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# GC–MS ANALYSIS AND QUANTITATIVE PHYTOCHEMICAL SCREENING OF AQUEOUS EXTRACTS OF RIPE PULP OF *CARICA PAPAYA*

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## ABSTRACT

*The present study aimed to investigate and characterize the bioactive phytocomponents of the aqueous extract of ripe pulp of* Carica papaya, *a tropical fruit widely recognized for its nutritional and therapeutic potential. Gas Chromatography–Mass Spectrometry (GC–MS) analysis was conducted to identify the chemical constituents present in the extract. Eight major compounds were detected, representing a diverse profile of bioactive molecules. The most abundant constituent was 1,2,3-propanetriol monoacetate (41.06%), followed by 4H-pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl (20.81%), D-glycerol-idoheptose (11.83%), and dimethylmuconic acid (7.80%). Additional compounds present in lower proportions included 2-deoxy-D-galactose (6.35%), isosorbide dinitrate (2.10%), L-glucose (3.55%), and 3-deoxy-D-mannoic lactone (1.59%). In addition to GC–MS profiling, a qualitative phytochemical screening was performed to evaluate the presence of key secondary metabolites. The aqueous extract revealed a strong presence of saponins (+++) and a moderate concentration of proteins (++). Trace amounts of other phytochemical classes were also detected, including flavonoids, reducing sugars, phenolic compounds, alkaloids, anthraquinones, phlobatannins, cardiac glycosides, terpenoids, and steroids. These findings underscore the diverse phytochemical composition of* Carica papaya *ripe pulp, which may contribute to its reported pharmacological and nutritional benefits. The high abundance of glycerol derivatives, pyranones, and other bioactive molecules suggests potential antioxidant, antimicrobial, and anti-inflammatory activities. Further studies, including quantitative* *analysis and in vivo biological evaluation, are recommended to validate these findings and explore their potential applications in nutraceutical and therapeutic product development.*

**KEYWORDS:** aqueous extracts, ripe pulp, *Carica papaya*, GC–MS analysis, phytochemicals, bioactive compounds.

## 1.0 INTRODUCTION

Carica papaya L. (family Caricaceae) is a tropical fruit-bearing plant indigenous to tropical America and now widely cultivated in Africa, Asia, and Latin America [1,2]. The genus *Carica* comprises multiple species, but *C. papaya* remains the most economically and nutritionally significant [3]. Traditionally, papaya has been valued for both nutritional and medicinal uses, owing to its rich complement of enzymes, vitamins, minerals, and bioactive secondary metabolites [4–7,1]. Koul et al. emphasized that *Carica papaya* is a tropical fruit with extensive nutritional, medicinal, and industrial applications extending well beyond tropical regions [8].

Nutritionally, *C. papaya* pulp is a powerhouse of vitamins (A, B, C, E, and K), minerals (calcium, magnesium, potassium, copper), dietary fiber, and carotenoids such as β-cryptoxanthin, β-carotene, and lycopene, which are responsible for the characteristic coloration of the fruit and possess potent antioxidant activity [9–12]. Also, hypoglycemic, hypolipidemic, body weight reduction, hepato- and renal-protective effects of *Carica papaya* unripe pulp, roots and leaves have been studied extensively [10,13–15]. Beyond micronutrients, papaya contains diverse secondary metabolites—alkaloids, flavonoids, phenolic compounds, glycosides, saponins, tannins, steroids, and terpenoids—that collectively contribute to its pharmacological profile [1,16,17]. Devanesan et al. reported that *Carica papaya* leaf–derived silver nanoparticles exhibit potent antimicrobial and anticancer activities [18]. Hariono et al. demonstrated that *Carica papaya* leaf extract effectively inhibits SARS-CoV-2 main proteases while showing no significant activity against TMPRSS2 [19].

Several studies have documented the therapeutic effects of papaya extracts, including antioxidant, antimicrobial, antidiabetic, anticancer, hepatoprotective, immunomodulatory, and wound-healing activities [20–24]. Ferreira et al. demonstrated that virus coat protein transgenic papaya provided effective control of Papaya ringspot virus in Hawaii, contributing to the genetic improvement and stability of papaya varieties relevant to compound characterization studies [25]. Enzymes such as papain and chymopapain, quantified through LC–MS/MS, are particularly important for proteolysis, digestion, and meat tenderization [26].

Additionally, papaya seeds have demonstrated antimicrobial properties against clinically relevant pathogens [27]. Teh et al., Charan et al., and Srikanth et al. reported (via evidence syntheses/clinical study) that *Carica papaya* leaf preparations show therapeutic potential in dengue through platelet enhancement and immune modulation [28–30]. Sathyapalan et al. demonstrated that *Carica papaya* leaf extract significantly improved platelet counts and was well tolerated in adults with severe dengue-associated thrombocytopenia [31]. Batista et al. evaluated edible coatings on post-harvest papaya and found significant improvements in physicochemical stability and sensory quality [32]. Dhekney et al. reviewed progress in papaya biotechnology, highlighting advances in genetic transformation, disease resistance, and crop improvement [33]. Wei and Wing highlighted the successful completion of the papaya genome project, providing insights into papaya genetics relevant to crop improvement [34]. Babalola et al. reviewed pharmacological activities of *Carica papaya* and characterized papain as a key bioactive enzyme with therapeutic and industrial relevance [35]. Sagadevan reviewed medicinal properties of *Carica papaya* Linn, emphasizing its pharmacological potential in inflammatory, oxidative, and infectious diseases [36]. Goriainov et al. analyzed papaya seed oils from different regions and reported geographic variation in fatty acid composition and bioactive constituents [37]. Barroso et al. evaluated papaya seed oil extracted via supercritical $CO_2$, identifying a profile rich in unsaturated fatty acids with potential nutraceutical applications [38].

Despite these advances, fewer studies have performed detailed GC–MS profiling of aqueous extracts of ripe papaya pulp [39,40]. Most previous work relied on organic solvent extraction of leaves or seeds, potentially overlooking hydrophilic bioactives relevant to dietary consumption [41]. Therefore, this study focuses on aqueous extraction of the ripe pulp followed by GC–MS characterization to better reflect human consumption patterns and to profile water-soluble bioactives. Gonsalves discussed the commercialization of transgenic papaya, emphasizing agricultural benefits and potential ecological risks associated with GMO dissemination [42].

## 2.0 Methodology

Sample Collection, Identification, and Preparation Ripe fruits of *Carica papaya* were harvested from the University's experimental farm located at Nkpolu Oroworukwo, Port Harcourt, Rivers State, Nigeria. The selection criteria for "ripe" included orange to yellow skin coloration, slight softness under gentle pressure, and absence of significant blemishes. A voucher specimen was authenticated by a food scientist in the Department of Food Science and Technology, Faculty of Agriculture, Rivers State University, and assigned a herbarium accession number for future reference.

Drying, Milling, and Sample Storage Approximately 120 g of the prepared pulp was weighed using a triple beam balance (Ohaus model TJ 611, U.S.A./Germany). Drying was conducted in an oven at 60 °C until the sample became crispy and moisture-free (i.e. shows constant weight), following a modified protocol of Eleyemi (as adapted) [43]. After drying, the pulp was pulverized into a fine powder using a Thomas-Wiley milling machine (ASTM D-3182, India). The milled powder was sieved through a 3 × 3 $mm^2$ wire mesh screen to ensure uniform particle size distribution, which improves extraction efficiency and reproducibility. The powder was then stored in airtight, screw-capped plastic containers and refrigerated at 4 °C until further extraction.

Aqueous Extraction Procedure Twenty-five grams (25 g) of the powdered sample was weighed and transferred into a 250 mL stoppered Erlenmeyer flask. To this, 250 mL of distilled water was added (yielding a 1:10 w/v ratio). The mixture was agitated to homogenize and allowed to stand at ambient temperature for 24 hours to facilitate extraction via maceration. Following this period, the suspension was filtered through Whatman No. 24 filter paper to obtain the aqueous filtrate. The filtrate was concentrated using a rotary evaporator (Büchi Rotavapor R-200) under vacuum at 50 °C over 12 hours to remove bulk water while preserving thermally labile compounds.

The concentrated residue was further dried in a vacuum desiccator until constant weight to yield a dry extract. The yield percentage was calculated as:

Yield (%) = (Mass of dry extract / Initial mass of powdered sample) × 100.

In this study, the observed yield was 6.06 %. A portion of the extract was dissolved in ethyl acetate (or suitable GC-MS solvent) to prepare for GC–MS injection.

GC–MS Analysis of Aqueous Extract Instrumentation and Conditions Compound identification in the aqueous extract was conducted via GC–MS, following standard methods [44,45]. The GC–MS configuration comprised an Agilent 7890A gas chromatograph coupled to a 5975C mass selective detector (Agilent Technologies, California, U.S.A.). A DB-SMS capillary column (30 m × 0.25 mm internal diameter, 0.25 µm film thickness; J & W Scientific, CA, U.S.A.) was employed.

…(instrument conditions unchanged)…

Compound Identification

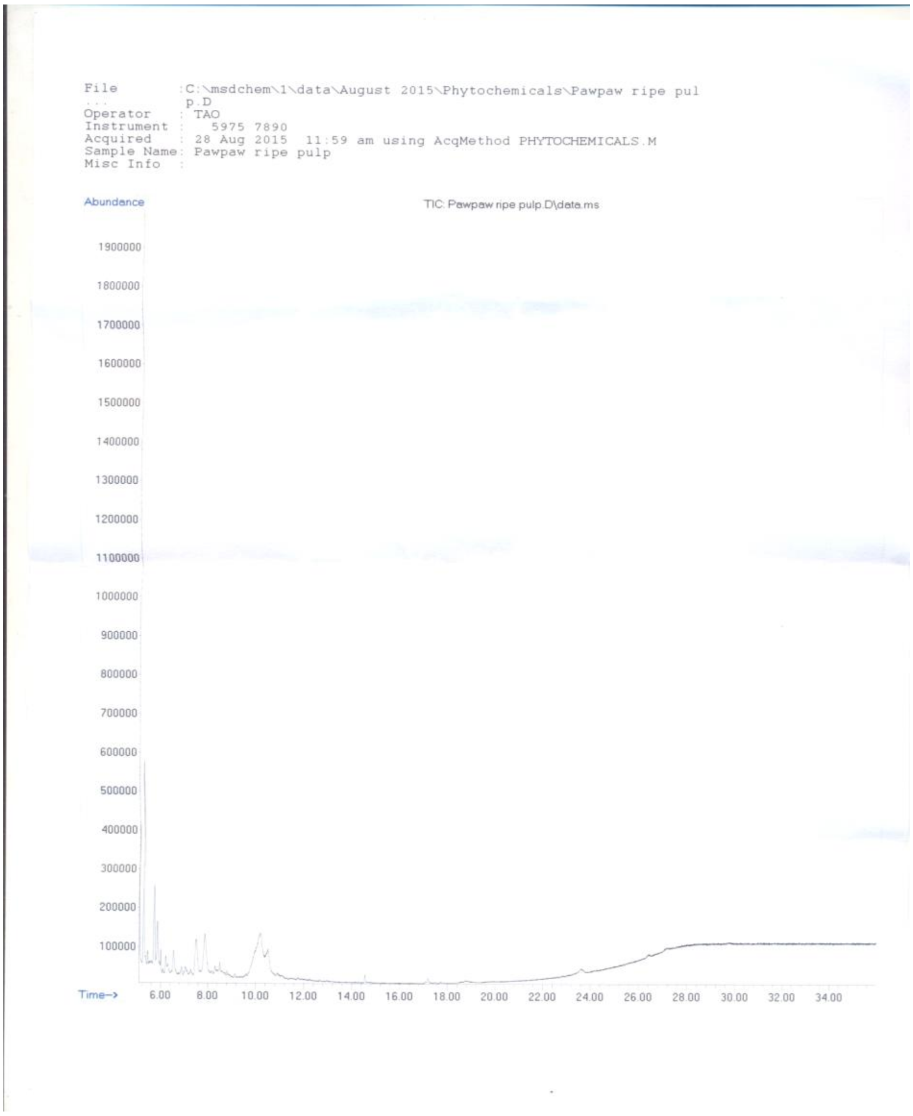
Spectral peaks were processed and compared to reference spectra in established libraries (NIST 08 and Wiley 7n) [46,47]. Only compounds with reliable match scores and chemical plausibility were reported.

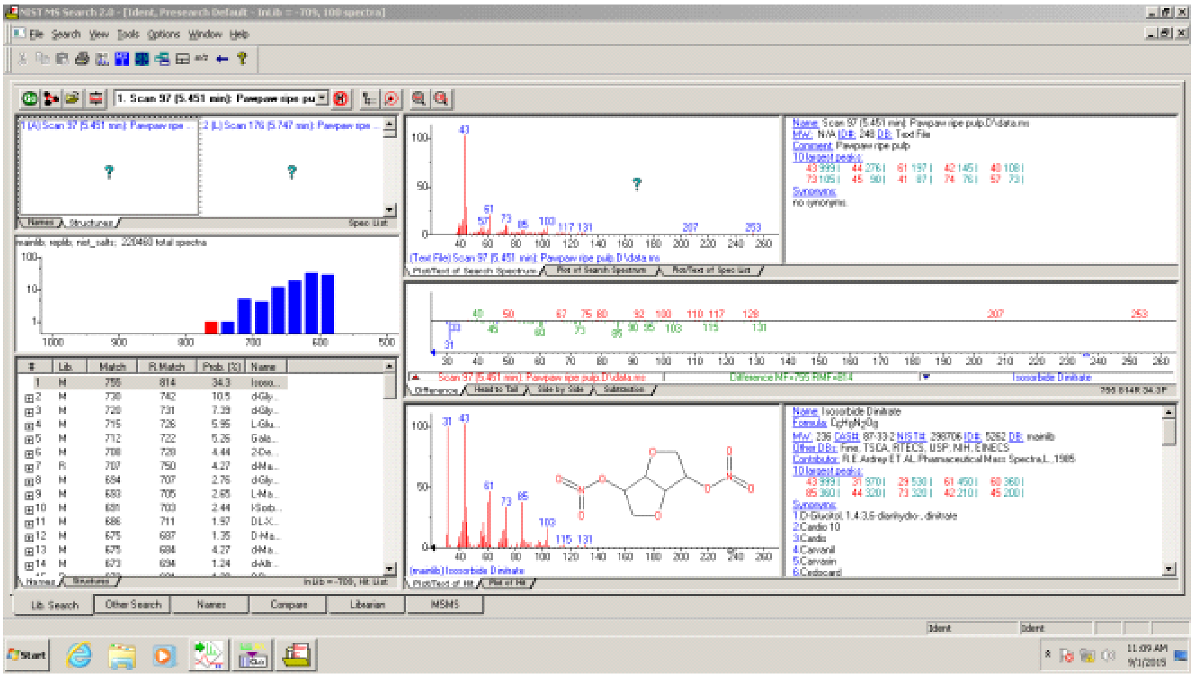
Quantitative Phytochemical Screening Simultaneously, a quantitative phytochemical screening was performed using standard chemical tests [48,49].

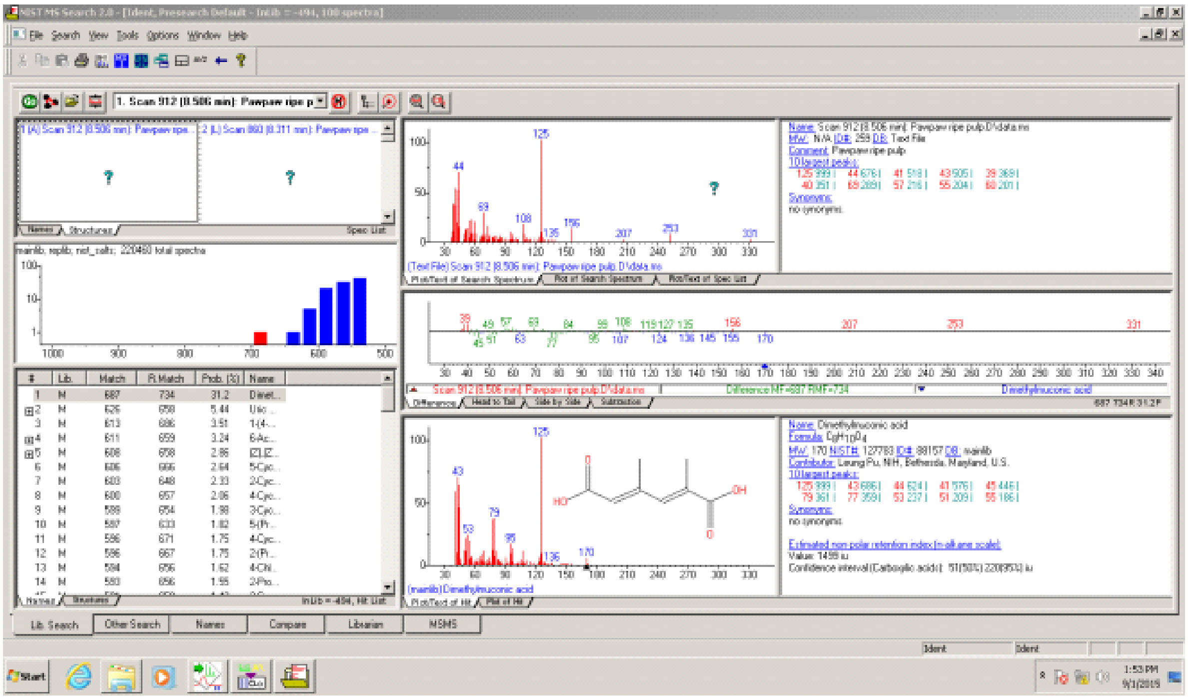
## 3.0 RESULTS

**(i)** Chromatogram of GCMS studies of aqueous extract of ripe pulp of Carica papaya.

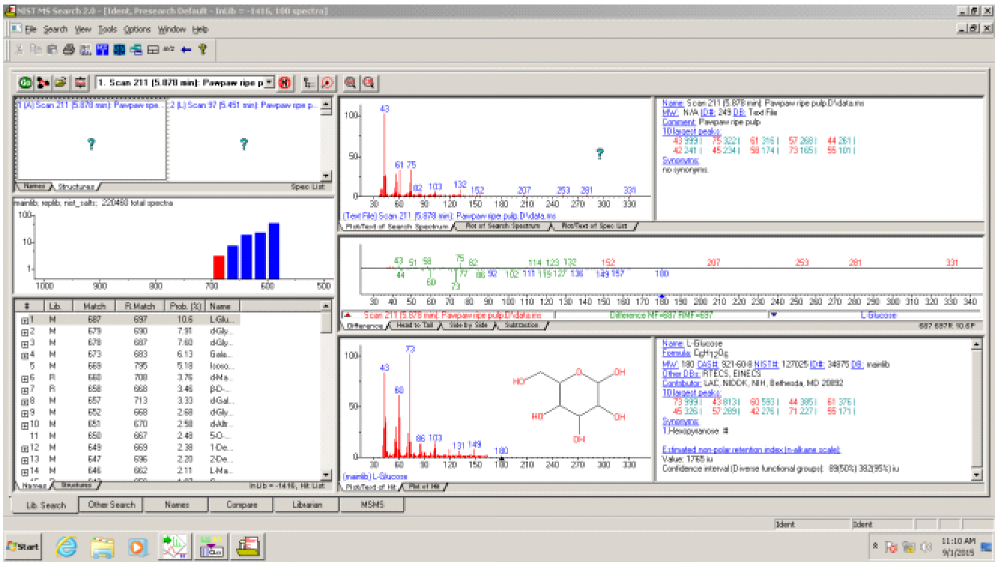
(ii) Phytochemical components of the ripe pulp of Carica papaya.

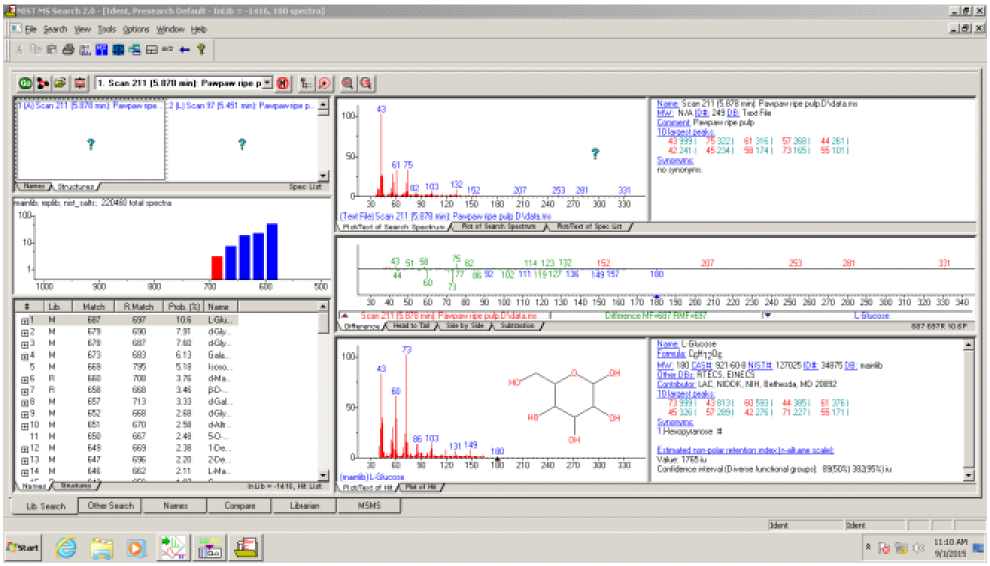


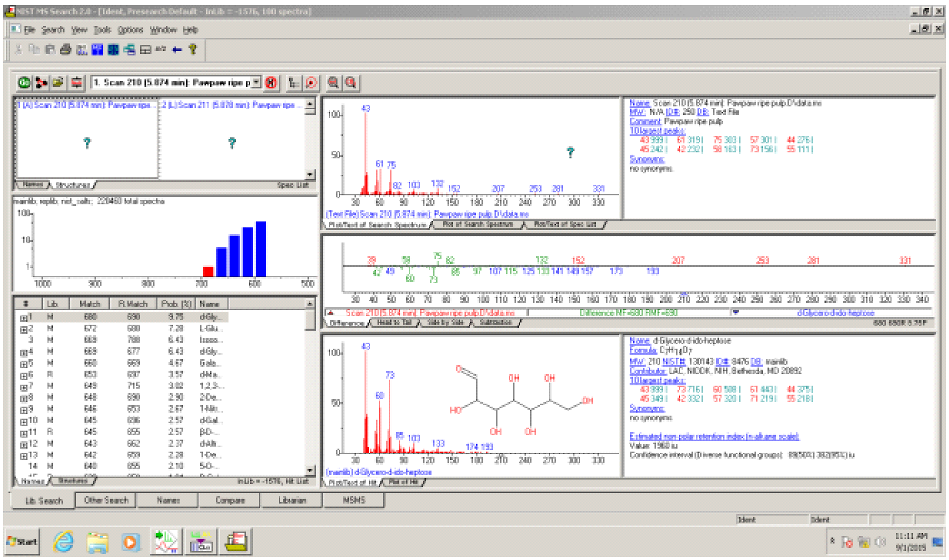


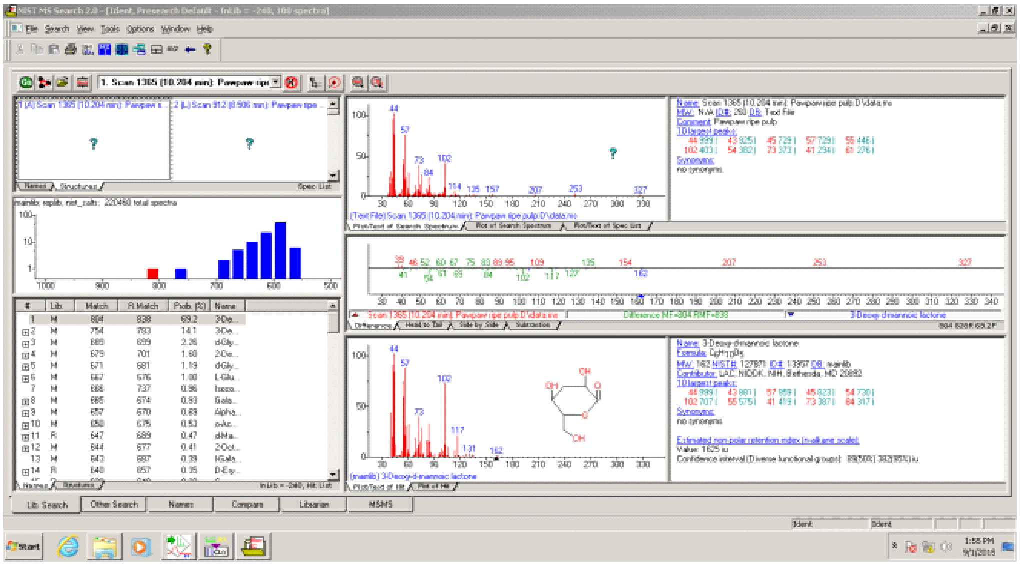


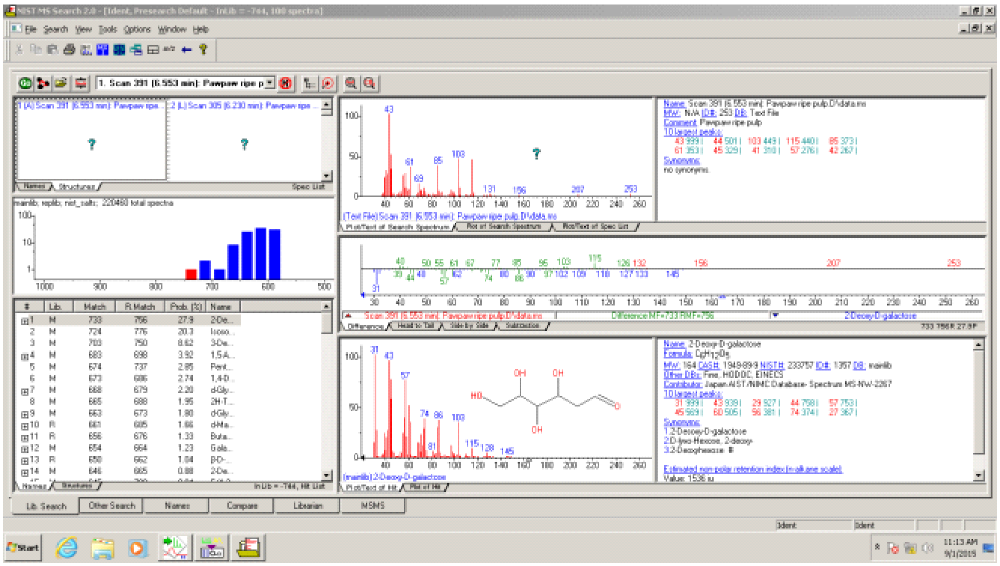
(iii) Molecular structures of phytocomponents











- Table showing GCMS components of ripe pulp of carica papaya (PAWPAW).

**Ripe pulp (pawpaw)**

| S/N | | RT | COMPOUND NAME | MOLECULAR FORMULA | MW | PEAK AREA % |
|---|---|---|---|---|---|---|
| 1 | | 5.289 | 1,2,3-Propanetriol, monoacetate | $C_6H_8O_4$ | 134 | 41.06 |
| 2 | | 5.451 | Isosorbide Dinitrate | $C_6H_8N_2O_8$ | 236 | 2.10 |
| 3 | | 5.747 | 4H-Pyran-one, 2,3-dihydro-3,5-dihydroxy-6-methyl | $C_6H_{10}O_4$ | 144 | 20.81 |
| 4 | | 5.874 | d-Glycer-d-ido-heptose | $C_7H_{14}O_7$ | 210 | 11.83 |
| 5 | | 5.878 | L-Glucose | $C_6H_{12}O_6$ | 180 | 3.55 |
| 6 | | 6.553 | 2-Deoxy-d-galactose | $C_6H_{12}O_5$ | 164 | 6.35 |
| 7 | | 8.506 | Dimethylmuconic acid | $C_8H_{10}O_4$ | 170 | 7.80 |
| 8 | | 10.204 | 3-Deoxy-d-mannoic lactone | $C_6H_{10}O_5$ | 162 | 1.59 |

## 4.0 DISCUSSION

This study revealed that the aqueous extract of ripe *Carica papaya* pulp contains significant levels of saponins, proteins, flavonoids, alkaloids, terpenoids, and cardiac glycosides, consistent with previous findings **[1,12]**. Saponins, detected abundantly, are known to exert anti-inflammatory, cholesterol-lowering, and anticancer effects **[22,50]**. Proteins present in papaya contribute to immune enhancement and metabolic modulation, supporting its nutritional and therapeutic potential **[10]**.

Flavonoids identified in the extract are potent antioxidants capable of mitigating oxidative stress and reducing cellular injury **[51,52]**. Alkaloids, terpenoids, and cardiac glycosides observed here corroborate earlier reports of antimicrobial, antiparasitic, and cardioactive activities **[53,54]**. Steroidal compounds detected may further contribute to bone health and hormonal modulation **[55]**.

GC–MS analysis identified 1,2,3-propanetriol monoacetate (monoacetin) as the most abundant compound, known for antimicrobial and excipient roles in pharmaceutical formulations **[56]**. Other notable compounds included 4H-pyran-one, 2,3-dihydro-3,5-dihydro-6-methyl (reported anti-inflammatory and antiproliferative activity), 2-deoxy-D-galactose (linked to modulation of glycosylation processes) **[57,58]**, and isosorbide dinitrate (a cardioprotective vasodilator) **[54]**. The presence of L-glucose and 3-deoxy-D-mannoic lactone suggests additional roles in metabolic modulation and sensory properties **[59,60]**.

Overall, these findings underscore that *Carica papaya* ripe pulp is not merely a dietary fruit but a functional food source with bioactive compounds capable of conferring cardioprotective, antidiabetic, antioxidant, antimicrobial, and anticancer benefits **[4,6,26]**. The combined evidence positions papaya as a promising candidate for nutraceutical product development and drug discovery applications **[26]**.

## 5.0 CONCLUSION

This study has provided substantial evidence supporting the pharmacological potential of the aqueous extract of ripe *Carica papaya* pulp. The quantitative phytochemical screening revealed a richness in saponins, proteins, and flavonoids, all of which are associated with antioxidant, anticancer, and metabolic regulatory functions. GC-MS analysis confirmed the presence of eight key compounds, several of which—such as 1,2,3-propanetriol monoacetate, 4H-pyran-one, and L-glucose—possess documented antimicrobial, anti-inflammatory, cardioprotective, anticancer, and antidiabetic activities.

The findings suggest that *Carica papaya* ripe pulp could be further explored as a natural therapeutic candidate for managing chronic diseases such as diabetes mellitus, inflammatory disorders, cardiovascular disorders, and certain cancers. Its nutritional profile also supports its use as a functional food ingredient. Nonetheless, while these results are promising, further studies involving in vivo models and clinical trials are needed to validate these bioactivities and establish dosage guidelines.

Given its abundance, affordability, and safety profile, *Carica papaya* ripe pulp represents an underutilized bioresource that could contribute to drug discovery, nutraceutical development, and functional food formulation. Future work should focus on isolating, purifying, and characterizing these compounds for potential pharmaceutical applications.

## REFERENCE


1. Aravind G, Bhowmik D, Duraivel S, Harish G. Traditional and medicinal uses of *Carica papaya*. J Med Plants Stud. 2013;1(1):7–15.
2. Nakasone HY, Paull RE. *Tropical fruits*. Wallingford: CABI Publishing; 1998.
3. Rajasekhar P. Ethnobotanical review of papaya (*Carica papaya*). World J Pharm Pharm Sci. 2018;6(8):99–106.
4. Applied Biological Chemistry. (2024). Full details not provided—please supply title/volume/pages/DOI or URL.
5. ScienceDirect. (2023/2024). Full details not provided—please supply exact article/book chapter details or URL.
6. Sharma A, Sharma R, Sharma M, Kumar M, Barbhai MD, Lorenzo JM, et al. *Carica papaya* L. leaves: Deciphering its antioxidant bioactives, biological activities, innovative

products, and safety aspects. Oxid Med Cell Longev. 2022;2022:2451733. doi:10.1155/2022/2451733.

7. (Unspecified "ScienceDirect, 2023" entry in text). Full details not provided.
8. Koul B, Pudhuvai B, Sharma C, Kumar A, Sharma V, Yadav D, et al. *Carica papaya* L.: A tropical fruit with benefits beyond the tropics. Diversity. 2022;14(8):683. doi:10.3390/d14080683.
9. Ezekwe AS, Wokocha PG, Amakiri OK, Achor MT, Fubara BN. Comparative effects of aqueous leaf extracts of *Vernonia amygdalina* and seed extract of *Irvingia gabonensis* in alloxan-induced diabetic rats. Asian J Biotechnol Genet Eng. 2024;7(2):367–378. doi:10.9734/ajbge/2024/v7i2155.
10. Ezekwe AS, Chikezie PC. GCMS analysis of aqueous extracts of unripe fruit of *Carica papaya*. J Nutr Food Sci. 2017;7(3):144–150. doi:10.11648/j.ijnfs.20170603.12.
11. Scientific African. (2021). Full details not provided—please supply.
12. Amakiri OK, Ezekwe AS, Wokocha PG. Phytochemical profile and bioactive compounds in aqueous seed extract of *Irvingia gabonensis*: A GC-MS analysis. Asian J Res Biochem. 2024;14(6):138–143. doi:10.9734/ajrb/2024/v14i6336.
13. Ezekwe AS, Nwadike C, Eboagwu I, Odika P, Njoku S. Studies on biochemical effects of aqueous extracts of *Carica papaya* leaf on alloxan induced diabetic albino rats. Food Biol. 2017;6:28–35.
14. Ezekwe AS, Chikezie PC. GC-MS analysis / hypoglycemic activity of aqueous root extracts of *Carica papaya* and effects on blood lipid profile and hepatorenal biomarkers. J Diabetes Metab. 2017;8(5):740. *(Formatting/DOI unclear in your list—please verify.)*
15. Ezekwe AS, Elekwa I, Osuocha KU. Hypoglycemic and body weight effects of unripe pulp of *Carica papaya* using diabetic albino rat model. J Pharmacogn Phytochem. 2014;2(6).
16. Kaul V, Kapoor AK. Phytochemical screening of some medicinal plants used in traditional system of medicine. Indian J Tradit Knowl. 2001;1(1):60–66.
17. Koche D, Shirsat R, Kawale M, Shinde A. Overview of major classes of phytochemicals, their types, and role in disease prevention. Hispalis J. 2018;9(1–2):1–11.
18. Devanesan S, Jayamala M, AlSalhi MS, Umamaheshwari S, Ranjitsingh AJA. Antimicrobial and anticancer properties of *Carica papaya* leaves derived di-methyl flubendazole mediated silver nanoparticles. J Infect Public Health. 2021;14(7):902–910. doi:10.1016/j.jiph.2021.02.004.

19. Hariono M, Hidayat I, Djunarko I, Julianus J, Saqallah FG, Khawory MH, et al. *Carica papaya* leaf extract inhibits SARS-CoV-2 main proteases but not human TMPRSS2: An in-vitro and in-silico study. arXiv. 2022;2212.00273. doi:10.48550/arXiv.2212.00273.
20. Bnouham M, Ziyyat A, Mekhfi H, Tahri A, Legssyer A. Medicinal plants with potential antidiabetic activity—A review. J Ethnopharmacol. 2006;104(1–2):1–24. doi:10.1016/j.jep.2005.08.012.
21. Nguyen TTT, Shaw PN, Parat M-O, Hewavitharana AK. Anticancer activity of *Carica papaya*: A review. Mol Nutr Food Res. 2013;57(1):153–164. doi:10.1002/mnfr.201200388.
22. Waheel SA, Sheng X, Aziza SA. A review of saponins from medicinal plants: Chemistry, isolation and determination. J Nanomed Res. 2019;8(1):282–288. doi:10.15406/jnmr.2019.08.00249.
23. Saha S, Giri TK. Breaking the barrier of cancer through papaya extract and their formulation. Anticancer Agents Med Chem. 2019;19(13):1577–1587. doi:10.2174/1871520619666190722160955.
24. Santana LF, Inada AC, do Espirito Santo BLS, Filiú WFO, Pott A, Alves FM, et al. Nutraceutical potential of *Carica papaya* in metabolic syndrome. Nutrients. 2019;11(7):1608. doi:10.3390/nu11071608.
25. Ferreira SA, Pitz KY, Manshardt R, Zee F, Fitch M, Gonsalves D. Virus coat protein transgenic papaya provides practical control of Papaya ringspot virus in Hawaii. Plant Dis. 2002;86(2):101–105. doi:10.1094/PDIS.2002.86.2.101.
26. International Journal of Applied Pharmaceutics. (2024). Full details not provided—please supply article title/authors/volume/pages/DOI or URL.
27. Upe FB, Eze SO, Anosike CA. Antimicrobial activity of ethyl acetate extracts of *Citrullus lanatus* seeds. Trop J Pharm Res. 2017;16(7):1631–1635. doi:10.4314/tjpr.v16i7.20. *(Note: this reference is about watermelon seeds, not papaya seeds—please confirm it's the intended citation.)*
28. Teh BP, Ahmad NB, Mohamad SB, Tan TYC, Razak MRMA, Afzan AB, et al. *Carica papaya* leaf juice for dengue: A scoping review. Nutrients. 2022;14(8):1584. doi:10.3390/nu14081584.
29. Charan J, Saxena D, Goyal JP, Yasobant S. Efficacy and safety of *Carica papaya* leaf extract in dengue: A systematic review and meta-analysis. Int J Appl Basic Med Res. 2016;6(4):249–254. doi:10.4103/2229-516X.192596.

30. Srikanth BK, Reddy L, Biradar S, Shamanna M, Mariguddi DD, Krishnakumar M. Efficacy and safety of *Carica papaya* leaf extract for thrombocytopenia associated with dengue fever in pediatric subjects. Pediatr Health Med Ther. 2019;10:5–11. doi:10.2147/PHMT.S176712.
31. Sathyapalan DT, Padmanabhan A, Moni M, P-Prabhu B, Prasanna P, Balachandran S, et al. Efficacy and safety of *Carica papaya* leaf extract in severe thrombocytopenia in adult dengue—pilot study. PLoS One. 2020;15(2):e0228699. doi:10.1371/journal.pone.0228699.
32. Batista DVS, Reis RC, Almeida JM, Rezende B, Bragança CAD, da Silva F. Edible coatings in post-harvest papaya: Impact on physical–chemical and sensory characteristics. J Food Sci Technol. 2020;57(1):274–281. doi:10.1007/s13197-019-04057-1.
33. Dhekney SA, Kandel R, Bergey DR, Sitther V, Soorianathasundaram K, Litz RE. Advances in papaya biotechnology. Biocatal Agric Biotechnol. 2016;6:150–158. doi:10.1016/j.bcab.2016.01.004.
34. Wei F, Wing RA. A fruitful outcome to the papaya genome project. Genome Biol. 2008;9:227. doi:10.1186/gb-2008-9-6-227.
35. Babalola BA, Akinwande AI, Otunba AA, Adebami GE, Babalola O, Nwufo C. Therapeutic benefits of *Carica papaya*: A review on its pharmacological activities and characterization of papain. Arab J Chem. 2023;16(11):105369. doi:10.1016/j.arabjc.2023.105369.
36. Sagadevan P. Medicinal properties of *Carica papaya* Linn: Review. Madridge J Novel Drug Res. 2019;3(1):1–6. doi:10.18689/MJNDR-1000118.
37. Goriainov S, Orlova S, Nikitina E, Vandishev V, Ivlev V, Esparza C, et al. Study of the chemical composition of *Carica papaya* L. seed oils of various geographic origins. Horticulturae. 2023;9(11):1227. doi:10.3390/horticulturae9111227.
38. Barroso PTW, de Carvalho PP, Rocha TB, Pessoa FLP, Azevedo DA, Mendes MF. Composition of *Carica papaya* L. seed oil extracted with supercritical $CO_2$. Biotechnol Rep. 2016;11:110–116. doi:10.1016/j.btre.2016.08.004.
39. Ghosh G, Kar DM, Subudhi BB, Mishra SK. GC–MS analysis of bioactive compounds in methanolic extracts of *Clerodendrum viscosum* leaves. Pharmacogn Res. 2015;7(1):110–113. doi:10.4103/0974-8490.147224.
40. Yao KF, Chen J, Wu Y. GCMS analysis of induced metabolites in medicinal plants. Chem Res J. 2017;2(5):320–333.

41. Gupta M, Kaur K. Qualitative analysis for free radical scavenging and acid value of honey including GCMS spectra. Res J Pharm Biol Chem Sci. 2016;7(6):1998–2003.
42. Gonsalves D. Commercialization of transgenic papaya: Weighing benefits and potential risks. In: Proceedings of the OECD Workshop on Dissemination of GMOs in Agro-Ecosystems. Grossrussbach, Austria; 2003. p.131–137.
43. Eleyemi (as adapted). Full details not provided—please supply exact source.
44. Analytical Science Journals. (n.d.). Full details not provided—please supply.
45. GC–MS Profiling. (2024). Full details not provided—please supply.
46. Phytopharma Journal. (2022). Full details not provided—please supply.
47. GCMS Analysis. (2024). Full details not provided—please supply.
48. Harborne JB. *Phytochemical methods: A guide to modern techniques of plant analysis*. 3rd ed. London: Chapman & Hall; 1998.
49. Mathe N, et al. (2023). Incomplete details in your list—please supply full citation (title, journal, volume, pages, DOI).
50. Valayutham P, Kurthi S. GCMS profile of in vivo, in vitro and fungal elicited in vitro leaves of *Hybanthus enneaspermus*. Int J Pharm Pharm Sci. 2015;7(10):260–267.
51. John B, Sulaiman CT, George S, Reddy VRK. Total phenolics and flavonoids in selected medicinal plants from Kerala. Int J Pharm Pharm Sci. 2014;6(1):406–408.
52. Lopez V, Akerreta S, Casanova E, García-Mina JM, Cavero RY, Calvo MI. Screening of Spanish medicinal plants for antioxidant and antifungal activities. Pharm Biol. 2007;45(8):602–609. doi:10.1080/13880200701575366.
53. Muthulakshmi & Mohan (2022). Not provided in your reference list—please supply full details.
54. Parker MD, Girello BS, Stone JA. Pharmacology of nitrates and tolerance mechanisms. Therapy and Prevention Journal. 2003;12(2):88–95.
55. Bello et al. (2023). Not provided in your reference list—please supply full details.
56. PubChem. (2017). Your reference entry is mismatched (it describes a different GCMS paper). Please provide the correct PubChem compound page citation or the correct paper.
57. Henderson PJ, Giddens RA. Galactose transport in *Escherichia coli*: Kinetic studies. Biochem J. 1977;168(1):15–22. doi:10.1042/bj1680015.
58. Malaise WJ. The riddle of L-glucose pentaacetate sulinotopic action. Int J Mol Med. 1998;2(4):383–388.
59. Marabita F, Manca M, Corongiu FP. Natural antioxidants in food and biological systems. Mol Nutr Food Res. 2002;46(4):237–240.