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Evaluation of functional groups and phytochemical composition of selected medicinal plants

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Abstract

Plants contain several active ingredients which are medicinal and can be therapeutic in nature. Phytochemicals present in plant helps prevent diseases in organisms by triggering host defense against disease. Phytochemicals belong to different functional groups which are known to have anti-oxidant and antimicrobial activities which are capable of medicinal effects in human beings. The present medicinal plants selected for the study include leaves of pawpaw (*Carica papaya*), guava (*Psidium gujava*) and orange (*Citrus cinensis*). The Fourier Transform Infrared spectrophotometer analysis (FT-IR) was performed to know the functional groups of the active components present in the leave extract based on the peaks values in the region of Infra-Red radiation either directly or by inference while Quantitative phytochemical analysis of the plants extract were performed using Gas Chromatograph Flame Ionizing Detector (GCFID) to quantify the phytochemicals found in the plant extract. Results From the spectral analysis for the extracts, showed the characteristic peak area ranges from 723.1 cm^{-1} to 3406.8 cm^{-1} for *Psidium gujava*, 805.1 cm^{-1} to 3336.0 cm^{-1} for *Citrus cinensis* and from 723.1 cm^{-1} to 34388.2 cm^{-1} for *Carica papaya, which* corresponded to 16 (sixteen) distinctive functional groups including alcohol (OH), alkane (CH), amine (NH), aromatic (CH), α,β-unsaturated ketone (C=C), nitro compound (N-O), sulfonamide (S=O), secondary alcohol (C-O), sulfoxide (S=O), alkene (C=C), carboxylic (OH), Isothiocyanate (N=C=S), flouro compound (C-F), aliphatic ester (C-O), alkyne (CΞC) and thiocyanate (S-CΞN). The phytochemicals present in leave extracts generally include proanthocyanin, lunamarin, quinine, epihedrine, anthocyanin, flavan, sapogenin, phenol, flavonones, naringenin, steroids, epicatechin, kaempferol, phytate, flavone, oxalate, catechin, resveratrol and tannin. The plant exreacts can be used for diverse medicinal purposes.

Keywords: Anti-oxidant, FT-IR, Medicinal plants, phytochemicals

1. Introduction

Some medicinal plants serve as a good source of medication for traditional systems of medicine, modern medicines, nutraceuticals, food supplements, pharmaceutical intermediates and chemical entities for synthetic drugs (Nostro *et al.,)* [15] Plants are rich and contain a lot of active components which are therapeutic. They are a good reservoir of chemical compounds such as tannins, flavonoids, saponins resins, alkaloids etc (Doss, 2009) [7]. Plants have a variety of compounds which are natural belonging to different molecular families which have numerous vital properties to humans (Raaman, 2006) [17]. The medicinal plants have proven to be important in curing of human diseases due because of their active components (Govindappa *et al.,*) [9] Phytochemicals are present in whole plants or different segments of the plant. Constituents of the plant provides defense barrier which serves as a means of protection of organisms from numerous diseases (Sen *et al.,*). Seventy percent of populations in developed and developing countries depend on plants with medicinal value for their medical health needs, which aids as a vital resource for curing of different diseases (wichtl, 2004) [25].

The medicinal plants chosen for this study include leaves of pawpaw (*Carica papaya*), guava (*Psidium gujava*) and orange (*Citrus cinensis*). These leaves are vital for varieties of treatments in traditional medicine for example *Carica papaya* leaves serves as treatment for malaria (Titanji *et al.,* 2008) [24], can induce abortion, stop purging, or smoked to ease asthmatic attack (Morton, 1987) [14]; *Psidium guajava* and *Citrus cinensis* leaves have been recommended for treating inflammation, diabetes, hypertension, caries, wounds, pain relief, fever, diarrhea, rheumatism, lung diseases, and ulcers (Gutiérrez *et al.,* 2008) [8].

The purpose of this research is to evaluate the phytochemical constituents present in leaves of pawpaw (*Carica papaya*), guava (*Psidium gujava*) and orange (*Citrus cinensis*) by ethanol and find the secondary metabolites with functional moieties which are present by FTIR. Efforts were made for detailed study for further research.

2. Material and methods

2.1. Collection of plant materials

Leaves of *Carica papaya* (PawPaw), *Psidium gujava* (Guava), and *Citrus cinenesis* (Orange) were collected from Owerri, Imo state, Nigeria and used in the study.

2.2 Preparation of Plant Extract

Preparation of the plant extracts were performed using the method reported by Ibe *et al.*, (2017).The obtained plant material were air-dried by shade at room temperature, grinded into fine powdered form using domestic mixture and were properly preserved in an airtight labeled plastic sampling bags for further studies.

2.3 Extraction of plant samples

The grinded plant samples were extracted using ethanol. Extractions were performed the method modified by Hussaini and Mahasneh. The plant materials were extracted at room temperature with ethanol 95%(100 mL/10 g of plant material). The extract of each plant were filtered using (Whatman No.1) filter paper and evaporated under vacuum at 40 °C using a rotary vacuum evaporator, the concentrated extract thus obtained was collected in screwcap vial and used for further studies.

2.4 Quantitative test for phytochemicals

Quantitative phytochemical analysis of the plants extract were performed using a Buck 530 Gas Chromatograph (USA) equipped with an on-column, automatic injector, Electron capture detector, and HP 88 capillary column (100 m x 0.25 µm film thickness). The detector temperature was set at 280 ºC, column temperature was set at 210 ºC, and injector temperature will be set at 250ºC while the integrated chart speed was set at 2 cm/min (Duru and Enyoh, 2020) [8].

3. Result

3.1 Fourier Transform Infrared (FTIR) analysis of extract

The results for the Fourier transform infrared analysis of the plant extracts are presented in Figures 1-3 and summarized in Table 1-3.

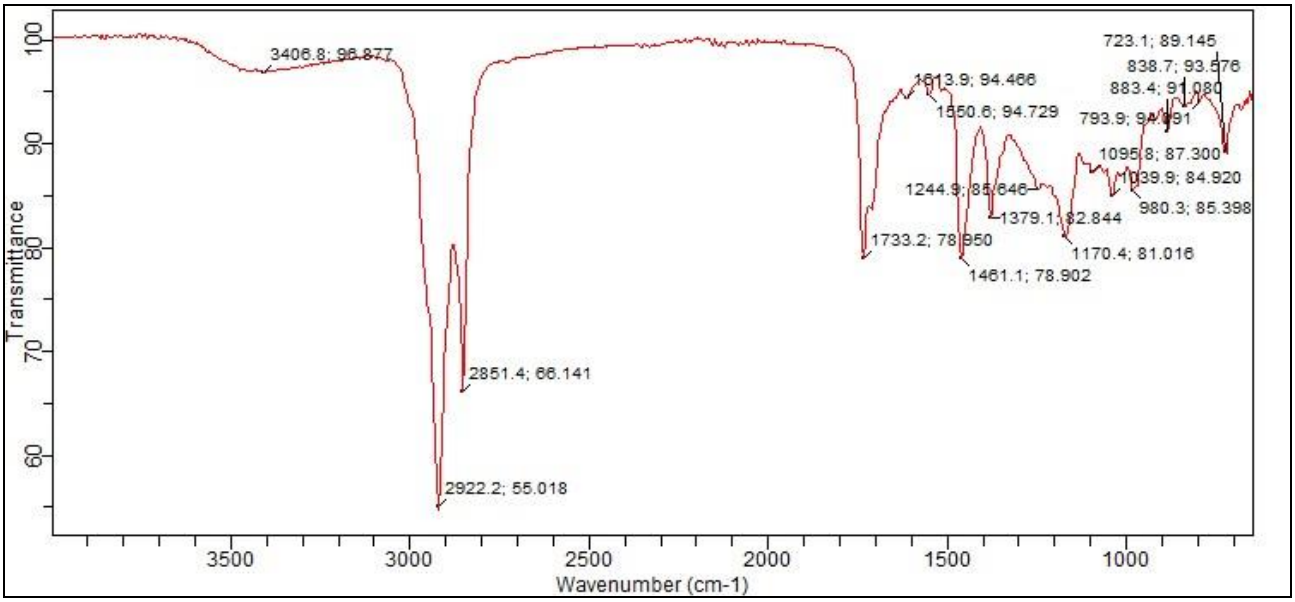

Fig 1: FTIR spectra for *Psidium gujava* leave extract

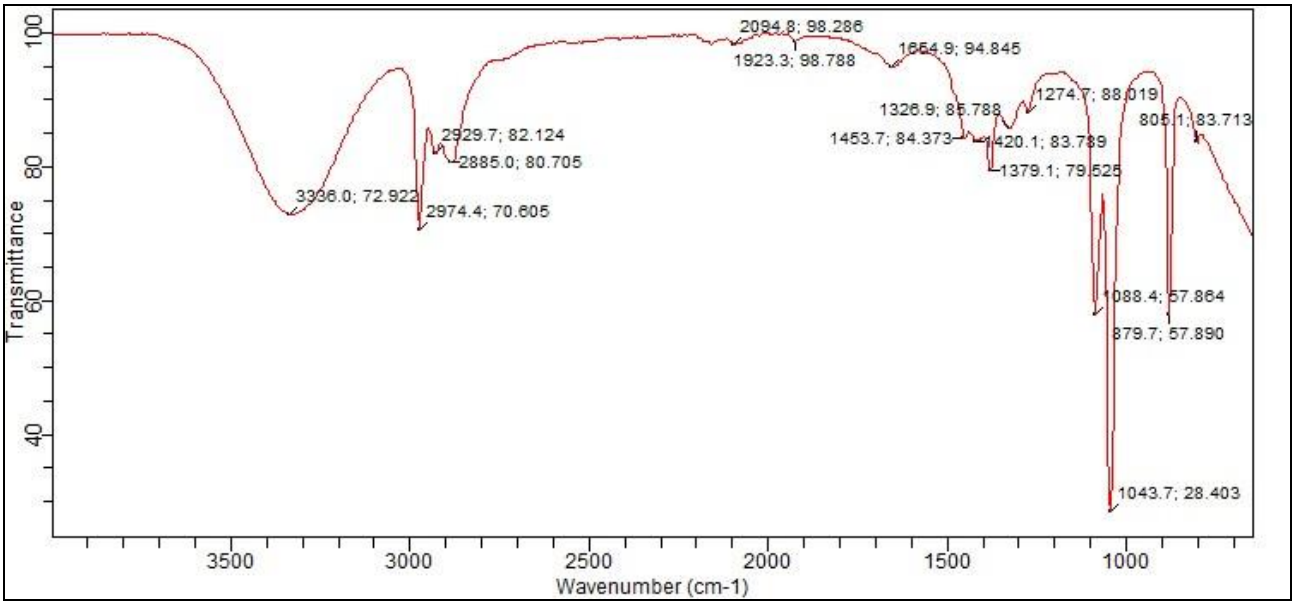

Fig 2: FTIR spectra for *Citrus cinensis* leave extract

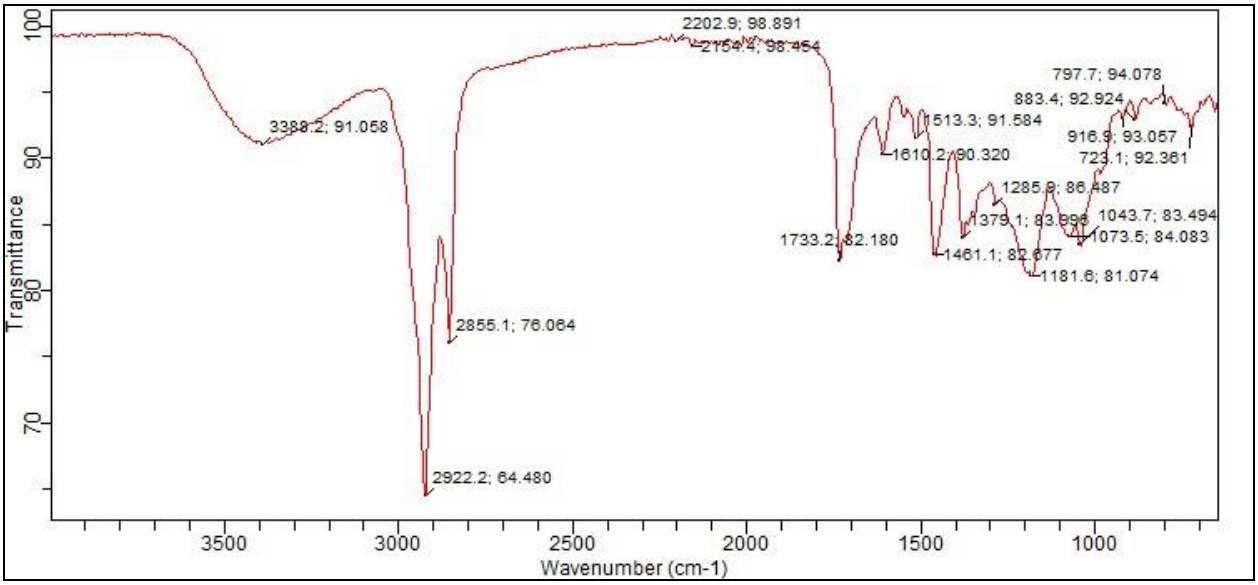

Fig 3: FTIR spectra for *Carica papaya* leave extract

Table 1: Interpretation of Infrared spectrum for *Psidium gujava*

Psidium gujava		
Peaks (cm^{-1})	**Functional group**	**Remark**
3406.8	Alcohol, OH	Stretching
2922.2	Alkane, CH	Stretching
2851.4	Amine, NH	Stretching
1733.2	Aromatic, CH	Bending
1613.9	α,β-unsaturated ketone, C=C	Stretching
1550.6	nitro compound, N-O	Stretching
1461.1	Alkane, CH	Bending
1379.1	Alkane, CH	Bending
1170.4	Sulfonamide, S=O	Stretching
1095.8	Secondary alcohol, C-O	Stretching
1039.4	Sulfoxide, S=O	Stretching
980.3	Alkene, C=C	Bending
883.4	Alkene, C=C	Bending
838.7	Alkene, C=C	Bending (trisubstituted)
793.9	Alkane, CH	Bending
723.1	Alkane, CH	Bending

Table 2: Interpretation of Infrared spectrum for *Citrus cinensis*

Citrus cinensis		
Peaks (cm^{-1})	**Functional group**	**Remark**
3336.0	Alcohol, OH	Stretching
2974.4	Alkane, CH	Stretching
2929.7	Amine, NH	Stretching
2885.0	carboxylic, OH	Stretching
2044.8	Isothiocyanate, N=C=S	Stretching
1923.3	Aromatic, CH	Bending
1654.9	Aromatic, CH	Bending
1326.9	Nitro compound, N-O	Stretching
1453.7	Alkane, CH	Bending
1420.1	Alkane, CH	Bending
1379.1	Alkane, CH	Bending
1274.7	Flouro compound, C-F	Stretching
1088.4	Aliphatic ester, C-O	Stretching
1043.7	Sulfoxide, S=O	Stretching
805.1	Alkane, CH	Bending

Table 3: Interpretation of Infrared spectrum for *Carica papya*

Carica papaya		
Peaks (cm^{-1})	**Functional group**	**Remark**
3388.2	Alcohol, OH	Stretching
2922.2	Alkane, CH	Stretching
2855.1	Amine, NH	Stretching
2202.4	Alkyne, CΞC	Stretching
2154.4	Thiocyanate,S-CΞN	Stretching
1733.2	Aromatic, CH	Bending
1610.2	α,β-unsaturated ketone, C=C	Stretching
1513.3	nitro compound, N-O	Stretching
1379.1	Alkane, CH	Bending
1285.9	Flouro compound, C-F	Stretching
1181.6	tertiary alcohol, C-O	Stretching
1073.5	Secondary alcohol, C-O	Stretching
916.9	Alkene, C=C	Bending
883.4	Alkene, C=C	Bending
797.7	Alkane, CH	Bending (1, 2, 3-trisubstituted)
723.1	Alkane, CH	Bending

3.2 Phytochemical analysis of extract

The GC analysis for phytochemicals in the plant extract is presented in Figures 4 to 6.

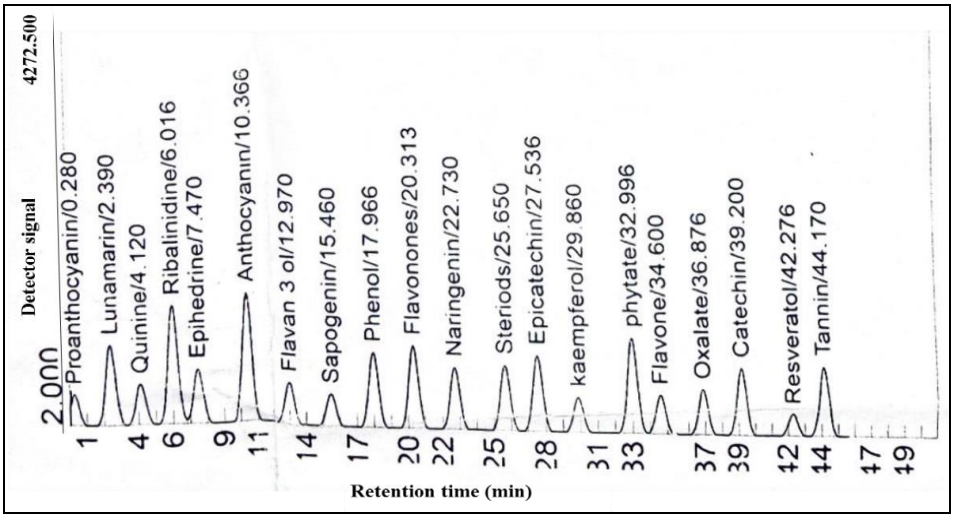

Fig 4: GC spectra for *Psidium gujava* leave extract

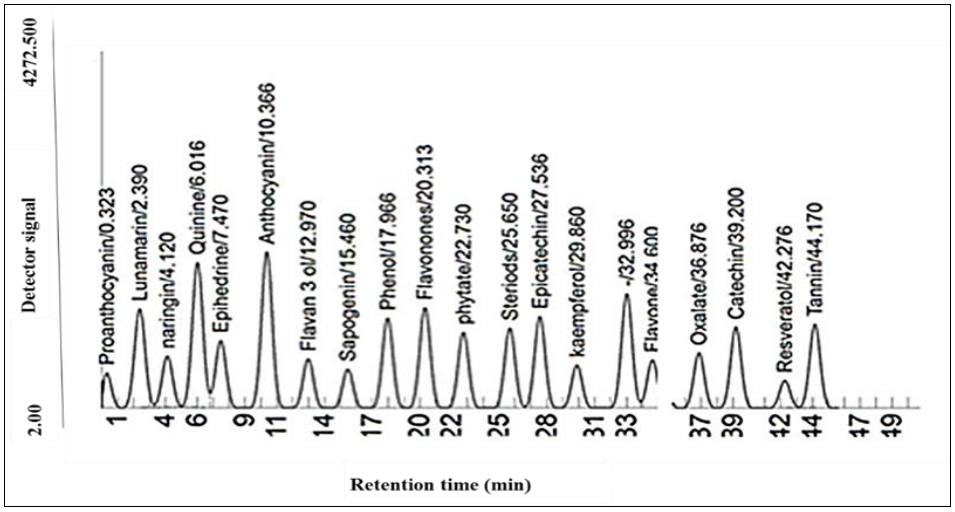

Fig 5: GC spectra for *Citrus cinensis* leave extract

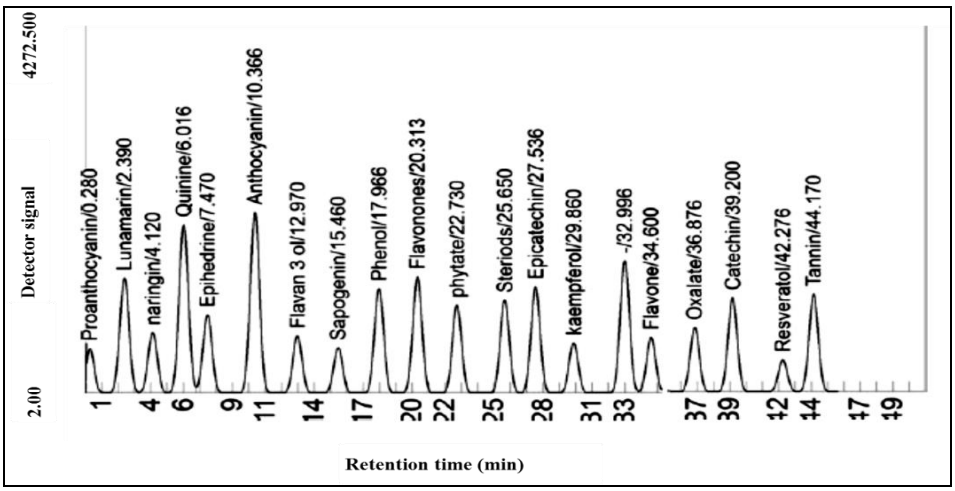

Fig 6: GC spectra for *Carica papaya* leave extract

4. Discussion

4.1 Fourier Transform Infrared (FTIR) analysis of extract: The FT-IR spectrum was used to identify the functional groups of the active constituents found in the leave extract based on the peaks values in the region of Infra-Red radiation either directly or by inference. When the

extracts were passed into the FT-IR, the functional groups of the constituents were separated based on its peaks ratio. The related changes in the spatial arrangement of the groups involved are reflected in the infrared spectrum as additional bands and added complexity. The results summarized in Table 1. From the spectral analysis for the extracts, the characteristic peak area ranges from 723.1 cm^{-1} to 3406.8 cm^{-1} for *Psidium gujava*, 805.1 cm^{-1} to 3336.0 cm^{-1} for *Citrus cinensis* and from 723.1 cm^{-1} to 34388.2 cm^{-1} for *Carica papaya.* Results showed that the plant extract has 16 (sixteen) distinctive functional groups including alcohol (OH), alkane (CH), amine (NH), aromatic (CH), α,β-unsaturated ketone (C=C), nitro compound (N-O), sulfonamide (S=O), secondary alcohol (C-O), sulfoxide (S=O), alkene (C=C), carboxylic (OH), Isothiocyanate (N=C=S), flouro compound (C-F), aliphatic ester (C-O), alkyne (CΞC) and thiocyanate (S-CΞN).These characteristic functional groups revealed the biochemical compositions, especially the phenolic compounds, carboxylic acids, alcohols, carbohydrates, and proteins in the plant, responsible for several medicinal properties and biological activities. The presence of phytochemicals carrying hydrogen functional group ⁻OH bonded found that the hydroxyl functionality is a vital part of most of phenolic phytochemicals such as polyphenols and flavonoids to provide a relative ranking of extracts in term of antioxidant activity. Therefore, the presence of characteristic functional groups that are known for various medicinal properties may be influence considerably the biological properties and contribute meaningfully to their solubility, partition coefficient, stereochemistry and inherent acid–base properties (Knittel & Zavod, 2008). The results gotten showed that the extracts may act as source of therapeutic agent. The richness of the samples–OH group enhances its ability for forming hydrogen bonding capacity and confirmed therefore, the higher potential of its antioxidant and antimicrobial activities (Diaz *et al*., 2012; Ibe *et al.*, 2019) [12].

4.2 Phytochemical analysis of extract

The GC analysis for phytochemicals in the plant extract is presented in Figures 4 to 7. The phytochemicals present in leave extracts generally include proanthocyanin, lunamarin, quinine, epihedrine, anthocyanin, flavan, sapogenin, phenol, flavonones, naringenin, steroids, epicatechin, kaempferol, phytate, flavone, oxalate, catechin, resveratrol and tannin. These compounds are famous for having anti-oxidant and antimicrobial activities. Proanthocyanidins are condensed tannins with various pharmacological properties. These phytochemicals are considered as 'offense and defense molecules because of their human health benefits (Siddhuraju *et al.*,) [21]. The attestation of their different health aspects, namely, antioxidant, anticancer, antidiabetic, neuroprotective, and antimicrobial has earned them repute in thermochemistry. Lunamarine is a quinolone alkaloid found in Boerhavia diffusa. The compound has revealed some *in vitro* anticancer, antiestrogenic, immunomodulatory, and anti-amoebic activity (Jamuna *et al.*,) [13]. Quinine has been discovered to be good for treatment of malaria and associated febrile states, leg cramps caused by vascular spasm. Ephedrine is a stimulant for the central nervous system ideal for stopping breathing problems (as a bronchodilator), nasal congestion (as a decongestant), low blood pressure problems (orthostatic hypotension), or urine-regulation issues are treated with Ephedrine (Shriram *et al.*,) [20]. Anthocyanins helps to reduce blood pressure, increase better visual acuity, lower cancer cell proliferation, prevent the formation of tumor, prevent diabetes, reduce the risk of CVD modulate cognitive and motor function. Flavan-3-ols has many health benefits which includes acting as antioxidant, anticarcinogen, cardio preventive, antimicrobial, anti-viral, and neuro-protective agents. Sapogenins are the aglycones, or non-saccharide, portions of the family of natural products known as saponins (Dholaria *et al.*,) [26]. Saponins may help lower cholesterol levels, strengthen the immune system, treats diabetes, and prevents tumor growth. They also enhance lipid metabolism and may help prevent and treat obesity. Plant materials which contain phenol are known to have antioxidants effects which means that they can inhibit the reaction of free radicals from other molecules in your body, avoiding destruction of DNA and preventing adverse health problems. Flavanones contain anti-inflammatory properties. They assist to manage your weight and cholesterol. Naringenin has a lot of biological effects on human health, which includes a reduction in lipid peroxidation biomarkers and protein carbonylation, promotes carbohydrate metabolism, increases antioxidant defenses. Steroids work by reducing inflammation and decreasing the activity of the immune system. They are ideal to treat numerous inflammatory diseases and conditions. Epicatechin is a strong antioxidant, has insulin mimic action which helps heart function (Oliveira-Junior *et al.*,) [16]. Epicatechin leads to blood vessel dilation by regulating nitric oxide, a molecule produced by the blood vessel endothelium to signal the surrounding muscle to relax. Kaempferol decreases the possibilities of chronic diseases, especially cancer (Adefuye *et al.*,) [1]. It modulates apoptosis, angiogenesis, inflammation and metastasis. Studies have shown phytic acid may protect against certain cancers. phytate or Phytic acid is particularly protective against colon cancer by suppressing oxidative damage to intestinal cells. Flavones is similar to a flavonoid subgroup which helps regulate cellular activity and ward off free radicals that cause oxidative stress on your body (Altemimi *et al.*,) [2]. In simpler terms, protecting the body from toxins and stressors encountered from day to day activities. Oxilate or oxalic acid act as an antioxidant in the body (Santana *et al.*,) [18]. Catechins can reduce free radicals from forming in the body, protecting cells and molecules from damage. These free radicals helps to prevent aging and many types of diseases. Resveratrol helps reduce body fats, It protects the brain, ease joint pain and increases insulin sensitivity (Bakal *et al.*,) [3]. Tannin has been verified to have a lot of health benefits like anti-oxidant, anti-cancerous, anti-allergic, anti-inflammatory, anti-helminthic and anti-microbial activities. Agricultural wastes and food processing wastes contains a large amount of proanthocyanidins, proper utilization can help produce dietary supplements and in gradients which are functional without depleting.

5. Conclusion and recommendation

The summary of findings of the study includes;

1. The plant extract contain 16 (sixteen) distinctive functional groups including alcohol (OH), alkane (CH), amine (NH), aromatic (CH), α,β-unsaturated ketone (C=C), nitro compound (N-O), sulfonamide (S=O),

secondary alcohol (C-O), sulfoxide (S=O), alkene (C=C), carboxylic (OH), Isothiocyanate (N=C=S), flouro compound (C-F), aliphatic ester (C-O), alkyne (CΞC) and thiocyanate (S-CΞN).

2. The phytochemicals present in leave extracts generally include proanthocyanin, lunamarin, quinine, epihedrine, anthocyanin, flavan, sapogenin, phenol, flavonones, naringenin, steroids, epicatechin, kaempferol, phytate, flavone, oxalate, catechin, resveratrol and tannin

Conflict of interest

The authors stated no conflict of interest concerning the publication of this article.

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