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Screening of The Bioactive Composition in Aqueous and Ethanolic Extracts of Tamarind fruit (*Tamarindus indica*) using GC-MS

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Abstract

This look at aimed to discover the bioactive compounds in tamarind (*Tamarindus indica*) fruits using aqueous and ethanolic extracts. GC-MS analyses revealed quite a few compounds found in those extracts. Tamarind is a tropical plant native to Africa but broadly cultivated globally. It is known for its nutrient-wealthy houses and numerous health blessings. It is thought for its nutrient-rich houses and numerous health benefits. In latest years, interest in herbal antioxidants and their role in ailment prevention and treatment has grown. Tamarind consists of an excessive attention of polyphenols and flavonoids, which can be presumed to be the primary materials liable for its powerful antioxidant houses. The phenolic compounds in tamarind make contributions to heart and immune health, along with their antimicrobial and antineoplastic consequences. Flavonoids found in numerous parts of the plant are also recognized for their anti-inflammatory, anti-diabetic, and lipid-lowering homes, making them beneficial inside the control of several fitness conditions. This study investigates the bioactive compounds in tamarind and their associated organic activities.

Keywords: Edible tamarind plant, GC-MS Analysis, Bioactive composition.

Introduction

Tamarindus indica is a widely recognized leguminous tree from the Fabaceae family, valued for its medicinal, nutritional, financial, and environmental benefits. Due to its versatility, it's miles taken into consideration a multipurpose plant. It can undergo dry durations of up to 5–6 months but has low resistance to extraordinarily bloodless temperatures [1].There are two foremost forms of tamarind: acidic and sweet-acidic. The acidic type thrives in warm, sunny climates and is the maximum typically observed, whilst the sweet-acidic range is greater, touchy to temperature adjustments, and is less broadly available. Tamarind fruit is quite widespread and may be consumed processed. Its precise candy and tangy taste come from a balance of tartaric acid and phytogenic saccharides [2].

The fruit is utilized in plenty of meal products, which include seasonings, confectionery, curries, chutneys, sauces, juices, and beverages.Tamarind seeds are a byproduct of industries that use the pulp. However, their excessive tannin content material and another dyeing substances in the seed coat make them mistaken for direct consumption [3].To be eaten, they need to first be soaked and boiled. One of the most crucial business products derived from tamarind seeds is tamarind kernel powder , which is used in the jute, paper, textile, and material industries [3].Additionally, jellose, a polysaccharide extracted from the seeds, serves as a stabilizer in cheese, mayonnaise, ice cream, and pharmaceutical merchandise.In a few growing nations, tamarind seeds are used as an opportunity protein source to assist fighting malnutrition. The plant’s flowers and leaves are also edible and can be consumed sparingly, cooked, or brought to curries, salads, and soups. Given its extensive variety of makes use of and potential fitness advantages, compiling present studies on Tamarind [2].

Gas chromatography-mass spectrometry (GC-MS) is a paradigm shift within the evaluation and structural elucidation of plant additives, with its excessive sensitivity for detecting compounds as low as one nanogram .With the development of chromatographic approaches,encompassing gas chromatography-mass spectrometry (GC-MS), it has end less difficult to investigate small portions of chemical compounds [4].This research was performed to assess the gas

chromatography-mass spectrometry (GC-MS) and Fourier transform infrared spectroscopic characterization of this plant extract.

Methodology

Preparation of extract

The fruits of the plant had been acquired from local markets to put together the extract. According to [5] with some modifications, an exceptional pattern (approximately one thousand g) was measured and positioned in a 2000 ml beaker, wherein it was soaked in distilled water for 24 hours. The answer changed into a combined one with an electric-powered mixer for 15 minutes and then filtered utilizing of Whatman No. 1 filter paper. For additional filtration, the filtrate changed into focused using a centrifuge. The filtrate was then dried, scraped, and amassed in a sealed box. This technique was used to put together the aqueous extract. For the ethanolic extract, the identical manner was followed, the use of ethanol in place of distilled water. The prepared extracts have finally been used for GC-MS evaluation.

GC-MS analysis of bioactive compounds from plant extracts

The bioactive unstable compounds in both (aqueous and ethanolic) extracts were tested utilizing gas chromatography-mass spectrometry (GC-MS). Analysis was done on a Shimadzu QP-2010 machine, using a 60-m non-polar RTX 5MS column. Helium was used as the provider gas. The temperature software initiated with a preliminary oven temperature of forty°C, held for three min, observed via a final temperature of 480°C at a rate of 10°C/min. A 2-µL sample become injected with the use of the splitless mode. Mass spectra have been recorded within the variety of 35–650 µA, with the electron effect ionization power set to 70 eV. The general analysis time for each pattern became forty-five minutes. To pick out the chemical additives in the methanol extracts, the retention instances of the chromatographic peaks were contrasted with the National

Institute of Standards and Technology (NIST) database, and relative retention indices have been obtained the usage a quadrupole detector. The amount of compounds turned into is determined by touching on the peak regions to the overall ion chromatogram (TIC) regions obtained from gas [5].

Results

Definition of phytochemical compounds in the aqueous extract of *Tamarindus indica* utilizing GC-MS technique

The effects of the GC-MS (Gas Chromatography-Mass Spectrometry) analysis of the aqueous extract of Tamarindus indica fruit display the identification of diverse chemical substances present in the extract. Several organic compounds have been detected, consisting of alkaloids, phenolic compounds, and flavonoids, which may be chargeable for the biological consequences of the extract. The results also showed the presence of compounds with antioxidant, antimicrobial, and anti-inflammatory homes. This analysis allows in an understanding the phytochemical profile of the extract and enhances the scientific understanding of its ability to be therapeutic programs. (Table 1).

Definition of phytochemical compounds in the ethanolic extract of Tamarindus indica utilizing GC-MS technique

The GC-MS (Gas Chromatography-Mass Spectrometry) analysis of the alcoholic extract of Tamarindus indica fruit identified a range of chemical constituents present in the extract. Among the compounds detected have been carboxylic compounds, phenolic compounds, flavonoids,parafines, and triterpenoid compounds which can be responsible for the extract's organic effects. The analysis additionally found out the existence of compounds with antioxidant, antimicrobial, and anti-inflammatory properties. These effects offer precious insight into the chemical composition of the alcoholic extract and advise its viable healing applications (Table 2).

Table 1: Identification of chemical compounds in the aqueous extract of *Tamarindus indica* utilizing Gas Chromatography-Mass Spectrometry

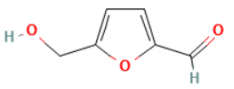
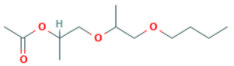
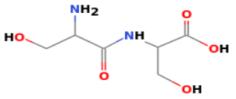
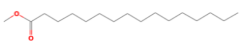
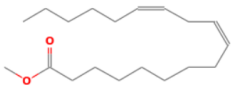
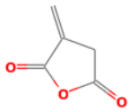
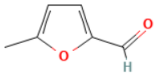
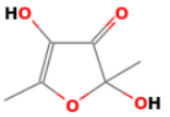
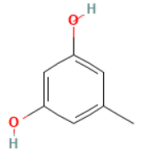
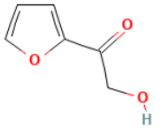
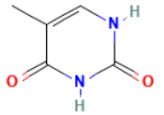
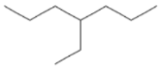
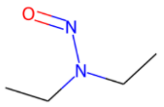
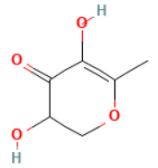
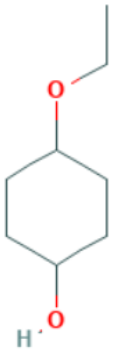
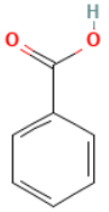
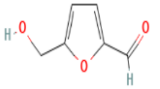
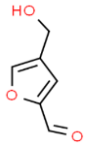
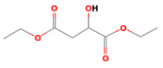
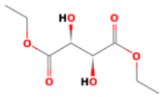
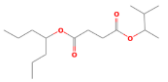
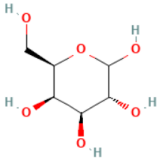
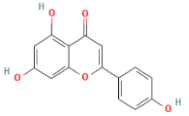
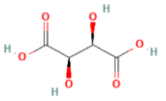
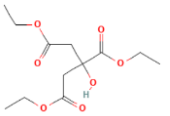
No.	Compound Name	Peak Area %	Rt. (min)	Quality	Mol. Formula	Mol. Structure	Mol. W. g/mol.	Biological activities
1	5-Hydroxymethylfurfural	7.58	12.456	45	$C_6H_6O_3$		126.11	Anti-allergenics and anti-diabetics [6]
2	1-tert-Butoxypropan-2-yl acetate	14.61	16.892	22	$C_{12}H_{24}O_4$		232.32	-
3	N-Serylserine	71.11	22.04	47	$C_6H_{12}N_2O_5$		192.17	Antioxidant and antidiabetic [7]
4	Hexadecanoic acid, methyl ester	1.42	26.04	90	$C_{17}H_{34}O_2$		270.5	Antimicrobial activity [8]
5	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	2.94	28.593	99	$C_{19}H_{34}O_2$		294.5	Hepatoprotective, Antihistaminic, hypocholesterolemic, Anti-eczemic[9]

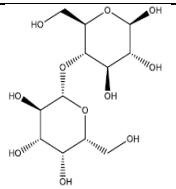
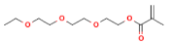
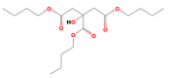
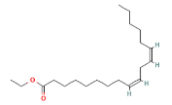
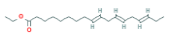
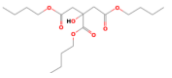
Table 2. Identification of chemical compounds in the ethanolic extract of *Tamarindus indica* utilizing Gas Chromatography-Mass Spectrometry

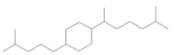
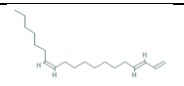
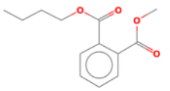
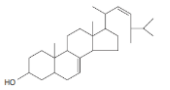
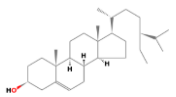
No.	Compound Name	Peak Area %	Rt. (min)	Quality	Mol. Formula	Mol.structure	Mol.W g/mol.	Biological activities
1	2,5-Furandione, dihydro-3-methylene-	8.34	4.927	7	$C_5H_4O_3$		112.08	Antimicrobial,antioxidant [10]
2	2-Furancarboxaldehyde, 5-methyl-	0.76	5.773	90	$C_6H_6O_2$		110.11	Antimicrobial activity [6]
3	2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one	0.39	6.313	87	$C_6H_8O_4$		144.12	Antioxidant, anti-proteus activity [10]
4	Cyclohexanone, 4-ethyl-	0.34	7.667	37	$C_8H_{14}O$		126.20	Hepatitis b antiviral agent, Inhibitors of viral replication, inhibitor of beta secretase [11]
5	Orcinol (1-(2-furanyl)-1-propanone)	0.24	8.056	49	$C_7H_8O_2$		124.14	Antibacterial [12]

6	Furyl hydroxymethyl ketone	0.71	8.476	46	$C_6H_6O_3$		126.11	Biofilm inhibitors,Antifungal, Antioxidant activity [12]
7	Thymine	0.85	8.679	64	$C_5H_6N_2O_2$		126.11	Biological, Antibacterial, and Antifungal [8]
8	Heptane, 4-ethyl-	0.36	9.177	43	C_9H_2O		128.25	-
9	Ethanamine, N-ethyl-N-nitroso-	0.35	9.327	49	$C_4H_{10}N_2O$		102.14	Boost immune system [13]
10	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	2.27	10.106	94	$C_6H_8O_4$		144.12	Antibacterial and antifungal activities [12]

11	Cyclohexanone, 4-ethoxy-	0.23	10.78	22	$C_8H_{16}O_2$		144.21	Antioxidant activities [14]
12	Benzoic acid	2.98	11.377	95	$C_7H_6O_2$		122.12	Antibacterial [8]
13	5-Hydroxymethylfurfural	14.04	12.031	91	$C_6H_6O_3$		126.11	Antidiabetics and antiallergenics [6]
14	4-Hydroxymethylfurfural	2.51	12.108	60	$C_6H_6O_3$		126.11	Antioxidant antimicrobial and antiproliferative, antibiofilm[12].
15	Butanedioic acid, hydroxy-, diethyl ester	1.69	12.887	83	$C_8H_{14}O_5$		190.19	Anti-ulcer[15]

16	Butanedioic acid, 2,3-dihydroxy-, diethyl ester, [S-(R*,R*)]-	2.56	14.806	91	$C_8H_{14}O_6$		206.19	-
17	Succinic acid, 3-methylbut-2-yl 3-heptyl ester	0.70	15.377	38	$C_{16}H_{30}O_4$		286.41	Antioxidant [2]
18	D-Galactose	0.94	15.813	47	$C_6H_{12}O_6$		180.16	Antioxidant [16]
19	5,7-Dihydroxy-2-(4-hydroxyphenyl)-4H-chromen-4-one (Apigenine)	0.82	16.737	50	$C_{15}H_{10}O_5$		270.24	Antioxidant and anti-inflammatory [2]
20	L-Tartaric acid	1.44	17.805	50	$C_4H_6O_6$		150.09	Antioxidant ,antimicrobial,Laxative [2]
21	Triethyl citrate	0.89	20.955	72	$C_{12}H_{20}O_7$		276.28	Anti-Ulcer and anti-inflammatory agent [15]

22	.beta.-D-Glucopyranose, 4-O-.beta.-D-galactopyranosyl-	0.36	21.552	47	$C_{12}H_{22}O_{11}$		342.30	Antioxidant,antibacterial, antifungal, and anti-inflammatory[14]
23	2-[2-(2-Ethoxyethoxy)ethoxy]ethyl methacrylate	41.43	23.923	43	$C_{12}H_{22}O_5$		246.30	-
24	Hexadecanoic acid, ethyl ester	1.71	27.145	98	$C_{18}H_{36}O_2$		284.5	Antioxidant and antidiabetic [7]
25	Butyl citrate(citric acid)	0.47	29.158	87	$C_{18}H_{32}O_7$		360.45	Antioxidant, anti-inflammatory [2]
26	Linoleic acid ethyl ester	3.08	29.61	99	$C_{20}H_{36}O_2$		308.5	Anti-hyperglycemic, Hypocholesterolemic Anticoronary, and antioxidant [18]
27	9,12,15-Octadecatrienoic acid, ethyl ester, (Z,Z,Z)-	0.25	29.662	99	$C_{20}H_{34}O_2$		306.49	Hepatoprotective, Anti-arthritic, Anti-asthma, diuretic.,Antioxidant activity, [9]
28	Butyl citrate	4.94	29.755	90	$C_{18}H_{32}O_7$		360.45	Antioxidant, anti-inflammatory [2]

29	Octadecanoic acid, ethyl ester (Eicosanoic acid)	0.42	30.175	98	$C_{20}H_{40}O_2$		312.5	Antimicrobial and antifungal. [10]
30	Cyclohexane, 1-(1,5-dimethylhexyl)-4-(4-methylpentyl)-	0.36	34.176	50	$C_{20}H_{40}$		280.54	Antibacterial, Anticancer activity [9]
31	E,Z-1,3,12-Nonadecatriene	0.45	36.313	94	$C_{19}H_{34}O_2$		294.5	Antimicrobial activity[17]
32	1,2-Benzenedicarboxylic acid, butyl methyl ester	1.54	37.242	91	$C_{13}H_{16}O_4$		236.26	Antioxidant and antibacterial [8]
33	Ergosta-7,22-dien-3-ol, .3)beta.,22E-(	0.25	42.856	91	$C_{28}H_{46}O$		398.7	Antioxidant and antitumor [10]
34	.gamma.-Sitosterol	1.33	44.226	99	$C_{29}H_{50}O$		414.71	Antimicrobial and anticancer agent [10]

Discussion

The outcomes of the chemical analysis of the aqueous and alcoholic extracts of the tamarind fruit (*Tamarindus indica*) using gas chromatography-mass spectrometry (GC-MS) showed a clear variation in the number and type of identified chemical compounds. Only five compounds were identified in the aqueous extract, compared to thirty-four compounds in the alcoholic extract. This variation is likely due to the different polarity of the solvent used, as alcohol has a higher ability to extract a wide range of active plant compounds, especially phenols, flavonoids, and terpenoids. [19-20].

The aqueous extract contained compounds such as 5-hydroxymethylfurfural, N-serylserine, tert-butoxypropane-2-yl acetate, hexadecanoic acid methyl ester, and 9,12-octadecadienoic acid (Z,Z) , methyl ester, which are compounds with biological activities, including hypocholesterolemic ,antioxidant, antimicrobial, and antidiabetic effects [6-9]. These results are partially consistent with those reported by (21), 5-Hydroxymethylfurfural and hexadecanoic acid, methyl ester, were detected in the aqueous extract of *T. indica*, while the remaining compounds varied. This variation is attributed to environmental and geographical factors that influence the chemical composition of the plant, as well as different extraction conditions and techniques [22].

The alcoholic extract was characterized by containing a wide spectrum of biologically active compounds, such as 2,5-Furandione, dihydro-3-methylene, Orcinol 1-(2-furanyl)-1-propanone, Furyl hydroxymethyl ketone, 4-Hydroxymethylfurfural, H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl, and Hexadecanoic acid, ethyl ester, these results were consistent with

those of [12] when analyzing a methanolic extract of the same plant using GC-MS, almost the same compounds were detected. These compounds were of great biological importance, as they possess antioxidant properties, antidiabetic activity, and antimicrobial and antifungal properties [9,12].

These results support the findings of [19] that solvent type plays a crucial role in determining the composition and effectiveness of plant extracts. Alcohol, thanks to its physical and chemical properties, is an effective solvent for extracting water-insoluble compounds, such as paraffins, alkaloids, and triterpenoids, this was supported by what [20] indicated that using alcohol as a solvent leads to a significant increase in the bioactivity of the extract, especially with regard to the concentration of antioxidant compounds.

It can be concluded that the alcoholic extract of *T. indica* fruit is more effective than the aqueous extract in terms of the number and diversity of active compounds, which indicates its high potential in pharmaceutical and therapeutic applications, especially in combating chronic diseases associated with oxidative stress, such as diabetes, cancer, and inflammation.

Conclusion:

This look at verifies confirms that both aqueous and alcoholic extracts of tamarind fruit contain bioactive compounds that contribute to its antioxidant and antimicrobial properties, supporting the plant's use in traditional medicine. Despite the remarkable effectiveness of the aqueous extract, the alcoholic extract demonstrated a clear superiority in terms of the number and diversity of active compounds, making it more effective and potentially a better option for future therapeutic applications.

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فحص التركيب الحيوي الفعال في المستخلصين المائي والإيثانولي لثمرة التمر الهندي (*Tamarindus indica*) باستخدام تقنية كروماتوغرافيا الغاز-مطياف الكتلة (GC-MS)

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الخلاصة

هدفت هذه الدراسة إلى تشخيص المركبات الحيوية الفعالة في ثمرة التمر الهندي (*Tamarindus indica*) في المستخلصين المائية والإيثانولي. كشف تحليل كروماتوغرافيا الغاز-مطياف الكتلة (GC-MS) عن وجود العديد من المركبات في هذين المستخلصين. التمر الهندي نبات استوائي موطنه أفريقيا، ولكنه يُزرع على نطاق واسع عالميًا. يُعرف بخصائصه الغنية بالعناصر الغذائية وفوائده الصحية العديدة. في السنوات الأخيرة، ازداد الاهتمام بمضادات الأكسدة العشبية ودورها في الوقاية من الأمراض وعلاجها. يحتوي التمر الهندي على تركيز عالٍ من البوليفينولات والفلافونويدات، والتي يُعتقد أنها المواد الأساسية المسؤولة عن خصائصه المضادة للأكسدة القوية. تساهم المركبات الفينولية في التمر الهندي في صحة القلب والمناعة، بالإضافة إلى تأثيراتها المضادة للميكروبات والأورام. كما تُعرف الفلافونويدات الموجودة في أجزاء عديدة من النبات بخصائصها المضادة للالتهابات والسكري وخفض الدهون، مما يجعلها مفيدة في السيطرة على العديد من الحالات الصحية. بينت هذه الدراسة المركبات الحيوية الفعالة الموجودة في التمر الهندي والأنشطة العضوية المرتبطة بها.

الكلمات المفتاحية: نبات التمر الهندي الصالح للأكل، تحليل كروماتوغرافيا الغاز ومطياف الكتلة، التركيب الحيوي النشط.