COMPARATIVE STUDY ON THE EFFECTS OF SOLVENT POLARITY ON THE PHYTOCHEMICAL PROFILE OF *Momordica charantia* LEAVES

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ABSTRACT

A comparative study of the phytochemical compounds present in *Momordica charantia* leaves was examined using petroleum ether and ethanol organic solvents. Extraction of the compounds were achieved by Soxhlet extraction, while separation was carried out by Gas chromatographic technique. Each compound's structure was characterized by Mass spectrometry. The results identified 20 phytochemical compounds in the ethanol extract which comprises of 4 aromatic compounds, 6 fatty acids, 4 esters, , and 1 sesquiterpene. 11 Phytochemicals were found in the petroleum ether extract, comprising 4 ester compounds, 3 fatty acids, 1 aromatic compound, 1 alkaloid, 1 di-terpene, and 1 triterpene. The plant leaves ethanol extract revealed a higher percentage of fatty acids, aromatic compounds, and terpenes, showing it was an excellent solvent for the classes of compounds identified. In the ethanol extract the most abundant fraction was n-Hexadecanoic acid (with 44.88%), while Methyl palmitate was the highest phytochemical found in the petroleum ether extract. The solvent and procedure of extraction largely impacted result of the study. More phytochemicals were found in the ethanol indicating it is an excellent polar solvent for extraction of *Momordica charantia* phytochemicals. Five phytochemicals were common to each extracts, showing varying amounts. The variation phytochemical composition of *Momordica charantia* highlights the effect of solvent polarity in extracting different classes of natural products from Momordica charntia leaves.

Keywords: phytochemicals, *Momordica charantia*, GC-MS, comparative study, solvent polarity.

INTRODUCTION

The plant, also referred to as bitter melon is a member of Cucurbitaceae family. The edible fruit of M. *charantia* is consumed for its nutritional benefits. The phytochemical profile of M. *charantia* leaves have shown it to be rich in different classes of lipids, fatty acids, esters, and alkaloids which show varying biological activities or medicinal properties [1-4].

Phytochemicals, such as flavonoids, phenolic acids, alkaloids and terpene have shown application in traditional medicine, skincare treatment, and the treatment of induced diabetic rats [5]. The creeping plant may attain up to five hundred centimeters in height. Leaves of this plant are arranged alternately, ranging from 4-12 cm in diameter, while the bitter melon fruit start growing two weeks after flowering. The fruit of *Momordica charantia* is a staple ingredient in many traditional cuisines, particularly in Asian and African cultures including Nigeria. It is valued for its

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nutritional and medicinal activities, as well as its potential anti-diabetic, anti-inflammatory, and antioxidant activities. The plant's versatility made it a valuable resource for food, medicine, and economic development in many culture around the world.

Importance of Solvent Polarity

Due to the hydroxyl group of most alcoholic solvent, alcoholic organic solvents proves to be more efficient extracting solvent for polar compounds. While hexane, or long chain hydrocarbon solvent tends to be a good extracting medium for samples. Hence, polarity or solubility of an extracting solvent and the solutes partition coefficient factor greatly influences type and concentration of extract from samples. In summary, solvent polarity, and optimized extraction method enhances extraction efficiency and selectivity of phytochemicals extracted [17]. Solvents with varying polarities will extract different compounds and amounts of phytochemicals, affecting the overall phytochemical composition of the extract [7-9].

Different phytochemicals have varying levels of polarity, and selecting a solvent with the appropriate polarity is crucial for efficient extraction. Polar solvents, like ethanol is an excellent solvent that can isolate polar phytochemicals like phenolic compounds as well as glycosides. While non-polar solvents, like n-hexane, petroleum ether, methylene-chloride, enhances isolation of compounds like isoprene and carotenoids. By optimizing extraction conditions, like pH, extraction time, choosing solvent with higher partition coefficient of solute will enhance selective extraction of classes of phytochemicals. Extraction of flavonoids from citrus peels has been optimized by selecting most appropriate organic solvent and extraction method for higher extraction yield [17].

Importance of Phytochemicals in Human Health

Different classes of plant natural chemical are of great importance because they are essential for the survival of the human race. Phytochemical compounds have application as flavours, and preservatives in food processing and production, as lead compounds in novel drug development, as antioxidants to suppress cancer inducing free radicals, as drug with stereo-chemical structure impacting specific pharmacological activities. Generally, in natural product chemistry, some plants are notable for producing defensive chemicals against invaders and microbial attacks. Study of some of these chemicals have proven to be potential drug with selective toxicity against foreign cells in the treatment of various diseases. According to Rodríguez-Negrete *et al.*, phytochemicals are low-molecular-weight natural products

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found in normal cellular metabolic processes with biological activities which helps promote healthy conditions [13].

Health benefits of Phytochemical in Momordica charantia

Momordica charantia, has been used in traditional treatment since ancient times. The plant's fruit, leaves, and seeds have been utilized to alleviate symptoms associated with high blood sugar, and gastrointestinal problems. According to Potawale (2020) bitter melon has been used in various ways, including: 1) Consumption of the fruit juice extract, raw fruit which is believed to treat various health conditions. 2) Use of the leaves and stems of the plant boiled in water to create a decoction and consumed as a tea. 3) The plant's extract is also used as skincare treatment for topical wounds.

Medicinal Properties of the Plant

Phytochemicals flavonoids, found in plants, have been linked to improved cardiovascular health and reduced risk of certain cancers. [14]. Phytochemicals with alternating conjugated dienes showing high antioxidant properties which when consumed in good amount can help reduce potential damaging effects of free radicals damage to cells in the body. Some phytochemicals present in *Momordica charantia* having insulin like properties can serve as potential anti-hyperglycemic conditions in the body. Polyphenols: Found in high amounts in herbs and spices, polyphenols helps protect against chronic diseases [14].

Anti-Inflammatory Properties: Non-steroid and steroid drugs such as ibuprofen aspirin, and corticosteroid are common compounds used as anti-inflammatory agents to relieve pain, reduce swollen and improve mobility of people suffering from inflammation. However, the plant have been reported to contain cucurbitacins, flavonoids, and phenolic compounds with similar mode of action to that can reduce inflammation and alleviate symptoms associated with conditions like arthritis.. Flavonoids have reported to show remarkable activities against free radicals as potentials antioxidant [13].

Polysaccharide phytochemicals in *M. charantia* have been reported to have anti-tumor activity have been claimed to have properties similar to anti-cancer protection in preventing unregulated profileration of cells within certain tissues or organs in the body and ensuring normal functioning of cell apoptosis. A study confirmed the use of bitter melon to lower blood sugar level and treat infectious wounds [5, 17]. Sterols and triterpenoids are also important phytochemicals found in M. *charantia* with antioxidant capacity to scavenge free radicals [1].

Alkaloids and Proteins

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M. charantia alkaloids may exhibit analgesic, anti-inflammatory activities while other phytochemicals shows insulin-like activities, increase number of beta cells leading to higher levels of insulin and corresponding lower blood glucose levels [1, 6].

Aim of Study: The study aim was to identify, quantify, and characterize phytochemicals in *Momordica charantia* petroleum ether and ethanol extracts.

Research Objectives:

- To compare phytochemicals in petroleum ether extract with ethanol extract of the plant leaves.
- To compare percentage yield of each phytochemical in each solvent extract.
- To determine the effect of solvent polarity on extraction efficiency.
- To determine the most efficient solvent in extracting phytochemicals form Momordica plant.

Phytochemical Extraction Methods

Phytochemical extraction involves various techniques to isolate and recover bioactive phytochemicals. The choice of solvent, and method of extraction determines type and amount of phytochemicals extracted.

Conventional Extraction Methods:

1. Maceration: A common approach which involves steeping the sample in a liquid for 3-7 days to extract their properties. This method is suitable for crude extraction [8].
2. Percolation: A method used for extracting essential oils from plant and involves immersing the plant material in a excess volume of solvent and before decanting [8].
3. Decoction: This procedure of extraction is useful in isolating heat-stable compounds. Whereby the samples are boiled for half an hour to two hours, and then strained [8].
4. Reflux Extraction: This method involves evaporation of the solvent re-condensation for several hours at a constant temperature, preventing loss of organic compounds during extraction. [8].
5. Soxhlet Extraction: It is a crude method of extraction which used refluxing hot extracting solvent to extract soluble analytes from both dried or wet homogenized samples at moderately high temperature. However, this method is not recommended for highly volatile solutes [8].

Novel Extraction Methods:

1. Pressurized Liquid Extraction (PLE): High temperature and high pressure are used in the extraction of analytes from a solid samples rapidly, proving to be a recommended method for extracting compounds with biological activities.
2. Microwave-Assisted Extraction (MAE): The use of strong microwaves with solvents is employed to extract plant metabolites in

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this method, resulting in wide and versatile application for rapid extraction of analytes.

3. Ultrasound-Assisted Extraction (UAE): A method based on acoustic cavitation, which helps increase extract yield in a limited short time period.

4. Pulsed Electric Field Extraction (PEF): This method uses direct high electric current to make the sample's cell membrane more conductive, porous, and permeable.

5. Enzyme-Assisted Extraction: This method catalyze reactions and isolate analytes of interest in the sample. This method offers an ecofriendly method of extraction [9].

Major Phytochemicals in Momordica charantia

GCMS analysis has identified several compounds, such as cucurbitacins, flavonoids, and saponins, responsible for the plant's medicinal properties [9]. Phytochemicals, including 3-epi-isocucurbitacin, cucurbitacin B, and momordicoside K. possess antioxidant, and antimicrobial activities [12]. Cucurbitacins exhibit anti-cancer and anti-inflammatory properties, while flavonoids have antioxidant and antimicrobial properties [9].

Biosynthesis of different classes of Phytochemicals in Plants

Fatty Acid Biosynthesis*:* Acetyl CoA is the primary metabolite and precursor for many phytochemicals including sterol, amino-acid, and ketones as well as malonyl CoA intermediate. However, malonyl CoA is a precursor for the biosynthesis of different classes of fatty acids, ester, lipids, phospholipids, prostaglandins, poly-ketides, and phenyl-propanoid phytochemicals.

Biosynthesis of fatty acid, via the PDH-ACC pathway, begins with conversion of acetyl-Co-enzyme A to malonyl Coenzyme A with help of a carboxylase enzyme. ACP synthase catalyzes the conversion of malonyl Coenzyme A to malonyl-ACP. The malonyl-ACP undergoes methylation, reduction reaction by keto-reductase enzyme, de-hydration by de-hydratase, and finally an enol-reductase enzyme catalyzes the removes the double bond at carbon 2 and 3, to form a saturated 4-carbon chain fatty acid derivative with SACP group replacing the hydroxyl group in the carboxylic group in Malonly-CoA. The above described process refers to the hydrocarbon elongation of a 2-carbon acetyl-CoA to a 4-carbon chain fatty acid intermediate. Malonyl CoA further repeats the elongation process, leading to elongation of the in biosynthesis of lipids.

Ester, Lipids and Phospholipids Biosynthesis:

Phospholipid are excellent structural lipid that helps maintain cell rigidity and pressure. The hydrocarbon group is lipophilic, while the carboxyl group in most fatty acid is polar. Ester are well known derivative of

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fatty –acids produced as part of the plant's oil or fatty acid content through the esterase enzymes.

Lipids generally refers to tri-glyceride in which a molecule of glycerol has been esterified with 3 molecules of fatty acids to form the lipids and essential oil content in plant's seed, peels and flowers and fruits. Extraction and characterization of most of these oil by GC-MS has truly shown presences of varying range of fatty acids, esters, lipids, and phospholipids in various plant extracts.

Biosynthesis of Carboxylic acid Derivatives: Fatty acid derivatives produced, catalyzed by enzymes such as acyltransferases are prominent in most plants. In plants, esters play important roles in defense, signaling, and cuticle formation. The biosynthesis of esters involves the transfer of acyl groups from CoA to alcohols, resulting in the formation of esters.

Biosynthesis of Polyketides and Macrolide:
Polyketides are produced through the decarboxylative condensation of malonyl-CoA. The condensation reaction allows for formation of carbon to carbon bonds. When the condensation occurs under basic conditions, a beta-keto ester or beta-diketone is formed. Structurally, different classes of phytochemicals with biological and pharmacological activities are produced. Examples of Type I polyketides include macrolides. Macrolides are the precursor to many classes of beta-lactam antibiotics such as erythromycin and tetracyclines.

Biosynthesis of Terpenes:
Diverse classes of terpenes found in plants include monoterpenes, sesquiterpene, di-terperne, sesterterpene, triterpene and the carotenoids. The first step to the production of terpene via the mevalonate pathway, which produce isoprene units that are then assembled into terpenes are stated below [15]. a) condensation of acetyl-CoA, with acetoacetyl-CoA to HMG-CoA.
b) Enzymatic reduction of (S)-3-hydroxy-3-methylglutaryl CoA (HMG-CoA) with hydrogen from NAD to produce (R) mevalonic acid. c) Two phosphorylations of mevalonic acid to give 5-pyrophosphaste mevalonate. d) The mevalonate-5PP undergoes trans-elimination of the tertiary hydroxyl group and the carboxyl group to give 3-methyl-but-3-enyl pyrophosphate also referred to as Isopentenyl pyrophosphate (IPP). e) IPP undergoes isomerism to give 3-methyl-but-2-enyl pyrophosphate known as dimethyl-allyl-pyrophosphate (DMAPP) f) Isomerization of two molecules of IPP to give Geranyl-pyrophosphate GPP g) Addition of further isoprene unit to the GPP give farnesyl-pyrophosphate FPP and geranylgeranyl pyrophosphate C20 which a parent precursor to the diterpenoids and sesquiterpenoids. h)

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Two molecules of farnesyl-pyrophosphate joined head to tail gives the pre-squalene-pyro-phosphaste. i) Alkylation of the double bond of one FPP unit by the pyrophosphate of the other, j) Rearrangement and reduction leads to the formation of squalene, a C30 terpenoid found in many plants including *Momordica charantia* [15].

Terpene Synthases

TPS are biological macromolecules responsible for biosynthesis of different terpenoids. [2]. According to Tholl (2011) he confirmed that enzymes catalyzing biosynthesis of phytochemicals in Arabidopsis thaliana consists of 32 members, involved in the synthesis of various terpenes [16]. Light is one of the major factors that is responsible for terpene synthase gene expression and production of terpenoids [3]. Some terpenes acts as attractants for pollinators, while some plant produces phytochemicals that are anti-feedant for insects, or anti-grazing chemicals for herbivores by producing false amino acid analogue of arginine that is toxic to herbivores [11].

Alkaloid Biosynthesis: These are heterocyclic compounds mostly derived from different amino acids in plants. Most alkaloid are heteroatoms with cyclic ring and N-methyl group. Their production pathways, may commence essential protein building block units such as tyrosine, tryptophan, or lysine. [4).

Vinblastine biosynthesis in Catharanthus roseus involves enzymes like synthase and decarboxylase in the production this alkaloid [10]. From the structurally resemblance of many alkaloids with amino acids, the biosynthesis of many alkaloids has been traced back to their possible amino acids. For examples, Nicotine found in tobacco plants is derived from L-aspartic acid, Ephedrine is derived from L-Phenylalanine, and Quinine found in neem leaves is derived from L-tryptophan, while quinolones and the isoquinolines are derived from the L-Tyrosine.

MATERIALS AND METHODS:

Sample preparation:

The study used a combination of phytochemical screening, GCMS analysis, and SAR studies to identify and characterize the bioactive compounds present in Momordica charantia extract. Plant samples (leaves) were washed with distilled water and air-dried at room temperature (25°C) for 7-10 days. Samples were oven-dried to remove residual moisture and the dried plant materials pulverized.

Petroleum ether and ethanol Soxhlet extraction:

A Soxhlet apparatus was used to extract 50g of leaf powder with petroleum ether. The extraction process was repeated for three

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hours, allowing the solvent to reflux and extract the desired compounds. The procedure was repeated using ethanol solvent. The solvent in each extract was removed over a hot water bath.

RESULTS AND DISCUSSION

Table 1.0: Gas chromatogram of Phytochemicals in Momordica Charantia petroleum ether extract.

#	RT	Area %	Phytochemicas	Classes
1	12.525	3.712	Pyrimidine, 4-fluoro-6-dimethylamine*	Alkaloid
2	13.915	3.772	N-Desmethyltapentadol	Aromatic compound
3	14.017	6.928	Tridecanoic acid	Fatty acid
4	14.017	4.907	Phytol	Diterpenoid
5	14.119	4.404	Methyl stearate	Ester
6	15.056	18.029	Hexadecanoic acid, methyl ester	Ester
7	15.250	6.079	Decanoic acid, ethyl ester	Ester
8	15.363	5.392	9-Octadecenoic acid, methyl ester	Ester
9	16.643	0.171	Squalene	Triterpenoid
10	19.133	7.092	n-Hexadecanoic acid	Fatty acid
11	22.999	5.769	Methyl 9-cis,11-trans-octadecadienoate	Fatty acid

Table 2.0: Gas chromatogram of Phytochemicals in Momordica Charantia ethanolic extract

#	RT	Area %	Phytochemicas	Classes
1	7.250	0.790	Decanoic acid, ethyl ester	Ester
2	11.186	1.229	3-Fluoroamphetamine	Stimulant
3	12.245	1.835	3,5,7-Triamino-1-azaadamantane*	Aromatic polyamine
4	12.479	1.955	Neophytadiene*	Sesquiterpene
5	12.926	0.609	1,2-Benzenediol, 4-[2-(methylamino)ethyl-	Aromatic compound
6	13.371	0.879	2-(Dicyanomethylidene)-8H-pyrrolo[2,3-b]indole-3-carboxamide*	Aromatic compound
7	13.407	2.350	Hexadecanoic acid, methyl ester	Ester
8	13.834	2.669	Dibutyl phthalate	Aromatic compound
9	13.959	44.880	n-Hexadecanoic acid	Fatty acid
10	14.082	8.286	Octadecanoic acid	Fatty acid

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11	15.042	3.168	9,12-Octadecadienoic acid (Z,Z)-methyl-ester	Ester
12	15.099	2.886	9-Octadecenoic acid, methyl ester-(E)	Ester
13	15.223	3.958	Phytol	Diterpenoid
14	15.351	0.750	Methyl stearate	Ester
15	15.595	12.102	Oleic acid	Fatty acid
16	15.715	3.072	9,12,15-Octadecatrienoic acid, (Z,Z,Z)*	Fatty acid
17	15.829	3.787	Octadecanoic acid	Fatty acid
18	15.919	0.252	Octadecanoic acid	Fatty acid
19	19.111	2.108	Phthalic acid-monooctyl-ester	Aromatic compound
20	22.977	2.456	Squalene	Triterpenoid

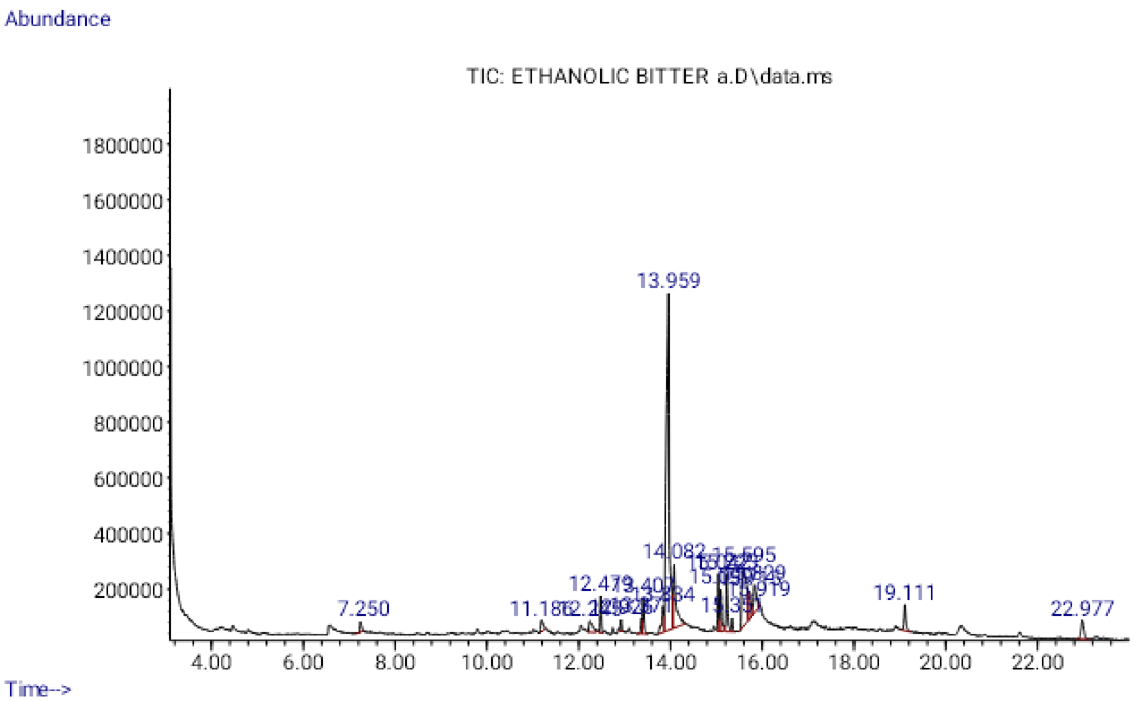

Figure 2.0: Gas chromatogram of *Momordica charantia* ethanolic extract.

Discussion on Table 1.0 on identified Phytochemicals in Momordica chatantia leaves petroleum ether extract.

The GC-MS analysis of Momordica charantia leaves revealed various classes of phytochemicals were identified, including alkaloids, aromatic compounds, fatty acids, diterpenoids, esters, and triterpenoids. These compounds have potential medicinal properties, making them valuable for further research and applications.

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Key Observations:

1) Hexadecanoic acid, methyl ester (18.029%) and n-Hexadecanoic acid (7.092%) are among the most abundant compounds, suggesting their potential importance in the plant's medicinal properties.
2) This extract predominantly comprises of various phytochemicals, such as alkaloids, aromatic compounds, carboxylic acids, diterpenoids, esters, and triterpenoids.
3) In the gas chromatographic petroleum ether extract of Momordica charantia, Pyrimidine, 4-fluoro-6-dimethylamine* alkaloid was the first to be eluted while Methyl-9-cis,11-trans-octadecadienoate fatty acid came out last of the column.

- **Alkaloids:** Pyrimidine, 4-fluoro-6-dimethylamine: This alkaloid may contribute to the plant's medicinal properties, although specific activities are not well-documented.
- **Aromatic Compounds:** N-Desmethyltapentadol: While its biological activity in Momordica charantia is unclear, tapentadol derivatives are known for analgesic properties.
- **Fatty Acids:** Tridecanoic acid, n-Hexadecanoic acid, and Methyl-9-cis,11-trans-octadecadienoate: These fatty acids have shown antimicrobial properties, which could contribute to the plant's medicinal value. n-Hexadecanoic acid, in particular, has demonstrated anti-inflammatory, antioxidant, and antimicrobial activities.
- **Esters:** Methyl stearate, Hexadecanoic acid, methyl ester, Decanoic acid, ethyl ester, and 9-Octadecenoic acid, methyl ester: These esters have shown antimicrobial properties, contributing to the plant's potential medicinal uses. Hexadecanoic acid, methyl ester is one of the most abundant compounds in the extract.
- **Diterpenoid** - Phytol has demonstrated antioxidant, antibacterial, and antifungal properties, making it a valuable compound for medicinal applications.
- **Triterpenoids:** *Squalene*: This triterpenoid has conjugated double bonds and high antioxidant activity and medicinal properties.

The identified phytochemicals in Momordica charantia leaves have potential implications for antimicrobial activity due to the fatty acids and esters which may contribute to the plant's antimicrobial properties. As well as antioxidant activity due to presence of phytol and squalene.

Discussion on Table 2.0 on identified Phytochemicals of Momordica chatantia leaves ethanolic extract.

The GC-MS analysis of the ethanolic extract of Momordica charantia leaves revealed a diverse range of phytochemicals, including fatty acids, esters, diterpenoids, triterpenoids, aromatic compounds, and sesquiterpenes.

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Key Observations:

1) n-Hexadecanoic acid (44.880%) and Oleic acid (12.102%) are the most abundant compounds in the extract, suggesting their potential importance in the plant's medicinal properties.

2) This extract predominantly comprises of various phytochemicals, such as carboxylic acids, esters, diterpenoids, triterpenoids, aromatic compounds, and sesquiterpenes.

3) In the gas chromatographic ethanolic extract of Momordica charantia, (Decanoic acid-ethyl ester) was the first to be eluted while squalene triperpenoid came out last of the column.

- Fatty Acids: The identified fatty acids, such as n-Hexadecanoic acid, Octadecanoic acid, Oleic acid, and 9,12-Octadecadienoic acid, have been reported to possess antimicrobial and anti-inflammatory properties. n-Hexadecanoic acid is the most abundant compound in the extract, suggesting its potential importance in the plant's medicinal properties.
- Esters: The esters identified in the extract, such as Decanoic acid, ethyl ester, Hexadecanoic acid, methyl ester, and Methyl stearate, have been reported to possess antimicrobial and antioxidant properties. These compounds may contribute to the plant's potential medicinal applications.
- Diterpenoids and Triterpenoids: Phytol, a diterpenoid, and Squalene, a triterpenoid, have been reported to possess antioxidant and anti-inflammatory properties. These compounds may contribute to the plant's potential health benefits and applications in medicine or food industries.
- Aromatic Compounds: The identified aromatic compounds, such as 3-Fluoroamphetamine and 1,2-Benzenediol, 4-(2-(methylamino)ethyl-, may possess various biological activities, although further research is needed to confirm their specific properties.
- Sesquiterpenes: Neophytadiene, a sesquiterpene, has been reported to possess antimicrobial and antioxidant properties, which may contribute to the plant's potential medicinal applications.

Potential Implications: Antimicrobial activity: Fatty acids and esters have shown antimicrobial properties, which could make Momordica charantia extracts useful for developing antimicrobial agents or preserving food products. Antioxidant activity: Phytol and squalene have antioxidant properties, which could contribute to the plant's potential health benefits and applications in medicine or food industries.

Summary of study

This research on effect of solvent polarity on the phytochemical profile of *Momordica charantia* leaves in petroleum ether and ethanolic extracts highlights the following major findings:

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Key Findings of study

- Phytochemical diversity: The study revealed a diverse range of phytochemicals in both extracts, including fatty acids, esters, diterpenoids, triterpenoids, aromatic compounds, and sesquiterpenes.
- Solvent effect: The ethanolic extract yielded more phytochemicals (20) than the petroleum ether extract [11], indicating that ethanol is a more effective solvent for extracting phytochemicals from Momordica charantia.
- Bioactive compounds: The study identified 4 bioactive compounds in the ethanolic extract and 1 bioactive compound in the petroleum ether extract, suggesting that the ethanolic extract may have more potential medicinal applications.
- Common phytochemicals: Five phytochemicals were found in both extracts, including 9-Octadecenoic acid-methyl ester, Decanoic acid-ethyl ester, n-Hexadecanoic acid, phytol, and squalene.
- 3 Phytochemicals was observed to give higher yield in ethanolic extract: 9-Octadecenoic acid-methyl ester with 5.392% yield compared to 2.886% in the ether, n-Hexadecanoic acid with 44.880% yield compared to 7.092%, and squalene with 2.456% yield compared to 0.171% in the petroleum ether extract.
- 2 Phytochemicals was observed to give higher yield in petroleum ether extract: phytol with 4.907% yield compared to 3.958%, and Decanoic acid-ethyl ester with 6.079% yield in comparison with 0.790% in the ethanolic extract.
- Last Elution time of fatty acid than its ester derivative: It is observed fatty acid eluted the column later than its ester derivatives. For example 1) Hexadecanoic acid-methyl ester eluted at 15.056 minute while the fatty acid (n-Hexadecanoic acid) eluted later at 19.133 minute in the petroleum ether. 2) Hexadecanoic acid-methyl ester eluted at 13.407 minute while the n-Hexadecanoic fatty acid eluted at 13.959 minute in the plant's ethanolic extract. 3) Hexadecanoic acid-methyl ester eluted at 13.407 minute while its fatty acid n-Hexadecanoic acid eluted at 13.959 minute in the plant's ethanol extract.

CONCLUSION

The study demonstrated that Momordica charantia leaves contain a diverse range of phytochemicals with potential medicinal properties. The ethanolic extract was found to be more effective in extracting phytochemicals than the petroleum ether extract. The study reveals that *Momordica charantia* may have potential applications in medicine, agriculture, or food industries.

RECOMMENDATIONS

Based on the observed results of this research, the following recommendations are suggested:

POTENTIAL APPLICATIONS

1. Explore the potential use of *Momordica charantia* extracts or isolated

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phytochemicals as antimicrobial or antioxidant agents.

2. Investigate the potential use of *Momordica charantia* extracts as natural pesticides or growth promoters.
3. Evaluate the potential use of *Momordica charantia extracts as food preservatives or additives*.
4. Standardize the extraction methods to ensure consistent yields and quality of phytochemicals.
5. Develop quality control protocols to ensure the authenticity and quality of Momordica charantia extracts.

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