minerals like calcium, potassium and other minor minerals. All these findings implied the availability of various active and phytochemical compounds and also some minerals from the peel. It might be the potential resources for the development of the antioxidant function of dietary foods.

Keywords: Phyto-chemical, Jackfruit, Artocarpus, Spectroscopy, Compounds.

INTRODUCTION

Plants are always a rich source of compounds that don't appear essential for primary metabolism, together with thousands of secondary metabolites and several macromolecules, such as peptides, proteins, enzymes, lignin and cellulose (1). Phytochemicals are compounds that act as the free radical scavengers to assist eliminate the highly charges oxygen molecules that are byproducts of metabolized oxygen (2), and are believed to supply various health advantages (3). The consumption of a plant-based or phytochemical-rich diet has been associated with a reduced risk of chronic human health problem such as certain types of cancers, inflammation, cardiovascular and neurodegenerative diseases (4).

"The Jackfruit are such large and interesting fruits and trees thus well behaved that it's difficult to explain the general lack of knowledge concerning them''(5). Jackfruit is a dicotyledonous compound fruit of the jack tree (A*rtocarpus heterophyllus*) which belongs to the family *Moraceae* grow in several of the tropical countries of Southeast Asia but is particularly abundant in Republic of India and Bangladesh (6). In South India, Jackfruit fruit production is higher than any other fruit. Hence significant the amount of peel is expected to be discarded as agricultural waste (7). The outer peel, that is usually fibrous and fairly rich in calcium and pectin, constitutes about 59% of the ripe fruit (8). Jackfruit was originally from India and spread out into tropic regions, including Indonesia (9). The marketplace for natural additives and ingredients is rapidly growing with some natural products obtaining high costs (10). The purpose of this work is to research the phytochemical screening, Gas Chromatography Mass Spectroscopic analysis of peel and other properties like Nuclear Mass Resonance Spectroscopy and Atomic Absorption Spectroscopy.

MATERIALS AND METHODS

Raw material collection

Mature Jackfruit was collected from the local market of Pudukkottai (district), TamilNadu, India. It was identified as A*rtocarpus integer* ((Thumb.). Merr. - Moraceae). Plant species authentication was done at Botanical Survey of India (BSI), Coimbatore, South India (Ref no. BSI/SRC/5/23/2013- 14/Tech/1714).

Preparation of Jackfruit peel powder

Jackfruit was peeled manually to discard the edible part including the seeds. The peels were cut into smaller pieces and treated according to the method reported by (11). The treated jackfruit peels were then washed with boiling water and pressed to remove excess amount of water. Subsequently, the Jackfruit peels were dried in a Cross Flow Dryer at 65ºC for 8 hours. The dried peels were grounded and packed in polyethylene bags and stored at room temperature.

Preliminary Phytochemical Screening

The methods used for detection of various phytochemical were followed by a qualitative chemical test to give the general idea regarding the nature of constituents present in the peel.

Preparation of Plant extracts (Ethanolic and Methanolic extract) from Jackfruit Peel

The powdered sample (approx. 50 gm.) were then packed in the soxhlet apparatus and extracted with 95% Ethanol and Methanol for eight to twelve hours (12). After the extraction was completed, the extracted powder was discarded and also the ethanol and methanol extract for further process. The excess solvent in the extract was removed by distillation and the concentrated extract so obtained was further dried under reduced pressure at a temperature not exceeding 40°C in a rotary evaporator. The extract was then collected (extractive value 10gm), kept in Petri dish and stored in the refrigerator. The condensed extracts were used for preliminary screening of various phytochemicals like in the presence of Steroids, Glycosides, Flavonoids, Tannins, Carbohydrates and so on.

Test for Steroids and Triterpenoids

Liebermann's Burchard test - Crude extract was mixed with few drops of acetic anhydride, boiled and cooled. Concentrated sulphuric acid was then added from the edges of the tube and observed for the formation of a brown ring at the junction of two layers. Green coloration of the upper layer and the formation of red colorize the lower layer would indicate a positive test for steroids and triterpenoids respectively (13).

Salkowski Test - 2ml of crude extracts, 2ml of chloroform and 2ml of concentrated sulphuric acid was added. The solution was shaken well. As a result chloroform layer turned red and acid layer showed greenish yellow (14).

Test for Glycosides

Borntrager's Test - 3ml of crude extracts, dilute sulphuric acid was added. The solution was then boiled and filtered. The filtrate was cooled and added an equal volume of benzene. The solution was shaken well and also the organic layer was separated. An equal volume of dilute ammonia solution was added to the organic layer. The ammoniacal layer turned pink showing the presence of glycosides (14).
Keller - Killiani Test - Test solution was treated with few drops of glacial acetic acid and ferric chloride solution and mixed. Concentrated sulphuric acid was added and observed for the formation of two layers. Lower reddish brown layer and the upper acetic acid layer which turns bluish green would indicate a positive test for glycosides (14).

Test for Saponins

Foam Test - Test solution was mixed with water and shaken and observed for the formation of froth, which is stable for ten minutes for a positive result (15)

Test for Alkaloids

Hager's Test - Test solution was treated with few drops of Hager's reagent. Formation of yellow precipitate would show a positive result for the presence of alkaloids (16).
Mayer's Test - To the 3ml of filtrate Mayer's reagent was added. Formation of yellow precipitate showed the presence of alkaloids (15).

Test for Flavonoids

Ferric Chloride Test - When the solution was treated with few drops of Ferric chloride solution would result in the formation of blackish red color indicating the presence of flavonoids (17).
Alkaline reagent Test - Test solution when treated with sodium hydroxide solution, shows an increase in the intensity of yellow color which might become colorless with the addition of few drops of dilute hydrochloric acid, indicates the presence of flavonoids (18).
Lead acetate solution Test - Test solution when treated with few drops of lead acetate (10%) solution would result in the formation of a yellow precipitate (18).

Test for Tannins and Phenolic compounds

Gelatin Test - When the solution was treated with gelatin solution would give white precipitate indicating the presence of tannins (18).
Ferric Chloride Test - On addition of five percent Ferric Chloride solution to the crude extract, the deep blue color appeared (19).
Lead acetate Test - On addition of lead acetate solution to the crude extract white precipitate appeared (14).
Dilute Nitric acid Test - On addition of the dilute nitric acid solution to the crude extract, the reddish color appeared (14).

Test for Proteins

Biuret Test - Test solution was treated with 10% sodium hydroxide solution and two drops of 0.1% copper sulphate solution and observed for the formation of violet/pink color (18).
Xanthoproteic Test - To the little amount of crude extract, 1ml of concentrated sulphuric acid was added. This resulted in the formation of a white precipitate which on boiling turned yellow. On addition of ammonium hydroxide, yellow precipitate turned orange (14).

Test for Carbohydrates

Fehling's Test: 1 ml. Fehling's A solution and 1 ml. of Fehling's B solution were mixed and boiled for one minute. Now the equal volume of test solution (crude extract) was added to the above mixture. The solution was heated in boiling water bath for 5-10 minutes. First a yellow, the brick red precipitate was observed (20).

Gas Chromatography Mass Spectroscopy Analysis

The volatile components of various extracts from jackfruit peel were analyzed using Thermo MS DSQ II (DB 5 - MS Capillary Standard Non - Polar Column for Methanol extract and ZB 5 - MS Capillary Standard Non - Polar Column for Ethanol extract), injector and oven temperature was 70°C raised to 260°C. The heating rate was programmed at 6°C/minutes. The injection was performed in the split ratio of 260 and the volume was 1µL. The flow of carrier gasses was maintained 1.0ml/minutes throughout the run.

The identification of the compounds was performed by similarity searches and mass spectra data in the NIST (National Institute of Standard and Technology) MS Search 2.0 Library
(20). The quantification of components was done by relative peak areas calculation. Relative peak areas were divided the peak area for the compound by the total peak areas for the entire compounds detected and expressing this value as the percent.

Characterization of Jackfruit peel Powder Nuclear Mass Resonance Spectroscopy (NMR)

^{13}C-NMR plays a vital role in deciding the structure of unknown organic molecules, reactions, and processes. ^{13}C-NMR to help you solve structures of unknown organic compounds. Samples of 15 mg were dissolved in 0.5 mL Dimethyl sulfoxide (NMR ^{13}C: 1mg in a 1mL solvent) and NMR spectra were recorded on a Bruker Avance 500 MHZ spectrometer equipped with a quadruple nucleus probe at room temperature for ^{13}C (21). Chemical shift δ were expressed in ppm by frequency.

Atomic Absorption Spectroscopy (AAS)

The major and minor minerals present in the jackfruit peel was carried out in an Atomic Absorption Spectrophotometer (Agilent Technologies 200 series AA), equipped with a graphite furnace (22).

RESULTS AND DISCUSSIONS

Phytochemical Screening

The various extracts of peel have revealed the presence of saponins, tannins, proteins and carbohydrates. Glycosides were found to be absent in all the extracts. From this analysis, ethanolic extract of peel was found to have more constituents compared to methanolic extract. The results of preliminary phytochemical screening tests of each extract of peel presented in Table 1. The preliminary phytochemical screening tests might be useful in the detection of bioactive principles and revealed the presence of flavonoids, tannins, carbohydrate, saponins, alkaloids, tannins, triterpenoids, proteins in the peel extract. Further, the presence of different phytoconstituents in the two different extracts might be responsible for the therapeutic properties (23).

Table 1: Phytochemical screening for various extracts of Jackfruit peel

S.No	Chemical Tests	Peel extract	
		Ethanol	Methanol
1.	**Tests for Steroids and Triterpenoids:**		
	• Liebermann's Burchard Test	✓	•
	• Salkowski Test	•	•
2.	**Test for Saponins:**		
	• Foam Test	✓	✓
3.	**Tests for Alkaloids:**		
	• Hager's Test	•	•
	• Mayer's Test	✓	✓
4.	**Tests for Glycosides:**		
	• Borntrager's Test	•	•
	• Keller Killiani Test	•	•
5.	**Tests for Tannins and Phenolic compounds:**		
	• Gelatin Test	•	•
	• Ferric Chloride Test	✓	✓
	• Lead Acetate Test	✓	✓
	• Dilute Nitric acid Test	•	•
6.	**Tests for Flavonoids:**		
	• Ferric chloride Test	•	•
	• Alkaline reagent Test	✓	✓
	• Lead acetate Test	•	•
7.	**Tests for Proteins:**		
	• Biuret Test	✓	✓
	• Xanthoproteic Test	•	•
8.	**Test for Carbohydrates:**		
	• Fehling Test	✓	✓

Alkaloids are commonly found to have antimicrobial properties
(24). Flavonoids and tannins are phenolic compounds and plant phenolics are a major group of compounds acts as primary antioxidants (18). Tannins are reported to prevent the growth of the many molds, yeasts, bacteria, and viruses are inhibited by tannins (25). Since these compounds were found to be present in the extracts, it might be responsible for the antioxidant capacity of Jackfruit peel. The secondary metabolites and other chemical constituents were presented in Jackfruit peel. Since the whole peel extracts contain the various constituents and had the number of bioactive compounds. The preliminary phytochemical tests are helpful in finding chemical constituents in the plant material that may lead to their quantitative estimation (18). Indeed, a suitable extracting procedure should be developed and improved to recover as many antioxidants as possible before an extract rich in natural antioxidants could be further explored for possible application in health - promoting supplements for the food industry (26).

Gas Chromatography Mass Spectroscopy Analysis (GC - MS)

The results of the GC - MS analysis of various extracts (ethanol and methanol)identified the various compounds present in the peel.

Ethanol Extract

The major compounds present in the ethanolic extract of peel as identified by GC - MS was Hexadecanoic acid (CAS) with 23.95 (retention time) and 21.90 % relative peak area was the highest followed by Squalene with 38.36 RT (retention time), and 16.34 % relative peak area is shown in fig. 1and other various compounds present in the Jackfruit peel powder (Table 2).
Hexadecanoic acid (CAS) is the most common saturated fatty acid found in animals, plants, and microorganisms (27). According to the WHO, the evidence is 'convincing' that consumption of Hexadecanoic acid will increase risk of developing cardiovascular diseases (28) supported studies indicating that it may increase LDL levels in the blood.
Squalene is a hydrocarbon, triterpenoid compound, is a natural and very important a part of the synthesis of all plant and animal sterols, as well as cholesterol, steroid hormones, and vitamin D in the human body. Squalene is used in cosmetics and recently used as an immunologic adjuvant in vaccines (29). Squalene has been proposed to be a crucial part of the Mediterranean diet, because it may be a chemopreventive substance that protects people's from cancer (30).

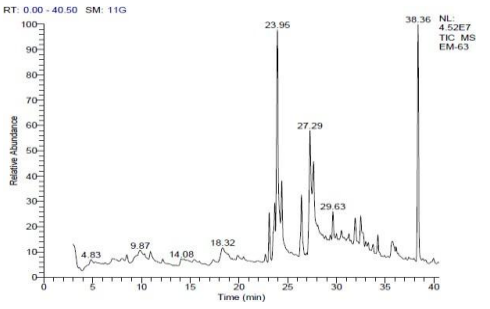


Figure 1: Relative peak areas of ethanolic extract from Jackfruit peel

Some of the other compounds are also identified from the ethanolic extract of peel; Cyclopropaneotanic acid, 2-[(2-(2-ethycyclopropyl)methyl)]-methylester (CAS) (RT - 27.29 and 12.54 % peak area), Ethyl linoleate (RT - 27.65 and 6.40 % peak area), Methyl, 8,11,14 - heptadecatrienoate (RT - 26.11 and 5.40
% peak area), Acetonitrile, isothiocyanate-(RT - 35.72 and 98 % peak area) and so on. The activities of some phytochemicals with compound nature of flavonoids, palmitic acid (hexadecanoic acid) as antimicrobial, antioxidant hypochlolesteremia, cancer preventive, hepatoprotective and anti-coronary (31).

Table 2: List of Volatile compound in Jackfruit peel ethanol extract

RT (Retention time)	Compound Name	Molecular Formula	Molecular Weight	Area (%)
4.85	2-n-Butylmercapto-2-imidazoline	$C_7H_{14}N_2S$	58	0.57
7.02	1,-(3-Nitrophenylsufonyl)-2-phenylethylene	$C_{14}H_{11}NO_4S$	289	1.00
8.03	2-[(z)-But-z-en-1-yl]benzyl alcohol	$C_{11}H_{14}O$	162	0.51
8.50	Naphthalene (CAS)	$C_{10}H_8$	128	0.82
9.85	(E)-2-[N-hydroxy-N-phenylo-amino]-3-[N-(phenylamino)]-indole	$C_{22}H_{19}N_{30}$	341	3.22
14.08	O-Dithiane-3-carboxylic acid	C5H8O2S2	162	1.89
17.36	1,4-Diphenyl-2-Butene	C16H16	208	0.63
18.32	Eicosane,2-methyl-	C21H44	296	3.44
19.87	L-Mannitol,1-deoxy-,cyclic3,4-(ethyl boronate)2,5,6-triacetate	C14H23BO8	330	0.53
22.70	Methylhexadec-9-enoate	C17H32O2	268	0.67
23.11	Hexadecanoic acid methyl ester	C17H34O2	270	3.17
23.95	Hexadecanoic acid (CAS)	C16H32O2	256	21.90
24.39	Hexadecanoic acid, ethyl ester (CAS)	C18H36O2	284	2.90
26.41	Methyl,8,11,14-heptadecatrienoate	C18H30O2	278	5.40
27.65	Ethyl linoleate	C20H36O2	308	6.40
30.51	Eicosane,7-hexyl-	C26H54	366	1.08
31.28	Tetradeanal (CAS)	C14H28O	212	0.83
31.91	Octadec-9-Enoic acid	C18H34O2	282	2.43

32.48	Hexadecanoic acid,2-hydroxy-1-(hydroxy methyl)ethyl ester	C19H38O4	330	3.31
34.23	Betulin	C30H50O2	442	1.44
35.72	Acetonitrile, isothiocyanato-	C3H2N2S	98	3.47
32.41	14-Oxonodec-10-enoic acid, methyl ester	C20H36O3	324	0.48
38.36	Squalene	C30H50	410	16.34
39.95	Phosphonothio acid, methyl-s-butyl-ethyl ester (CAS)	C7H17O2PS	196	0.64

Methanol Extract

The major compounds present in the methanolic extract of peel as identified by Gas Chromatography - Mass Spectroscopy was Calophyllolide with 34.14 RT (retention time), and 38.64 % relative peak area is shown in fig. 2 and other various compounds present in the Jackfruit peel powder (Table 3). Calophyllolide has been reported to exhibits some biological activity, including lower capillary vascular permeability (32), anti -cancer (33) and anti - coagulant (34) properties. Some of the other compounds were also identified from the methanolic extract of Jackfruit peel powder; Thialisopyine with (37.86 RT and 10.28 % relative peak area) A-D-glycopyranose,4-O-a-D-galactopyrosyl (RT - 6.82 and 19.99 % peak area), (+ -) lnophylum D (RT - 36.30 and 6.40 % peak area), 9-octadecannamide (CAS) (RT - 38.94 and 5.04 % peak area), 1,2-cyclopentanedione (RT - 5.00 and 3.93 % peak area), and so on.

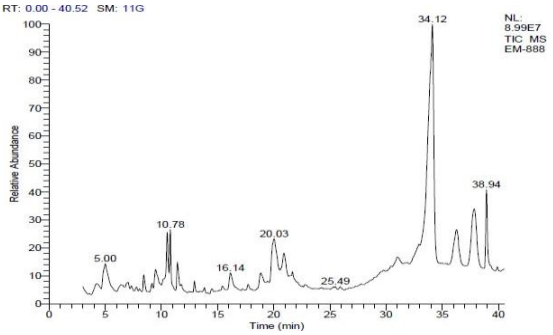


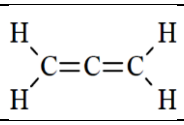
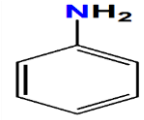
Figure 2: Relative peak areas of Methanolic extract from Jackfruit peel Table 3: List of Volatile compounds in Jackfruit peel ethanol extract

RT (Retention time)	Compound Name	Molecular Formula	Molecular Weight	Area (%)
4.24	6-(2,2,5-trimethyl-(1,3)dioxan-4-yl)-hepta-2,4-dienoic acid, methyl ester	C15H24O4	268	1.58
5.00	1,2-Cyclopentanedione	C5H6O2	98	3.93
6.38	1,2-Octanediol	C8H18O2	146	0.80
7.04	2,2,dimesityl-2Silatetracyclo)7.6.0.0.(3,8).0(10,15) hexadecadodeane	C3H32Si	444	0.77
8.42	4H-pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl	C6H8O4	144	1.05
9.18	Cycloheptasiloxane, tetradeca-methyl	C14H42O7Si7	518	0.53
9.48	Hydrozine,(1-methylethyl)	C3H10N2	74	1.86
23.11	Hexadecanoic acid methyl ester	C17H34O2	270	3.17
11.42	N,2,3-trimethyl-1,4-thiazone-s-dioxide	C7H15NOS	161	1.67
12.94	Cyclohexanol, 2-(dimethylamino)-cis	C8H18O2	143	0.61
13.84	3,4-dihydro-2H-1,5-(3"-t-butyl)benzodioxepene	C13H18O2	206	0.44
14.45	Cyclononasiloxane, octa Deca methyl	C18H54O9Si9	666	0.30
16.14	2-vinyl-5-methoxy-2,3-dihydrobenzofuran	C11H12O2	176	1.83
17.71	Piperdine, 1-methyl-(CAS)	C6H13N	99	0.40
18.81	1,2-hexanediol,1,2-diphenyl	C18H22O2	270	1.48
19.99	AD-glycopyranose,4-O-a-D-galactopyranosyl	C12H22O11	342	6.82
20.91	Pregan-5-ene-12,20-dione,3,4,15-trihydroxyl-(3a,14a,15a)	C21H30O5	362	2.88
21.68	Hexadecanoic acid, methyl ester	C17H34O2	270	0.89
25.49	Heptadecanoic acid, 9-methyl-methylester (CAS)	C19H38O2	298	0.42
31.00	Benehexaethanol, hexaacetate	C30H42O12	594	1.29
34.14	Calophyllolide	C26H24O5	416	38.64
36.30	(+ -) lnophylum D	C25H24O5	404	6.40
37.86	Thialisopyine	C21H25NO5	371	10.28
38.94	9-octadecanaamide (CAS)	C18H35NO	281	5.04

Fruits and vegetables are most popular due to their nutritional value worldwide and rich sources of beneficial anti-oxidants, minerals, vitamins and fibers (35). By-products of Jackfruits aren't the only good source of bioactive compounds but also could be used as several value-added products (36). Phenolic compounds are secondary metabolites ubiquitous in plants and plant derived foods and beverages (37). It acts as a vital part of the human diet, a dare of considerable interest due to their inhibitor properties.
Many phenolic compounds have antioxidant properties. Phenolic compounds can be used as ingredients in pharmaceuticals, nutraceuticals and food (38). Flavonoids are polyphenolic compounds present in plants as secondary metabolites and also have antioxidant activity.

Nuclear Mass Resonance Spectroscopy (NMR)
The Nuclear Mass Resonance data displayed the six carbon atoms of the aromatic ring, methylene group side chain, carbon bearing OH group and the methylamino group, were all diagnostic for phenyl ethyl amine moiety, containing a hydroxyl group at the para position of the aromatic ring present in Table
4. The ^{13}C Nuclear Mass Resonance spectrum of Jackfruit peel powder is shown in figure 3. Chemical shifts were expressed in δ (ppm).

Table 4: List of various chemical compounds and assignments present in Jackfruit peel

Compounds	Assignments	ppm (Chemical Shift)	Carbon Environment	Functional Group
n- Butylamine	$CH_3CH_2CH_2CH_2NH_2$	δ42.18	Alkyl Chlorides (RCH_2Cl); (40 - 45 ppm)	Alkyl group and Sp3 Hybridization
Methoxide	CH_3O	δ59.43 δ59.60	Methanamine or amide (RCH_2NH_2); (30 - 65ppm)	Alkyl or Aryl group and Sp3 Hybridization
Methyl ether Methanol	Me_2O CH_2OH	δ61.22 δ62.21 δ62.73	Primary Alcohol (RCH2OH); (60 - 70 ppm)	Carbon bearing OH group and Sp3 Hybridization
Methylene	CH2	δ66.40	Alkynes *(R-C≡C-R);* *(65 - 85 ppm)*	Alkyl group and Sp3 Hybridization
2-Methyl-2-Propanol	Me_3COH	δ70.29 δ70.32	Primary Alcohol (RCH2OH); (60 - 70 ppm)	Carbon bearing OH group and Sp Hybridization
1, 2-dimethoxyethane	$CH_3OCH_2CH_2OCH_3$	δ71.61 δ72.98	Alkynes *(R-C≡C-R);* *(65 - 85 ppm)*	Alkyl group and Sp Hybridization
tertbutyl methyl ether	(CH3)3COCH3	δ73.29		
1,2-propene		δ74.23 δ74.60 δ74.80		
Hexane	CH3[CH2]4CH3	δ127.91	Trans - Alkene (RCH=**C**HR); (120 - 140 ppm)	Alkyl (or aromatic) group attached to a carbonyl function and Sp2 Hybridization
Nitrile	R—C≡N	δ145.31	Aromatic Rings C (125 = 150 ppm)	Alkyl or aromatic group and Sp2 Hybridization
Carboxylic amides		δ164.09	Amide($RCONR_2$); (160 - 180 ppm)	Alkyl or aromatic group and Sp2 Hybridization
Carboxylic acids	O ‖ /C\		Carboxyl(R**C**OOH); (160 - 180 ppm)	
Ketones	O ‖ /C\ R R	δ197.51	Carbonyl (R**C**OR'); (190 - 205 ppm)	Alkyl or aromatic group and Sp2 Hybridization
Aldehydes	O ‖ /C\ R H		Aldehyde (R**C**HO); (190 - 205 ppm)	

(Ref; (39); (40); (21) - Identification of various compounds in ^{13}C NMR).

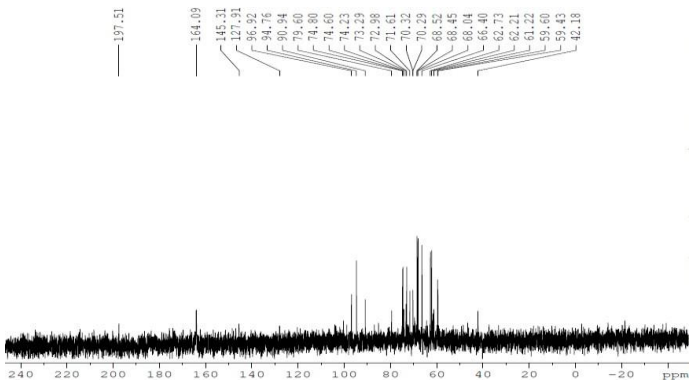


Figure 3: Nuclear Mass Resonance Spectroscopy analysis of Jackfruit Peel

Atomic Absorption Spectroscopy

The elemental content of peel is given in Table 5. The mineral content showed that the higher concentration of calcium (Ca) was present as 30.45 ppm.

According to (41), the proportion of calcium immersed depends on the total quantity of elemental calcium devoted at one time; as the quantity increase, the proportion absorption decrease. Incorporation is highest doses ≦ 500 mg. The concentration of aluminum (Al) present in the peel was found to be 2.16 ppm. According to (42) established a PTWI (Provisional Tolerable Monthly Intake) for Al of 1 mg/kg BW (body weight) for all aluminum compounds in food, including additives; previously established ADIs and PTWI for aluminum compounds were withdrawn. The JECFA (Joint FAO/WHO Expert Committee on Food Additives) concluded that aluminum compounds have the potential to affect the reproductive system and developing the nervous system at doses lower than those used in establishing the previous PTWI. The JFAO also noted that dietary exposure to Al is expected to be very high for infants fed on soya-based formula. The concentration of iron (Fe) in the peel was found to be 4.2 ppm. The permissible limit set by FAO/WHO in edible plants or fruits 20 ppm (43). Fe is necessary for the formation of haemoglobin and also plays an important role in other metabolic functions. The Provisional Tolerable Monthly Intake (PTWI) of 0.8mg/kg body weight (BW) body weight applies to iron from all sources except iron oxides used as the colouring agent, supplemental iron taken during pregnancy and lactation, and supplemental iron for specific clinical requirements. Important dietary sources include water, beverages and iron medication. The average daily intake of iron has been estimated to be 17mg / day for males and 9 - 12 mg/day for females. Iron fortification of food, but also contamination of food during its preparation (iron - rich soil) could increase intake of iron (42).

According to (44); the permissible limit of Cu in edible plants is up to 3.0 ppm. In this study, the concentration of copper Cu was found to be 0.735 ppm. According to (42), the dietary copper intake will vary with the types of food consumed, the condition of the solids the foods are produced on (e.g. copper content) and drinking - water characteristics. Copper is ubiquitously distributed in foods, but the richest sources of copper in food are liver, seafood (especially shellfish and crustaceans), grains, cereal products, and potatoes, which contribute to about 65% of total dietary intake. Also, drinking -water may contribute for a considerable part to the total daily intake of copper. The average daily intake of copper has been estimated to range from 0.5 to
0.7 mg for infants for 6 months of age or less up to 2-3 mg for adults, however, this level is likely to be exceeded in arid areas where there may be a high intake of containing high levels of copper. The concentration of lead (Pb) present in the peel was found to be 0.28 ppm. According to (42), the mean dietary exposure estimates for children aged about 1-4 years ranged from 0.03 to 9 µg/kg BW (body weight) per day and adults from
0.02 to 3 µg/kg BW (body weight) per day. The higher end of the exposure range for children was deemed by the FAO to be a concern, as it was higher than the level 1.9 µg/kg BW (body weight) per day calculated by the FAO to be associated with a population decrease of 3 IQ points. For adults, the higher end of the exposure range, a population increase of approximately 2 mmHg (0.3 kPa) in systolic blood pressure would be expected to occur.

Table 5: Elemental/mineral Contents of Jackfruit peel

Chemical Elements / minerals	mg / L (or) ppm
Silica (Si)	0.24
Aluminum (Al)	2.16
Cadmium (Cd)	0.001
Calcium (Ca)	30.445
Chromium (Cr)	0.027
Cobalt (Co)	0.008
Copper (Cu)	0.735
Iron (Fe)	4.184
Lead (Pb)	0.28
Manganese (Mn)	1.873
Nickel (Ni)	0.118
Silver (Ag)	1.071
Zinc (Zn)	0.9982

The positive impact of zinc present in the Jackfruit peel powder is (Zn - 1ppm) supplementation on the growth of some stunted children, and on the prevalence of selected childhood diseases such as diarrhoea, suggests that zinc deficiency is likely to be a significant public health problem, especially in developing countries (43). According to FAO's food balance data, it has been calculated that about 20% of the world's population could be at risk of zinc deficiency (44). Zinc is an essential trace element; the requirement of zinc changes throughout life and health effects associated with zinc deficiency are numerous. According to (42), level ranges from high for oysters with lesser amounts in other seafood, muscle meats, nuts, whole cereals. Sugar, citrus, and non-leafy vegetables are poor sources of zinc. The interaction with other dietary factors affects the absorption of zinc. The average daily intake of zinc has been estimated to be maximally 20mg / day for adults. Zinc, Calcium and a few traces of chromium, etc., play important roles in the maintenance of normal glucose - tolerance and in the release of insulin from beta cells of islets of Langerhans (45).

CONCLUSION

As the current trend in the world, today is to utilize and convert waste into useful products and to recycle waste product as means of achieving sustainable development. The presence of various phytoconstituents makes the peel useful for treating different ailments and have a potential of providing useful drugs of human use. In the present study, Gas Chromatography - Mass Spectroscopy analysis of ethanolic extract showed the presence of important bioactive compounds especially Hexadecanoic acid (CAS) and Squalene which has to increases the risk of developing cardiovascular diseases and Chemopreventive substance that protects from cancer. Since the ethanolic extract of peel contains more constituents it can be considered beneficial for further investigation. In conclusion, the result of this investigation demonstration the potentials of peel extracts as a source of useful structures for the development of new chemotherapeutic agents that could be hardnessed for use in the health care delivery. Furthermore, byproducts represent a very important source of sugars, minerals, dietary fiber and phenolics which have a wide range of action which includes antitumoral, antiviral, antibacterial, cardio preventive and antimutagenic activities and it could provide health benefits to humans and may be used in food preservation and pharmaceutical purposes.

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