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Chemical Composition and Antimicrobial Activity of the Essential oils of 14 known *Ficus* species – A Concise Review

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Abstract: Compounds useful for drugs, cosmetics, and food have been obtained directly or indirectly from living organisms over the years. However, there has been a renewed interest in getting useful compounds from living organisms, especially plants. Essential oils, interchangeably called volatile oils, are bioactive compounds found in minute quantities in some plants. Essential or volatile oils have been known for years to find usefulness in foods, drugs (antimicrobial, antifungal), and cosmetics. This review attempts to summarize information on the essential oil from *Ficus* species concerning their morphology, pharmacology, bioactivity, and application. This was achieved by gathering information on essential oils from different *Ficus* species. Essential oils from *Ficus* species are a good source of bioactive compounds for use in drug, food, and cosmetic industries. It is worthy to note that Nigerian Figs were characterized by the high presence of phytol and 6,10,14-trimethyl-2-pentadecanone, and these compounds are, therefore, seen as markers. Furthermore, this review presents numerous insights on how to best harness the different potentials of the essential oils and possibilities to be examined.

Keywords: essential oil; *Ficus* plants; bioactive compounds; phytol; drugs; cosmetics.

1. Introduction

Of recent, there has been a shift in the use of conventional therapies to treat ailments to other natural methods, as interest has grown over the last decade in seeking alternative therapies from the phytochemicals present in plants of natural origin [1–3]. It is no longer news that these essential oils and the different extracts contained in plants could be used in conventional drugs to treat myriads of infectious diseases [3]. A group of plants called aromatic plants is implicated in traditional medicine due to the high level of essential oils [4]. In the last few years, the use of these aromatic plants, as well as their essential oils, have increased, as there has been a great deal of input both industrially and research-wise [5] to see to their usefulness in food [6,7], drugs [8] and as beauty products [7,9,10] of which *Ficus* species have been an essential part. Presently, about 3000 of these oils are known, with 10% of them garnering quite a high level of importance economically [11].

Essential oils can be extracted from the leaves [4,12], stem barks [13], fruits [14,15], seeds [7,16], latex [17] and roots [18] of plants. *Ficus* (Moraceae) is one of the largest genera of angiosperms, including trees, hemiepiphytes, shrubs, creepers, and climbers located in the tropics and subtropics worldwide, totaling over 800 species [19]. The genus *Ficus* also contains vines, shrubs, and woody trees located in forests, tropical and subtropical areas around the globe [20]. This genus is widespread across warmer parts of Asia, Africa, America, and Australia [21]. Collectively known as fig trees, the most popular *Ficus* species is the common Fig (*Ficus carica* Linn), the source of the commercial fruit-fig [22]. This large genus with high nutritional and economic value plays a vital role as a genetic resource, making up a good and significant part of the biodiversity in the rainforest's ecosystem [23]. Animals in the tropical habitat, which are consumers of fruit, see figs as a good source of nourishment [24].

Some examples of the different species of *Ficus* plant include; *Ficus aspera* G.Forst (clown fig), *Ficus lacor* Buch.-Ham (Pakur tree), *Ficus auriculata* Lour. (Roxburgh fig), *Ficus asperifolia* Miq, *Ficus benghalensis* L (Indian banyan), *Ficus altissima* Blume (Council tree), *Ficus benjamina* L (weeping fig), *Ficus carica* L (common edible fig), *Ficus binnendykii* (Miq.)Miq. (narrow-leaf ficus), *Ficus celebensis* Corner (willow ficus), *Ficus glomerata*, *Ficus capensis* Thunb, *Ficus elastic* (Indian rubber tree), *Ficus exasperata* Vahl, *Ficus deltoidei* Jack (mistletoe fig), *Ficus lingua* Warb. ex De Wild. & Dur. (box-leaved fig), *Ficus lyrata* (fiddle-leaf fig), *Ficus macrophylla* Desf. ex Pers. (Moreton Bay fig), *Ficus saussureana* DC., *Ficus microcarpa* L (Chinese banyan), *Ficus nitida*, *Ficus palmate* Forssk, *Ficus pseudopalma* Blanco (Philippine fig), *Ficus pumila* L (creeping fig), *Ficus polita* Vahl, *Ficus racemosa* L, *Ficus religiosa* L (bo tree or sacred fig), *Ficus retusa* L, *Ficus rubiginosa* Desf, *Ficus sagittata* J.Konig ex Vahl, *Ficus stricta* (Miq.) Miq, *Ficus subulata* Blume, *Ficus sycomorus* L, *Ficus tikoua* Bureau (Waipahu fig) *and Ficus tsiela* Roxb [25].

In this review, some *Ficus* plants' essential oils' morphological, pharmacological, and phytochemical attributes are enumerated. This study focused on the essential oils of *Ficus* plants with a special emphasis on their phytochemical components, usefulness, bioactivity, and insight into some of the important species.

2. Essential Oils

Essential oils are complex mixtures of natural origin that may comprise about 20-60 constituents of varying concentrations [26]. Essential oils are also referred to as volatile or ethereal oils, are odorous (possess fine fragrance) compounds found only in a small percentage of kingdom Plantae (about 10%) [27,28]. Their synthesis is completed in the petals and has been observed in numerous flowers. They are stored in special brittle secretory structures, such as secretory ducts, glands, secretory hairs or resin ducts, and secretory cavities in plants [28–37]. Essential oil is hydrophobic; thus, it is not quite soluble in water and other polar solvents. However, this mostly yellow-color solution is highly soluble in nonpolar solvents [38]. Three biosynthetic pathways play an important role in producing these oils in plants; the mevalonate pathway, the methyl-erithrytol-pathway, and the shikimic acid pathway yielding sesquiterpenes, mono- and diterpenes, and phenylpropenes, respectively [39]. Various plants with high essential oil yield content implicated commercially are termed "Essential oil plants" [40]. The Jasmine (*Jasminum sambac* (L.) Aiton), rose (*Rosa sp.*), and tuberose (*Polyanthes tuberosa* L) are examples of essential oil plants, as they produce large quantities of volatile compounds [39].

Plants use essential oils as means of defense, internal messengers, as well as pollinating agents, attracting insects for pollination [16,40,41]. Various methods suitable for extracting these essential oils exist, but majorly, steam/water distillation, hydro-distillation, and steam distillation are used for this process [37,42–45]. Among the distillation methods for extraction, hydrodistillation is the most common, oldest, and easiest method often employed. Some researchers are interested in the volatile constituents, compounds or aroma active compounds in essential oils; therefore, they explore other methods, which include: solid-phase microextraction (SPME) [46–49], solvent-assisted flavour evaporation (SAFE) [50], supercritical fluid extraction (S.F.E.) [51,52], simultaneous distillation extraction (SDE) [27,53], solvent-free microwave extraction (SFME) [54], and the purge-and-trap technique [53,55–57]. Some researchers reported that if one is interested in genuine essential oils and active aroma compounds, hydrodistillation may not be the best choice because of the high temperature [47] involved. It is crucial to mention that SPME as a method is focused on aroma profile analysis based on the qualitative composition of essential oil. It is gaining cognizance because of advantages such as energy-saving, reduction in extraction time, and preservation of thermo-labile components of essential oils from degradation considering the high temperature required for extraction when using the conventional hydrodistillation or steam distillation method [46,52]. Other advantages of SPME are the use of a relatively small amount of sample for extraction [48], the high degree of automation [47], and the non-extraction of non-volatile substances [47,48]. Sometimes a modified SPME known as HS-SPME (Headspace solid-phase microextraction) is often used, for example, the extraction of volatile compounds from the fruit of *Seseli libanotis* (L.) W.D.J.Koch was compared using hydrodistillation and HS-SPME [48]. Some other Researchers [47] also compared the extraction of essential oil and related compounds from aromatic plants using five different methods of which SPME was among the methods compared. The researchers reported that SPME is the most useful method for the extraction of essential oil; the remaining four methods are hydrodistillation, supercritical fluid extraction, solvent extraction, and accelerated solvent extraction. The researchers, however, documented that hydrodistillation will be viewed as the best method when it comes to essential oil extract and essential oil content because essential oil is defined in pharmacopeias according to the use of this procedure, but to investigate genuine odorous compounds, hydrodistillation often leads to the transformation of sensitive genuine odorous compounds. The essential oil from cultivated and wild lotus (*Nelumbo Lucifera* Gaertn) was compared using three different extraction techniques. The researchers documented that SPME is most favorable for the highly volatile components of essential oils [58].

Solvent-assisted flavor evaporation (SAFE) is an efficient method of extracting volatiles and has been reported to extract with high efficiency with emphasis on avoidance of pyrolysis of components of essential oil leading to oils with fresh flavor [50]; SAFE and hydrodistillation was compared in the extraction of volatile compounds from *Magnolia obovata* Thunb leaves [50].

The use of a volatile and non-toxic solvent such as carbon dioxide for extraction has made S.F.E. gain attention as a method of extraction coupled with the protection of extracts by

CO_2 from both solvent contamination and thermal degradation [47,51], though it has been reported to sometimes extract non-essential oil and non-volatile compounds [47].

SDE is a method of extraction that combines distillation with solvent extraction. , The combination of the two techniques (distillation and solvent extraction) has led to the avoidance of the setback linked to the two techniques. Simultaneous distillation extraction was compared with hydrodistillation in the extraction of essential oil from *Aloe debrana* Christian roots, and it was reported that SDE was a more efficient method in extracting more compounds from the roots of *Aloe debrana* when compared to hydrodistillation [27]. SDE was reported to be more advantageous in terms of the time consumed, extraction efficiency/yield, and even the biological activity of the extracted oil [27].

SFME is a novel method that combines dry distillation with microwave heating at atmospheric pressure to isolate and concentrate essential oils and volatiles from plant material [54].

The purge and trap technique is a solvent-less extraction method with a high extraction efficiency though it was first developed for water and soil concentration of analytes [59]. The purge and trap technique was compared with simultaneous distillation extraction to analyze volatiles from *Citrus sudachi* [53].

The duration of distillation for complete extraction of essential oil is varied; for example, 3 hours [60–62], 4 hours [4,63–66], 5 hours [3], and 6 hours [42] depending on the interest of the analyst. Many factors may affect the quantity and quality of essential oil. Such factors include the method of extraction, temperature, time of extraction and distillation, and the analytical procedure of the phytochemical components of the essential oil. Apart from the technical and mechanical factors of the extraction procedure, the biological and physical condition of the plant may also contribute to the differences in the quality and quantity of essential oil. For instance, there is an effect on the quantity and quality of some essential oil components concerning distillation time [57,67].

It is also worth mentioning that essential oil chemical composition and yield can be affected by the maturity of the parts of the plant being investigated, especially leaves and fruit [68]. Some researchers [69] observed significant differences in the essential oil components of berries of *Juniperus oxycedrus* L. ssp. *oxycedrus* at different maturity stages; the same type of variation in chemical composition regarding maturity was also reported for essential oil from peppermint leaves [70]. Other factors affecting the quality and quantity of essential oils are soil composition and climate change [52].

The relevance of essential oils to conventional medicine cannot be overemphasized. Their usefulness is mirrored in different activities such as analgesic, anticancer, anti-inflammatory, antimicrobial, antioxidative, wound healing, sedative, allelopathic, spasmolytic [7,71–74]. One of the most recent applications of essential oils in medicine is their use in regenerative medicine, drug delivery, and tackling drug resistance by the combination of essential oils with known antibiotics [75–80]. For example, the reconstruction of tissue damage following the resection of bone cancer by using composite materials made from collagen and hydroxyapatite mixed with eugenol acetate (a derivative of eugenol, which is a common constituent of essential oils). In this research, the researchers reported that the release of eugenol acetate is consistent such that its behavior suggests that it can be used in drug delivery systems with potential application as fillers in the orthopedic field in bone cancer treatment [80]. Majorly, the studies show how essential oils can be introduced in damaged tissue, either as bioactive compounds in bone fillers [79] or by encapsulating the essential oils in the drug delivery system, which could enhance the activity of the essential oils since they are highly volatile [78]. In the design of a drug delivery system, it is important to get the appropriate platform to convey the essential oil-bearing anticancer, anti-inflammatory, or anti-microbial properties to the desired site of action to ensure its release [81].

Also, with respect to the antibiotic action of some essential oils in dealing with multi-drug resistant bacteria, several reports attest to the synergistic effects of the combination of essential oils with antibiotics, e.g., the synergistic effect of tea tree essential oil with oxacillin as observed in its action against Multi-resistant *staphylococcus aureus* (MSRA)[75]; and the synergistic effect of peppermint, cinnamon bark and lavender essential oils with piperacillin employed in it use against *Escherichia coli* [77].

Essential oils composition, functional groups present in active constituents, and their synergistic interactions are factors that determine the activity of essential oils [82,83]. It is important to note that the antimicrobial property or, in a more general term, the bioactivity of a given essential oil may depend only on one or two of the major constituents of the oil. Furthermore, it is imperative also to know that the interactions between the major and minor constituents are also of utmost importance and that the inherent activity of a particular essential oil may also depend on the ratio of the constituents [26].

According to the literature, many compounds have been identified in different essential oils of different plants; these compounds have been grouped and are presented in Table 1. The biological activities of the different classes of these compounds are also shown.

2.1. Phytochemical components in the essential oil of some of the Ficus plants.

2.1.1. *Ficus asperifolia.*

Ficus asperifolia is a small tree, sometimes average-sized. It is considered tellurian or epiphytal, measuring to a height of 20 m. Native to Nigeria, Cameroon, Tanzania, South Africa, Senegal, Madagascar, and Uganda, *Ficus asperifolia* though ubiquitous in the savannah regions, is situated at an altitude of up to 1100 m, especially in marshy areas and along river banks [101]. The ethanol and hot water extracts of the roots of *Ficus asperifolia* consist of saponins, alkaloids, glycosides, tannins, and flavonoids. Saponins and alkaloids were also reported in the aqueous root extract of *Ficus asperifolia* [102]. It was also observed that the extract showed strong inhibition of the bacteria *S. pneumoniae* showing its bactericidal property [103] with a 30.17 mm zone of inhibition which compared favorably with the antibiotic gentamycin used in the study with a 29.17 mm zone of inhibition. The plant is also known for its antioxidative property [101]. Using hydro distillation and the use of gas chromatography as well as gas chromatography-mass spectrometry(GC-MS), information pertaining to the major compounds present in the leaves of *Ficus asperifolia* and their percentage compositions were found to be; myristicin (16.4%), limonene (15.7%), Phytol (11.1%), methyl salicylate (10.8%) and cyclododecane (9.9%) [104]. The authors also investigated the oil against *Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Kiebsiella spp., Proteus spp., Pseudomonas spp., Salmonella spp., Penicillium notatum,* and *Rhizopus stolonifera*. The minimum inhibition concentrations ranged between 0.16-10 mg/ml; the oil had the highest activity against *Rhizopus stolonifera* and the least activity to *Pseudomonas spp.* Table 2 shows the presence of compounds like myristicin, limonene, phytol, and methyl salicylate in abundance, all of which have been reported to show the antimicrobial property [16,105–108]. The antimicrobial property of this oil should be expected because, according to Table 1, methyl salicylate an ester, limonene, a hydrocarbon both have antifungal and antibacterial properties.

As gotten from literature, myristicin, limonene, phytol, and linalool are odorous compounds [50,109,110], and they are also present in the essential oil of this plant.

2.1.2. *Ficus benghalensis* L.

Ficus benghalensis L. is found in large quantities in tropical areas [115], native to a wide area in Asia [116]. Pharmacologically, extracts of *Ficus benghalensis* have been implicated in possessing various beneficial properties such as anti-rheumatic [115], antioxidant [115,117], hepatoprotective [118], antibacterial [22,119], anti-allergic [120], anti-inflammatory, analgesic [121,122]. It was also recorded that a methanol extract of *Ficus benghalensis* protects against oxidative liver injury in rats [123]. Certain researchers [116] reported the acetylcholinesterase inhibition of the total methanol extract of Ficus *benghalensis* L leaves, the IC_{50} of 194.6 μg/ml of the methanol extract compared favorably with the drug “donepezil” which has an IC_{50} of 186.1 μg/ml.

Information from the first report of the essential oils from *Ficus benghalensis* revealed 24 compounds present, responsible for 96.4% of the total oil content. α-Cadinol, germacrene D-4-ol, γ-Cadinene, α-Muurolene and β-Caryophyllene epoxide making up 25.1%, 14.9%, 11.8%, 9.6%, and 6.2% respectively constituted a majority of the oil [63]. Table 2 shows the compounds that make up the essential leaf oil of the plant, as determined by gas chromatography-mass spectrometry (GC-MS) and their percentage composition.

This oil's likely odorous compounds are α-phellandrene, limonene, linalool, β-caryophyllene, and α-cadinol. The researchers did not investigate the oil for any bioactivity, but one may try to infer its bioactivity based on the components of the oil. For instance, the oil could possess insecticidal potentials because of the high amount of germacrene-D-4-ol – a compound with reported repellant effectiveness against mosquitoes and known cytotoxic property [124,125]. Furthermore, the oil could also be investigated for the bioactivities listed for its odorous compounds, as listed in Table 3.

2.1.3. *Ficus benjamina.*

This species, many of which are found cultivated by man, is one of the diverse species of this genera. *Ficus benjamina* is a tropical plant like most Moraceae, considerably the most common and found in Northern Australia and South Asia [66]. Traditionally, the plant has been used to treat cancers, piles, leprosy, skin disorders, inflammation, and malaria[148]. Literature report [148] described the extraction of different parts (stem, roots, and leaves) of *Ficus benjamina* with methanol. The methanol extract was thereafter fractionated with different solvents (chloroform, ethyl acetate, n-hexane, and n-butanol). The extracts were further investigated for their antimicrobial activity against *Aspergillus niger, Candida albicans, Escherichia coli, Pseudomonas aerugonosa, Bacillus cerus, and Bacillus subtilis*; it was discovered that the n-butanol fraction of the leaves and roots performed well with low M.I.C. values in the range 0.7-1.5 mg/ml and 0.77-1.99 mg/ml respectively.

According to previous research, it was discovered that cyclosativene, α-copanene, and β-ocimene made up the compounds with the highest abundance present in the oil [149]. Day and night samples of *Ficus benjamina* were analyzed differently, and a total of forty-seven and thirty-eight compounds were isolated, respectively [66]. Thus, begging the question, “why the discrepancy in the essential oil content of the two samples gotten?' This could be a result of the difference in plant activity during the day and night. α-pinene, abietadiene, germacrene-D-4-ol, and cis-α-bisabolene, representing 13.9%, 9.7%, 8.4%, and 8.2%, respectively, were the main compounds extracted. Also, isobornyl acetate (5.0%) and abietatriene (4.9%) were also present in sizeable quantities. Germacrene-D-4-ol (31.5%), however, was the most prevalent in the night sample, followed by 1,10-di-epi-cubenol, hexahydrofarnesyl-acetone, E-geranyl acetone, and 1, 8-cineole with respective percentages of 8.8%, 8.3%, 6.2%, 5.5% and 4.2% [66].

The oil's probable odorous compounds should include α-phellandrene, 1,8-cineole, caryophyllene oxide, β-caryophyllene, linalool, α-Pinene, camphor, myrcene, carvacrol, trans-nerolidol, limonene, and p-Cymene. It is worthy of mentioning that 1,8-cineole is a well-known antibacterial agent [150]

The authors did not investigate the oil for any bioactivity. The probable odiferous compounds in the night sample are caryophyllene oxide and camphor, which has been previously reported in the literature to both have insecticidal properties as shown in Table 3, coupled with a very high amount of germacrene D-4-ol (31.5%), which have also been reported to have insecticidal properties[124].

In another report, 2-Pentanone, 9,12-Octadecadienoic acid, hexadecanoic acid, palmitic acid were present in the stem's essential oil, while the root essential oil had eight compounds: arsenous acid, methanamine, cyclopentanone, methyl-2-phenylindole, cyclopropaneoctanal, 9,12-octadecadienoic acid, hexadecanoic acid, palmitic acid [148]. Though the stem and root have some similar compounds in their essential oil, there are no such compounds in the essential oils of the leaves.

2.1.4. *Ficus capensis.*

Ficus capensis Thunb is also known as *Ficus sur* Forssk, varies in height, ranging from 4 to about 9 meters. Predominantly in Tropical Africa, as well as in South Africa of varying species, the tree is described as being low branched with a spherical crown. In Nigeria, it is called "opoto" by the Yoruba ethnic group, "akororo" by the Igbo, "uwaryara" in Hausa [151]. It is believed to have fetish attributes because it promotes increased crop yield and fertility [3,60]. Some features of the leaves of *Ficus capensis* are; elongated elliptic leaves or ovate, ranging between 7.5 to 15cm in length and 5 to 10cm in width, acute apex with diverse kinds of the base, somewhat leathery, dark green without epidermal hairs, and dentate, wavy or entire margin. Its fruits could be paired figs or lone figs [152].

Ficus capensis has been shown to be of great ethnomedicinal use, such as in the treatment of diarrhea, 100-400 mg/kg of aqueous extracts of the leaves delayed the onset of stooling in albino rats [152]. It was also reported to be antibacterial as its crude extract hindered the growing process of *Shigella sp.* and *E. coli* [153], with M.I.C. values ranging between 500-2000 µg/ml. Also, its leaves seem to possess antimicrobial, anti-inflammation, and antioxidative action, and this was linked to the presence of phytochemicals such as flavonoids, tannins, phenolics, and anthocyanins [3]. *Ficus capensis* has been reported traditionally to have a blood-boosting effect. The effect of the aqueous leaf extract on biochemical parameters of phenylhydrazine-induced-anemic rats was studied by [151]. The researchers reported that at 200 mg/kg, the aqueous leaf extract does not have any antagonistic effect on the biochemical parameters of the rats.

The essential oil content of three parts (leaves, stem bark, and root bark) of this species was investigated. The essential oil from the leaves contains about 27 compounds which are the highest among the parts investigated; this was followed by that of the stem (16), while the roots have the least number of compounds (13). The major compounds in the leaves are α-cadinol (10.6%), α-pinene (9.3%), geranyllinalool (6.9%), n-tetradecane (6.5%), α-humulene (6.5%) and α-ionone (6.4%); the stem bark had n-hexadecanoic acid (33.3%), α-pinene (12.2%), β-pinene (8.9%), α-humulene (4.7%) and limonene (4.4%) as its major essential oil composition and the root bark contained α-pinene (36.7%), n-hexadecanoic acid (15.5%), β-pinene (14.9%), limonene (7.9%) and m-cymene (5.8%) [60]. Table 2 gives information on all the compounds present in the essential oil of the three parts of this plant. α-pinene and limonene are the odiferous compounds common to the three parts of this plant; *(E)*-β-caryophyllene is common to both the leaves and the root, α-phellandrene is common to stem and root and isocaryophyllene is common to the leaves and stem. Nerolidol and α-cadinol are exclusive to the leaves. The researchers also reported toxicity to brine shrimps for the essential oils gotten from the stem bark, leaves, and root bark of *Ficus capensis* Thunb; toxicity to brine shrimps is a significant test because it has been related to antibacterial, pesticidal, cytotoxic, and antitumor properties [154]. The LC_{50} for the essential oil from stem bark, root bark, and leaves are 43.11 μg/mL, 39.40 μg/mL, and 16.38 μg/mL, respectively. The percent composition of hexadecanoic acid in the stem essential oil is the greatest (33.3%), followed by that of root bark (15.5%), while it was not detected in the leaf essential oil at all. The leaf oil has the lowest LC_{50} value, and comparing the value to that of the root and stem shows an increase in the LC_{50} value, which may be because of the presence of n-hexadecanoic acid, because the higher the percentage of hexadecanoic acid, the higher the LC_{50} value thus, it looks as if n-hexadecanoic acid reduced the toxicity level of the oil. n-Hexadecanoic acid has the highest percent composition among the constituents of the essential oil in the stem bark. It has been reported to exhibit antioxidant and anticancer [97], pesticidal [94,155], and anti-inflammatory properties[96]. The researchers also conducted an acetylcholinesterase enzyme assay, and Huperzine A was used as a positive control. The activity of the three essential oils against Acetyl cholinesterase enzyme compared favorably with that of Huperzine A; this activity against Acetyl cholinesterase could be linked to the presence of significant amounts of α-pinene and β-pinene in oils [136,137]. The IC_{50} values are 14.65 μg/mL (leaf), 14.11 μg/mL (stem bark) and 11.22 μg/mL (root bark)) while that of Huperzine A is 7.23 μg/mL.

Huperzine A, a compound isolated from a Chinese plant, has been implicated in the treatment of fever and improvement of memory. It is important to mention that the root bark has the lowest value of IC_{50}, and the percentage abundance of α-pinene and β-pinene is highest in the root bark, which can be seen from Table 2; comparing the IC_{50} of the stem and the leaves, the value of IC_{50} increased with decrease in the amount of α-pinene and β-pinene. The authors inferred that the oil from *Ficus capensis* could be explored to treat conditions involving memory improvement such as Alzheimer's disease. However, there is a need to deduce the relationship between the observed activities and the constituents of the oils[60].

However, in another report [104], the number of compounds found in the essential leaf oil was just 8; limonene and β-ionone were the common compounds in both of these species of leaf essential oil. According to the literature, limonene is the only odorous compound among the constituents for the essential leaf oil reported by these researchers. The antimicrobial potential of the essential leaf oil of *Ficus capensis* was also investigated by the authors. The microorganisms used in their research were *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli*, *Kiebsiella spp.*, *Proteus spp.*, *Pseudomonas spp.*, *Salmonella spp.*, *Penicillium notatum*, and *Rhizopus stolonifera* with M.I.C. values ranging from 0.08-10 mg/ml. The oil was reported to be active against all the microorganisms except *Kiebsiella spp*. Overview of the bioactivity of *Ficus capensis* is presented in Table 4.

2.1.5. *Ficus carica.*

Ficus carica L, a transitory plant, is commonly known as “fig”. The common fig is said to be one of the first-ever cultivated plants by man and is found mostly in the Eastern Mediterranean and Southwest Asia. It is consumed both in its fresh and dry form and is widely sought after as an important product in the world [23]. *Ficus carica* L. consisting of over 1400 species, is grouped into about 40 genera [23,156]. Species of *Ficus carica* consist of small trees or shrubs, whose roots are not adventitious with barks slightly rough [23]. *Ficus carica* has been used traditionally for its medical purposes, which include; metabolic, cardiovascular, and respiratory remedy [157], figs have also been reportedly used conventionally as a laxative [158], the fruit juice of *Ficus carica* mixed with honey is used for hemorrhage, inflammation, swellings, and tumors, it is often rubbed with the fruit paste to ease the pain [23]. The Methanol extract of the leaves of *Ficus carica* showed strong activities against *S. anginosus*, *S. gordonii*, *P. intermedia*, *A. actinomycetemcomitans*, and *P. gingivalis* [159]. Analysis of five Portuguese varieties of the leaves of *Ficus carica* was found to consist of diverse kinds of volatile compounds belonging to various chemical classes [14]. The latex of *Ficus carica* yielded the following essential oils: alkanals (octanal, heptanal, hexanal, pentanal, and benzaldehyde); alcohols (phenyl propyl alcohol, 1-butanol-2-methyl, 1-hexanol,1-pentanol, 1-heptanol, phenyl ethyl alcohol, and1-butanol-3-methyl); monoterpenes (cis-linalool oxide, epoxylinalool, eucalyptol, linalool, limonene, α -pinene, β-pinene, α-thujene, and terpinolene); sesquiterpenes (cadinene, germacrene D, α -guaiene, β -caryophyllene, trans- α -bergamotene, α -bourbonene, α -calacorene–muuroleneand α -caryophyllene); ketone (6-methyl-5-hepten-2-one) [17].

The components and percentage composition of the various volatile constituents of the leaves of *Ficus carica* grown in Egypt as determined by gas chromatography-mass spectrometry(GC-MS) were found to contain higher amounts in terms of percentages of (Z)-3-hexenyl benzoate making up 19.8 %, n-tetracosane with 11.6 %, n-hexadecanoic acid constituting 9.2 %, n-docosane (7.7 %), (*E*)-2-hexenal with 7.2 %, phytol (6.7 %) and n-nonanal having 3.9 % [111] is shown in Table 2. The latex and the leaves of this plant, however, contain hexanal, octanal, α –pinene as similar components, which means there could be similarities in the essential oil components of different parts of a plant with probable different percentage compositions. α-pinene, 1,8-cineole, (E)-β-caryophyllene, and phytol are some of the likely odorous constituents of this oil.

2.1.6. *Ficus elasticoidies* De Wild.

The essential oil of *Ficus elasticoidies* De wild, which is one of the more than 44 species of the *Ficus* genera found in Nigeria [160] analyzed by G.C. and GC-MS, revealed the constituents present. The high content compounds in this species of *Ficus* are; (*E*)-phytol (20.9 %), 6,10,14-trimethyl-2-pentadecanone (8.7 %), and β-carophyllene (6.8 %), 28 compounds totaling 76.5% of the oil were identified in the essential oil [64]. The compounds in the essential leaf oil of *Ficus elasticoidies* alongside their percentage composition is shown in Table 2. α-pinene, limonene, linalool, β-caryophyllene, caryophyllene oxide, and *(E)*-phytol should be the odorous constituents of this oil.

2.1.7. *Ficus exasperata* Vahl.

Ficus exasperata Vahl is one of the nearly 1000 species of *Ficus* plants found worldwide. It is a terrestrial afro-tropical small tree with scabrous, ovate leaves that grows up to about 20m in height, being found in secondary forest and evergreen areas [160]. In India, it is commonly known as Brahma's banyan, rough banyan, and "sandpaper" fig, sandpaper owing to its rough leaf surface [161]. The phytochemical investigations of this species showed the presence of terpenoids, saponins, tannins, cardiac glycosides, and flavonoids, while alkaloids and anthraquinones were absent [162]. The leaves of *Ficus exasperata* have been known to be used in the treatment of many ailments. For example, in Nigeria, the leaves are used as an antipyretic [163], it was also shown to have anti-inflammatory properties [164], the leaves have also been analyzed for their hypoglycemic and hypolipidemic potential, thus, strengthening its use by Nigerians in the treatment of diabetes [165], the leaves are highly valued in treating malaria as a native Cameroonian medicine [166], in some parts of Cameroon, it is used to treat hemorrhoids [167], and the water extract is administered orally in the treatment of diarrhea in some other places [168]. The leaves of *Ficus exasperata* have been identified to possess bactericidal properties, being that its ethanol extract showed great inhibitory activity against *E. coli* and *S. albus* [169]. The volatile leaf oil constituents of *Ficus exasperata* have also been analyzed, and it was discovered that the oil is comprised of terpenoids and aliphatic compounds. The compounds making up most of the volume of the oil are 1,8-cineole (13.8%), (*E*)-phytol (13.7%), and *p*-cymene (11.4%) [112]. Odorous compounds in the essential leaf oil of this plant should include 1,8-cineole, (*E*)-phytol, *p*-cymene, caryophyllene oxide, β-caryophyllene, and α-pinene.

The leaf oil was reported to be inactive as an antibacterial since it has a M.I.C. of 625 ppm for all the tested microorganisms (*Bacillus cereus*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*). One would expect better activity from this oil since phytol has been reported to inhibit *Staphylococcus aureus* and *Pseudomonas aeruginosa* [128]. Though, according to Table 1, cymene is an antibacterial compound, although it has been reported to be an ineffective antibacterial compound [82,170,171]. The inactive nature of the oil could also be due to a lack of synergy between the components of the oil or because of the presence of cyclooctasulfur, a compound that is a rare constituent of essential oils.

The volatile oil component of the root back of *Ficus exasperata* has also been analyzed, and its major compounds are; α-terpineol (33.7%), α-pinene (10.8%), sabinene (5.6%), and β-patchoulene (4.7%), which is probably identified for the first time in *Ficus exasperata* oils [18]. The volatile compounds present in the root bark oil of *Ficus exasperata* and percentage constitution is shown in Table 2. α-pinene, β-pinene, limonene, 1,8-cineole, linalool, geranyl acetate, β-caryophyllene, isocaryophyllene, α-phellandrene, β-mycrene, caryophyllene oxide are compounds expected to be odorous in this oil. Table 4 shows the bioactivity of the extracted essential oil. The essential oil obtained from the root bark of *Ficus exasperata* was investigated for anti-candidal activity. The researchers reported that the oil showed a significant zone of inhibition, and a 1.1 μg/mL was recorded as the minimum inhibitory concentration (M.I.C.). The authors concluded that the oil has antifungal potential because the current drug of choice, amphotericin B, as at the time of their research for the treatment of *C.albicans* has a minimum inhibition concentration of 0.39 μg/mL. Though the reason for the observed activity with regards to the composition of the oil was not explained by the researchers, it could be a result of the major compounds as well as minor compounds in the oil. Table 2 shows α-Pinene as the second-highest compound by composition in the oil, and it has also been reported to be highly effective against yeast which is a known fungus [172]. The oil also contains a considerable amount of esters such as α-frenchyl acetate (1.1%), geranyl acetate (1.0%), which according to Table 1, are considered as antifungal agents amongst other things; furthermore, the oil also contains a considerable amount of linalool which has been reported to have antifungal activity [173]. In addition, according to Table 3, geranyl acetate, 1,8-cineole, β-caryophyllene, and caryophyllene oxide are also antifungal agents. Phellandrene, limonene, sabinene, and α-pinene are presented in Table 1 as compounds with antibacterial properties. According to Table 2, they are present in reasonable quantities in the root bark oil means the root bark oil could also be an excellent antibacterial agent.

2.1.8. *Ficus lutea* Vahl.

This species, synonymous with *Ficus vogelii* (Miq.), is a rubber-producing tree in West Africa, doing so in varying quantities as it rapidly grows. Its bark and leaves are red in color. A report [174] described the leaves to possess anti-diabetic properties; acetone was used to extract from the leaves, after which the acetone extract was fractionated with different solvents: water, ethylacetate, hexane, n-butanol, dichloromethane, and chloroform. The ethylacetate fraction had a considerable antidiabetic activity at 250 μg/ml when compared with glibenclamide that was used as a positive control, and exhibited anti-diabetic activity at 50 μg/ml.

Having been judiciously analyzed, acorenone B (20.7%), followed by phytol (16.2%), demethoxyageratochromene (6.0%), 6, 10, 14 trimethyl-2-pentadecanone (5.1%), and zingiberene (5.2%) made up the most abundant components in the volatile oil of the leaves [113]. The percentage composition of the various compounds found in the essential leaf oil of *Ficus lutea* can be seen in Table 2. It can be seen from Table 2 that acorenone is the most abundant compound in this oil; this compound has been reported to inhibit acetylcholinesterases and butyrylcholinesterase, which have been related to Alzheimer's disease [137] therefore, the oil could be investigated for the inhibition of both enzymes. Some odorous compounds in this oil are α-pinene, β-caryophyllene, caryophyllene oxide, and phytol. The oil could also be effective against fungi because of the presence of α-pinene, β-caryophyllene, and caryophyllene oxide.

2.1.9. *Ficus mucoso* Welw.

The leaves and fruits of *Ficus mucoso* Welw. are edible; they are used to treat medical cases such as leprosy, insanity, and edemas [4]. Oils from the leaves were obtained via hydrodistillation, and its constituents were determined using GC-MS, and of 35 isolates, α-phellandrene, *p*-cymene, germacrene D, β-caryophyllene, 1,8-cineole and α-copaene with percentages of 13.0%, 11.3%, 10.5%, 9.7%, 9.5%, and 8.7% respectively made up the constituents in abundance [4]. The oil comprises the following odorous constituents *p*-cymene, 1,8-cineole, α-phellandrene, α-pinene, and α-cadinol.

The antimicrobial activity of the essential leaf oil of *Ficus mucoso* was also investigated, as shown in Table 4, the oil was tested against *Bacillus cereus*, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Candida albicans*, and *Aspergillus niger*, the oil was found to show greater potency against *Aspergillus niger* with a M.I.C. value of 78 μg/ml [4]. From Table 2, it can be seen that *p*-cymene (11.3%) is the major constituent of *F.mucoso* oil. This compound has been reported to be an ineffective antimicrobial compound, especially alone [82,170,171]. This could be the reason *F.mucoso* oil was only active towards *Aspergillus niger*, or it could be that the synergy between all the components of the oil can only affect *Aspergillus niger*. The cytotoxic effect of *Ficus mucoso* leaf essential oil and was also investigated. The *Ficus mucoso* oil displayed a strong inhibitory effect against human Hs578T breast ductal carcinoma cells with a 98.18 % kill at 250 μg/mL; however, the oil has no significant effect on human PC-3 prostatic carcinoma cells. The authors attributed the observed activity towards human Hs578T breast ductal carcinoma to the constituents of *Ficus mucoso* oil; from Table 2, it is obvious that *Ficus mucoso* oil comprises majorly sesquiterpenes such as β-caryophyllene and germacrene D, in which these compounds have been previously reported to show cytotoxic activity [72,125].

2.1.10. *Ficus natalensis* subsp. leprieurii.

Ficus natalensis subsp. leprieurii is also one of the abundant species of *Ficus* genera found in Nigeria. Traditionally it is used in medicine in inducing lactation and as a cure for influenza [64]. The stem bark of this plant possesses antimicrobial properties, and the methanol extract had a M.I.C. value of 0.625 mg/ml against *Pseudomonas aeruginosa* [175]. The components of the essential oil of the leaves of *Ficus natalensis* were extracted by hydrodistillation and analyzed. 24 compounds representing 78.3% of the oils were identified, and the main constituents in *Ficus natalensis* subsp. leprieurii essential oil were (*E*)-phytol having 37.6 % and 6,10,14-trimethyl-2-pentadecanone with 24.9 % [64]. Table 2 shows the compounds present in the volatile oil of *Ficus natalensis* subsp. leprieurii leaves and their percentage composition. The leaf oil of this plant contains the following (*E)*-phytol, α-pinene, limonene, linalool, β-caryophyllene, and caryophyllene oxide as odorous compounds.

2.1.11. *Ficus ovata* Vahl.

Ficus ovata is also one of the myriads of *Ficus* species found in relatively abundant quantities in Nigeria. The stem bark has been reported for its antimicrobial property; a M.I.C. value of 39 μg/ml was recorded against *Staphylococcus aureus*. [176]. The volatile leaf oil of this plant has been analyzed, and 23 compounds making 71.4% of the oil were established using G.C. and GC-MS. Of the 23 compounds identified, (*E*)-phytol (24.5 %), hexadecanoic acid, (10.0 %) caryophyllene oxide (7.6 %) and 6,10,14-trimethyl-2-pentadecanone (6.1 %) were in high proportion. Also, a significant amount of geranyl acetone (4.5 %) and β-ionone (3.1 %) were found in *Ficus ovata* leaf oil [64]. α-Pinene, benzaldehyde, linalool, β-caryophyllene, limonene, (*E)*-Phytol, and caryophyllene oxide are the likely odorous compounds in this oil.

2.1.12. *Ficus polita.*

Ficus polita Vahl, a huge tree towering a height of 10 to 16 meters, is native to coastal forests and evergreen forests. Locally given the name 'Durumi' by the Hausas and 'Rita' by the Kanuris in Nigeria [113,177].

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Table 1. Different classes of essential oils compounds and their bioactivities.

Class of compounds	Examples	Known Bioactivities	References
Hydrocarbons	Phellandrene, cymene, pinene, mycrene, sabinene, germacrene D limonene.	Decongestant, antibacterial, hepatoprotective, antiviral, antitumor, stimulant	[16,37,40,44,84–88]
Esters	Linalyl acetate, bornyl acetate, eugenol acetate, geranyl acetate.	Anti-inflammatory, antifungal, spasmolytic, anaesthetic, sedative.	[37,88–93]
Acids	Hexadecanoic acid, octadecanoic acid, tetradecanoic acid.	Anti-inflammatory, antioxidant, repellant, emulsifying	[94–97]
Oxides	Bisabolone oxide, sclareol oxide, linalool oxide, ascaridole carophyllene oxide.	Expectorant, stimulant, anti-inflammatory.	[37,88,92,93]
Lactones	Costuslactone, nepetalactone, dihydronepetalactone, alantrolactone, bergaptene.	Antiviral, sedative, antipyretic, antimicrobial, analgesic, hypotensive.	[37,88,93,98,99]
Alcohols	Citronellol, geraniol, borneol, linalool, citronellol, menthol, Germacrene D-4-ol, nerol.	Balancing, anaesthetic, spasmolytic, tonifying, anti-inflammatory, antiseptic.	[37,88,90–93]
Phenols	Carvacrol, thymol, chavicol, eugenol.	Spasmolytic, anaesthetic, immune stimulating, irritant, antimicrobial.	[37,88,92,93]
Aldehydes	Cinnamaldehyde, citral, benzaldehyde, cuminaldehyde, myrtenal, citronellal.	Calming, antiviral, antipyretic, tonic, sedative, vasodilators, spasmolytic, hypotensive, antimicrobial.	[37,82,88]
Ketones	Thujone, menthone, verbenone. fenchone, carvone, pulegone, camphor.	Antiviral, spasmolytic, sedative, mucolytic, neurotoxic, digestive, cell regenerating, analgesic.	[37,88,89,93,100]

Table 2. The essential oil composition of the 14 *Ficus* species under review.

Species	Compounds contained	Part of plant	References
F. asperifolia	Myristicin (16.4%), limonene (15.7%), phytol (11.1%), methyl salicyclate (10.8%), cyclododecane (9.9%), n-tricosane (4.2%), terpinen-4-ol (3.6%), (*E*)-2-nonenol (3.4%), tetradecanal (2.5%), safrole (2.5%), methyl eugenol (2.4%), 6,10-dimethyl-2-undecanone(1.9%), (*E*)-β-ionone (1.9%), geranyl acetone (1.7%), (*Z, Z*)-farnesylacetone (1.6%), 2-ethyl hexyl acetate (1.5%), Z-methyl isoeugenol (1.3%), (*E,E*)-α-farnesene (1.2%), linalool (1.2%), viridiflorol (1.0%) and elemicin (0.8%). **Total (96.6%)**	Leaves	[104]
F. Benghalensis	α-cadinol (25.1%), germacrene D-4-ol (14.9%), γ-cadinene (11.8%), α-muurolene (9.6%), β-Caryophyllene epoxide (6.2%), cyclosativene (4.7%), cubenol (4.1%), τ-cadinol (3.8%), (E)-β-Ionone (2.2%), δ-Cadinene (2.0%), β- Geranylacetone (1.8%), Toluene (1.7%), γ-Muurolene (1.1%), ethylbenzene (1.1%), α-copaene (1.0%),α-phellandrene (1.0%), linalool (1.0%), β-caryophyllene (0.8%), maaliene (0.7%), n-nonanal (0.5%), n-hexanal (0.4%), β-cyclocitral (0.3%), (E)-α-ionone (0.3%) and limonene (0.3%). **Total (96.4%).**	Leaves	[63]
F. benjamina	**Day Sample** α-pinene (13.9%), abietadiene (9.7%), germacrene D-4-ol (8.4%), cis-α-bisabolene (8.2%), isobornyl acetate (5.0%), abietatriene (4.9%), sabinene (3.7%), 4-terpineol (2.5%), trans-pinocarveol (2.5%), myrtenal (2.4%), verbenone (2.2%), ρ-Mentha-1,5-dien-8-ol (2.1%),1,8-cineole (2.1%), dehydro-ρ-cymene (2.0%), limonene (2.0%), Dipropyl trisulfide (1.5%), α-campholenal (1.4%), dipropyl disulfide (1.2%), p-cymene (1.2%), (E)-geranyl acetone(1.2%), hexahydrofarnesylacetone (1.2%), camphor (1.2%), pinocarvone (1.2%), camphene (1.1%), β-caryophyllene (0.9%), thuja-2,4(10)-diene (0.8%), (E)-β-farnesene(0.8%), myrcene (0.8%), inalool (0.8%), α-phellandrene (0.7%), β-cyclocitral (0.5%), cis-linalool oxide (furanoid) (0.3%), 1,10-di-epi-Cubenol (0.3%),trans-Carveol (0.2%), δ-cadinene(0.2%), methyl carvacrol (0.2%), (E)-α-ionone (0.2%), ρ-cymen-8-ol (0.2%), benzaldehyde (0.1%), α-terpinene (0.1%), γ-terpinene (0.1%), δ-3-carene (trace), 3,7-dimethyl-2,6-octadienal (trace), nonanal (trace), safranal (trace), carvone (trace). **Total (90.0%)**	Leaves	[66]

Species	Compounds contained	Part of plant	References
	Night Sample: Germacrene D-4-ol (31.5%), 1,10-di-epi-cubenol (8.8%), hexahydrofarnesylacetone (8.3%), (E)-geranyl acetone(6.3%), cubenol (5.5%), 1,8-cineole (4.2%), caryophyllene oxide (2.6%), β-caryophyllene (2.3%), linalool (1.6%), β-bisabolene (1.6%), (E)-β-ionone (1.5%), isoborneol (1.4%), (E)-α-ionone (1.3%), nonanal (1.3%), α-pinene (1.2%), camphor (1.2%), pentadecanal (1.2%) ,isobornyl acetate (1.0%), (E)-2-hexenal(0.9%), safranal (0.9%), β-cyclocitral (0.8%), β-pinene(0.6%), myrcene (0.6%), carvacrol (0.6%), trans-nerolidol (0.5%) (E)-β-damascone (0.5%),undecanal (0.5%), phenylacetaldehyde (0.5%), 6-methyl-5-hepten-2-one (0.5%), α-terpineol (0.4%), camphene (0.4%), benzaldehyde (0.4%), limonene (0.4%), n-hexadecane (0.3%),9-epi-(E)-caryophyllene (0.2%), α-copaene (trace), δ-cadinene(trace), p-cymene (trace). **Total (91.0%)**		
F. capensis	**Leaves:** α-cadinol (10.6%), α-pinene (9.3%), geranyllinalool (6.9%), α-humulene (6.5%), n-tetradecane(6.5%), α-ionone(6.4%), β-pinene (4.5%), caryophyllene oxide(3.9%), spathulenol (3.7%), isocaryophyllene (3.4%), E-nerolidol (3.1%), limonene (3.1%), (Z)-ocimenone (2.8%), germacrene (2.4%), m-cymene (2.1%), γ-terpinene (2.0%), n-tridecane (1.9%), (E)-β-caryophyllene (1.8%), neophytadiene, Isomer III (1.4%), 3E,7E-4,8,12-trimethyltri deca-1,3,7,11-tetraene (1.3%), δ-amorphene (1.2%), geranylacetone (1.1%), safranal (1.1%), β-ionone (1.0%), neophytadiene, Isomer I (0.9%), neophytadiene, Isomer II (0.8%), γ-humulene (0.7%),. **Total (90.4%)** **Stem:** n-hexadecanoic acid (33.3%), α-pinene (12.2%), β-pinene (8.9%), α-humulene (4.7%), limonene (4.4%), pentadecanoic acid (4.0%), γ-terpinene (3.7%), n-tetradecanoic acid (2.1%), ,erpinolene (1.9%), camphene(1.6%), p-cymene (1.5%), (E)-α-bergamotene (1.3%), cyperene (1.0%), α-phellandrene (0.8%) isocaryophyllene (0.5%), α-thujene (0.2%). **Total (82.1%)** **Roots:** α-pinene (36.7%), n-hexadecanoic acid (15.5%), β-pinene (14.9%), limonene (7.9%), m-cymene (5.8%), γ-terpinene (4.1%), (E)-β-caryophyllene (3.6%), α-humulene (3.2%), α-phellandrene (1.8%), neophytadiene, Isomer I (1.2%), α-thujene (0.7%), camphene(0.5%), terpinolene (0.1%). **Total (96.0%)**	Leaves, Stem bark & Root bark	[60]
	Leaves: n-tricosane (52.2%), n-hexacosane (24.2%), cyclotetradecane (15.4%), triacontane (3.3%), limonene (2.8%), trans-geranylgeraniol (0.7%), n-hexadecanoic acid (0.6%), (E)-β-ionone (0.5%). **Total (99.7%)**	Leaves	[104]
F. carica	(Z)-3-hexenyl benzoate (19.8%), n-tetracosane (C-24) (11.6%), n-hexadecanoic acid (9.2%), n-Docosane (C-22) (7.7%), (E)-2-Hexenal (7.2%), phytol (6.7%), n-nonanal (3.9%), n-pentacosane (C-25) (1.9%), n-heneicosane (C-21) (1.5%) (E,E)-α-farnesene(1.3%),6,10,14-trimethylpentadecan-2-one (1.3%), cis-muurola-4(15),5-diene (1.2%), n-heptadecane (1.0%), nonadecane (0.9%), phytane (0.9%), heptacosane(0.8%), n-octadecane (0.8%), β-ionone (0.8%), n-tetradecanoic acid (0.8%), (E)-β-damascenone(0.7%), farnesane(0.6%), α-Pinene (0.6%), nerylacetone(0.6%), methyl salicylate (0.6%), 1-octanol (0.5%), pentadecane (0.5%), dillether (0.5%), cis-eudesma-6,11-diene (0.4%), n-8(E)-2,6-dimethylocta-1,5,7-trien-3-ol (0.4%), Non-1-en-3-ol (0.4%), dodecanal (0.4%), myrtenal (0.4%), 3-thujene-10-al (0.4%), 4-isopropylcyclohexanol (Isomer 2) (0.4%), ethyl benzoate (0.3%), n-octanal (0.3%), ethyl hexadecanoate (0.2%), 1,8-Cineol (0.2%), methyl palmitate (0.2%), (E)-β-caryophyllene (0.2%), spathulenol (0.1%),viridiflorol (0.1%), 7,11-dimethylheptadecane (0.1%), neophytadiene (Isomer 2) (0.1%). **Total (88.5%)**.	Leaves	[111]
F. elasticoidies	(*E*)-Phytol (20.9%), geranyl acetone (9.4%), 6,10,14-trimethyl-2-pentadecanone (8.7%), β-carophyllene (6.8%), α-Ionone (4.5%), octacosane (2.5%), β-Ionone (2.4%), hexadecanoic acid (2.0%), oleic acid (2.0%), carophylleneoxide (2.0%), benzaldehyde (1.6%), β-selinene (1.5%), heptacosane (1.4%), 6-Methyl-5-hepten-2-one (1.3%), octadecanoic acid (1.3%), (E)-9-octadecenoic acid, ethyl ester (1.0%), limonene (0.9%), 1-Octen-3-ol (0.9%), 2-dimethoxy-4-ethyl-benzene (0.9%), n-nonanal (0.8%), α-pinene (0.8%), 3,4-dimethyl toluene (0.7%), 2-Hexen-1-ol benzoate (0.4%), isophytol (0.4%), linalool (0.4%),(E)-Menth-2-en-1-ol (0.4%), Z-Menth-2-en-1-ol (0.3%), neral (0.3%), . **Total (76.5%)**	Leaves	[64]

Species	Compounds contained	Part of plant	References
F. exasperata	**Root Bark:** α-Terpineol (33.7%), α-pinene (10.8%), sabinene (5.6%), β-patchoulene (4.7%), β-pinene (3.2%), limonene (3.1%), 1,8-cineole (3.1%), linalool (2.8%), α-thujopsene (2.1%), (*E*)-β-Ocimene (1.7%), α-Terpinene (1.7%), β-bisabolene (1.5%), α-Copaene (1.4%), *allo*-Aromadendrene (1.3%), (*Z*)-β-Ocimene (1.2%), α-Frenchyl acetate (1.1%), geranyl acetate (1.0%), β-caryophyllene (1.0%), cedrol (0.8%), 2-Carene (0.8%), isocaryophyllene (0.8%), α-phellandrene (0.8%),β-mycrene (0.7%), caryophyllene oxide (0.5%), globulol(0.5%), aromadendrene (0.5%), guaiol (0.5%), (*E*)-β-Farnesene (0.4%), α-Thujene (0.4%), ledol (0.4%), carotol (0.3%), D- β-cyclocitral (0.3%), (E,E)-α-farnesene (0.3%), δ-cadinene (0.3%), β-selinene (0.3%), α-cubebene (0.3%), α-ylangene (0.3%), verbenone (0.2%), β-copaene (0.2%), β-cubebene (0.2%), bornyl acetate (0.2%), dotriacontane (0.2%), germacrene D (0.2%),α-humulene (0.2%), α-selinene (0.1%), (*Z*)-3-hexenyl acetate (<0.1%),undecanal (<0.1%), cecanal (<0.1%), tetradecane (<0.1%), benzaldehyde (<0.1%),(E,E)-2,6-dimethyl-1,3,5,7-cyclooctateraene (<0.1%), benzyl alcohol (<0.1%), 4-methyl benzaldehyde (<0.1%), methyl benzoate (<0.1%), methyl salicyclate (<0.1%). **Total (91.8%)**.	Root bark	[18]
	Leaves: 1,8-cineole (13.8%), (*E*)-phytol (13.7%), *p*-cymene (11.4%), β-ionone (7.5%), 6,10,14-trimethyl-2-pentadecanone (7.0%), cyclooctasulfur (6.1%), caryophyllene oxide (5.4%), β-caryophyllene (4.3%), neryl acetone (4.2%), α-ionone (2.9%), α-Pinene (2.2%), 9-octadecanoic acid (2.9%), **Total (85.7%).**	Leaves	[112]
Ficus lutea	Acorenone B (20.7%), phytol (16.2%), demethoxyageratochromene (6.0%), zingiberene (5.2%), 6 ,10 ,14-trimethyl -2-pentadecanone (5.1%), caryophyllene oxide (4.4%), β-caryophyllene (4.3%), farnesyl acetone (4.0%), valencene (3.4%), (E,E)-α-farnesene (3.2%), γ-cadinene (2.5%), α-selinene (2.4%), β-sesquiphellandrene (2.3%), β-bisabolene (1.9%), (E)-β-ionone (1.7%), himachalene (1.6%), α-humulene (1.4%), α-pinene (1.3%), drimenol (1.2%), (E)-α-ionone (1.1%), hexadecanal (0.9%), 1,3,5-trimethylbenzene (0.9%),benzaldehyde (0.7%), β-pinene (0.7%), α-copaene (0.4%), ethyl linoleolate (0.3%). **Total (93.8%)**.	Leaves	[113]
Ficus mucoso	α-Phellandrene (13.0%), *p*-cymene (11.3%), germacrene D (10.5%), β-caryophyllene (9.7%), 1,8-Cineole (9.5%), α-copaene (8.7%), terpinolene (4.9%), α-humulene (3.5%), (3*Z*)-hexenol (3.4%), (*E*)-3-methyl-non-2-en-4-one (3.0%), linalool (2.1%), alloaromadendrene (2.0%), δ-cadinene (1.8%), spathulenol (1.7%), dill Apiole (1.6%),β-Ionone (1.6%), muurolene (1.3%),(3*Z*)-hexenyl benzoate (1.3%), methyl salicylate (1.2%), β-cyclocitral (1.0%), carotol (0.9%), safranal (0.7%), α-terpineol (0.6%),α-cubebene (0.6%), α-ionone (0.6%), α-pinene (0.5%),(*E*)-Nerolidol (0.5%), bicyclogermacrene (0.5%), α-Cadinol (0.5%), cubebene (0.4%), τ-cadinol (0.3%), β-elemene (0.3%), α- (*E,E*)-α-farnesene (0.2%), β- α-gurjunene (0.2%), γ-muurolene (0.2%),.**Total (100%).**	Leaves	[4]
Ficus natalensis subsp. leprieurii	*(E)*-Phytol (37.6%),6,10,14-trimethyl-2-pentadecanone (24.9%), geranyl acetone (2.8%), hexadecanoic acid (2.0%), carophyllene oxide (1.7%), oleic acid (1.6%), β-ionone (1.2%), octacosane (1.1%), α-ionone (0.9%), β-carophyllene (0.7%), heptacosane (0.6%), neral (0.5%),octadecanoic acid (0.5%), benzaldehyde (0.3%), (*E*)-menth-2-en-1-ol (0.3%), limonene (0.3%), n-nonanal (0.2%), *Z*-menth-2-en-1-ol (0.2%), 1-octen-3-ol (0.2%), isophytol (0.2%), 6-methyl-5-hepten-2-one (0.2%), linalool (0.1%), 3,4-dimethyl toluene (0.1%), α-pinene (0.1%). **Total (78.3%)**.	Leaves	[64]
Ficus ovata	*(E)*-Phytol (24.5%), hexadecanoic acid (10.0%),carophyllene oxide (7.6%), 6,10,14-trimethyl-2-pentadecanone (6.1%), geranyl acetone (4.5%), β-ionone (3.1%), linalool (2.3%), β-carophyllene (2.2%), n-nonanal (2.0%), octacosane (1.9%), octadecanoic acid (1.4%), heptacosane (1.2%), oleic acid (1.1%), isophytol (0.8%), benzyl tiglate (0.7%), α-ionone (0.6%), 6-methyl-5-hepten-2-one (0.4%), limonene (0.3%), benzyl benzoate (0.3%),.α-pinene (0.1%), benzaldehyde (0.1%), 2-Dimethoxy-4-ethyl-benzene (0.1%), 1-Octen-3-ol (0.1%), **Total (71.4%)**.	Leaves	[64]
Ficus polita	Phytol (23.3%), 6 ,10 ,14-trimethyl-2-pentadecanone (15.0%), (E)-6,10-dimethyl -5,9- undecadien-2-one (7.3%), drimenol (5.8%), (E)-β-ionone (4.1%), caryophyllene oxide (4.0%), farnesyl acetone (3.7%),β-selinene (2.0%), (E)-α-ionone (1.9%), hexadecanal (1.7%), acorenone B (1.4%), β-caryophyllene (1.3%), zingiberene (1.2%), (E,E) spathulenol (1.0%), 2,4-decadienal (1.0%), phenanthrene (0.9%), *p*-menth-4-en-3-one (0.8%),heptacosane (0.8%), 6 ,10 ,14-trimethyl-2-pentadecanol (0.7%), isocaryophyllene oxide (0.6%),dihydro-β-ionone (0.6%), epi-globulol (0.6%), safranal (0.6%), 2-pentylfuran (0.5%), 1,3,5-trimethylbenzene (0.5%), p-cymene (0.5%), fluoranthene (0.5%), caryophyllene alcohol (0.4%),	Leaves	[113]

Species	Compounds contained	Part of plant	References
	α-copaen-8-ol (0.4%), demethoxyageratochromene (0.4%), benzaldehyde (0.4%), salvial-4(14)-en-1-one (0.3%),6-methyl-5-hepten-2-one (0.3%), β-cyclocitral (0.3%), methyl hexadecanoate (0.3%), cadalene (0.2%), isophytol (0.2%), nonanal (0.2%), α-pinene (0.1%). **Total (85.8%)**.		
Ficus religiosa	Eugenol (27.6%), itaconic anhydride (15.4%),3-methylcyclopenetane-1,2-dione (10.8%), 2-phenylethyl alcohol (8.0%), benzyl alcohol (4.2%), allyl caproate (3.5%), coumaran (3.4%), β-eudesmol (1.8%), unidentified (1.7%), (*E*)-β-ionone (1.6%), salicylaldehyde (1.5%), benzeneacetonitrile (1.2%), (3Z)-hexenol (1.1%), catechol (1.1%), *p*-vinylguaiacol (1.1%),α-eudesmol (1.0%), epi-α-cadinol (1.0%), unidentified (0.8%), (2Z)-hexenol (0.7%), pentadecanal (0.7%), phenol (0.7%), phytol (0.7%), unidentified (0.7%), n-hexanol (0.7%), palmitic acid (0.7%), α-cadinol (0.7%), adipoin (0.6%),(*E*)-cinnamyl alcohol (0.6%), (3*Z*)-hexenyl tiglate (0.6%), phenylacetaldehyde (0.6%), (3*Z*)-hexenyl benzoate (0.5%), epi-γ-eudesmol (0.5%),(*E*)-linalool oxide (0.5%), (2*E*,6*Z*)-nonadienol (0.5%), (2E)-nonen-1-ol (0.5%), (2*E*,6*Z*)-nonadienal (0.4%), dihydroactinidiolide (0.4%), α-copaene-11-ol (0.4%), γ-eudesmol (0.4%), (2*E*)-hexenyl (3*Z*)-hexenoate (0.3%), linalool (0.3%), *n*-nonanal (0.3%). **Total (97.2%)**.	Leaves	[114]
Ficus thonningii	6 ,10 ,14-trimethyl-2-pentadecanone (18.8%), phytol (14.7%), acorenone B (7.6%), β-gurjunene (6.3%), o-xylene (4.6%),caryophyllene oxide (3.7%), zingiberene (3.4%), (E)-α-ionone (2.9%),octadecanal (2.9%), α-eudesmol (2.3%), (E)-6,10-dimethyl -5,9- undecadien-2-one (2.1%), (E)-β-ionone (1.9%), benzaldehyde (1.7%), arnesyl acetone (1.5%), isophytol (1.5%), 1,3,5-trimethylbenzene (1.5%), p-xylene (1.4%), β-eudesmol (1.3%), p-menth-4-en-3-one (1.3%), hexanal (1.2%), β-caryophyllene (1.2%), acetophenone (1.1%), 2-pentylfuran (1.0%), cyclosativene (0.9%), β-pinene (0.9%), fethyl benzene (0.8%), phenylacetaldehyde (0.8%), α-pinene (0.7%), 6-methyl-5-hepten-2-one (0.7%), β-cyclocitral (0.5%), α-copaene (0.5%), elemol (0.5%),. **Total (92.2%)**.	Leaves	[113]

Table 3. Odorous compounds in the essential oils.

Odorous compounds	Odour type	Bioactivity	References
Limonene	Turpentine like	Antioxidant, anticancer	[126,127]
Phytol	Floral	Antibacterial, antiinflammatory	[128,129]
1,8-cineole	Herbal	Antifungal, anti-inflammatory, analgesic	[130]
α-humulene	Woody	Anti-inflammatory, analgesic, anticancer	[126,127]
β-carophyllene	Woody	Antifungicidal, antibacterial, antioxidant, antiproliferative	[72,131]
Carophyllene oxide	Woody	Antifungal, insecticidal	[132]
Linalool	Floral	Antimicrobial, analgesic, antioxidant	[26,127,133]
Eugenol	Spicy	Antimicrobial	[26,127]
Thymol	Herbal	Antimicrobial, antioxidant	[16,26,127]
α-terpinene	Lemon	Antioxidant	[127]
p-cymene	Citrus	Antimicrobial, anti-inflammatory, anticancer, antioxidant	[26,132,134]
α-pinene and β-pinene	Herbal	Antibacterial, acetylCholinesterase	[132,135–137]
Nerolidol	Floral	Antimalarial, antileishmanial	[132]
α-cardinol	Herbal	Antifungal	[138]
Myrcene	Balsamic	Analgesic, sedative, antiinflammatory	[126]
Geraniol	Floral	Antimicrobial	[26]
Myristicin	Spicy warm balsamic woody	Anticancer	[127]
α-Phellandrene	Terpenic	Cholinesterase inhibition, antifungal	[139,140]
Camphor	Camphoraceous	Antibacterial, insecticidal, antiviral,	[127,141]
Carvacrol	Oregano like	Antibacterial, antioxidant	[127]

Odorous compounds	Odour type	Bioactivity	References
bicyclogermacrene	Balsamic	Cytotoxic	[142]
α-copaene	Spicy	Antioxidant	[143]
Nonanal	Citrus	Antifungal	[140]
terpinolene	Herbal	Antifungal, antioxidant	[127,144]
Geranyl acetate	Floral	Anti-inflammatory and antifungal	[145]
phenylacetaldehyde	Floral	Antifungal	[146]
aromadendrene	Woody	Antimicrobial and anti-inflammatory	[16,147]

Table 4. Bioactivity of the essential oil of some of the Ficus species under review.

Species	Bioactivity	Part of Plant	References
F.exasperata	Anti-candidal	Roots	[18]
F. mucoso	Cytotoxic, anti-microbial	Leaves	[4]
F. capensis	Acetyl cholinesterase inhibitory activity	Leaves, stem bark and root bark	[60]
F. capensis	Antimicrobial	Leaves	[104]
F. religiosa	Cytotoxic anti-bacterial against *Aspergillus niger*	Leaves	[114]
Ficus asperfolia	Antimicrobial	Leaves	[104]

This tree is known to hold medicinal properties such as anti-inflammatory; the dichloromethane extracts compare favorably with indomethacin; the anti-inflammatory activity was investigated by using the TPA-induced mouse ear edema; the edema reduced by 65% after the first hour and by 75% after the second hour [178]. The chloroform leaf extract of *Ficus polita* has been reported to rectify oxidative stress as well as possess hypolipidaemic activity [179].

Its ethanol extracts have also been shown to possess anti-malarial is as they inhibit the growth of plasmodium falciparum with an IC_{50} value of 20.8 μg/ml [180]; thus, it could be used as an alternative anti-malarial drug for people who are unable to purchase the modern drugs. The major components of the leaf essential oil of this tree with respect to the percentage composition are; 23.3% phytol, 15.0% of 6, 10, 14-trimethyl-2-pentadecanone, 7.3% (E)-6, 10-dimethyl-5, 9-undecadien-2-one, and drimenol making up 5.8% [113]. The information on the available compounds in this plant's leaf essential oil and their percentage abundance is given in Table 2.

2.1.13. *Ficus religiosa* Linn.

Ficus religiosa Linn is a very big tree of this species, ranging from 150m to 1550m in height, commonly referred to as 'Peepal tree' by the Hindus, is a widely branched tree and is said to be one of the oldest and sacred trees in their myth. [114,181]. Traditionally, *Ficus religiosa* is an aphrodisiac plant, which prompted [182] to investigate the plant's aqueous dry and fresh leaf extracts to cure polycystic ovary syndrome (PCOS) in rats model. The researchers documented that the fresh leaf extract in particular directly alleviates the steroid imbalances with the regular orchestrated estrous cycle in letrozole-administered PCOS-induced rats, which suggests that the leaf extract has the potential to cure PCOS.

Ficus religiosa is also a plant of known antimicrobial activity, as the aqueous extract showed high antimicrobial activity against *Bacillus subtilis* and *Pseudomonas aeruginosa* making it useful as a multi-resistant drug [183], at 500μg/ml, 70% aqueous-ethanol extracts hindered *Helicobacter pylori* growth, and this was observed across all strains [184]. The fruit of *Ficus religiosa* is known to contain many compounds beneficial to humanity, including but not limited to amino acids, sesquiterpenes, alcohols, aldehydes, ketones, etc. [185]. *Ficus religiosa* also has other properties, including anti-inflammatory and analgesic activity [186]. The essential oil content of the leaves of *Ficus religiosa* was analyzed. It was discovered that a total of 44 peaks were identified, making up 97.2% of the oil and eugenol (27.0%), itaconic anhydride (15.4%), 3-methyl cyclopentane-1,2-dione (10.8%), 2-phenyl ethyl alcohol (8.0%). Benzyl alcohol (4.2%) were the compounds with the highest quantities [114].

The compounds present in the oil are listed in Table 2, with about 3 compounds unidentified. The essential oil from the leaves of *Ficus religiosa* was inactive to *C.albicans* alongside organisms such as *Pseudomonas aeruginosa*, *Bacillus cereus*, *Staphylococcus aureus*, and *Escherichia coli* though the oil was reported to be slightly active towards *Aspergillus niger* with a minimum inhibitory concentration of 625 μg/mL[114]. Table 2 shows that Eugenol is the main constituent of the leaf essential oil (27.6%). Table 1 listed eugenol as one of the phenols in an essential oil that exhibits antimicrobial properties, Table 3 also listed it as an antimicrobial agent. Several reports also show that eugenol is effective as an antimicrobial compound [26]; therefore, one would expect a good antimicrobial property for the oil. The inactive nature of the oil could be as a result of no synergistic interaction between eugenol and other constituents of the essential oil or because other constituents that have antimicrobial activity are too small to exert moderate activity, for example, cinnamyl alcohol and α-eudesmol, which have also been reported to have antimicrobial property is just 0.6% and 1.0% respectively in the oil as shown in Table 2 [11,187]. Though, the oil showed *in vitro* cytotoxic activity against MCF-7 human breast tumor cell line with 80± 5% kill at 100 μg/mL. This could be due to the presence of α-eudesmol, which has been reported to produce a cytotoxic effect in human hepatocellular carcinoma [132]. In addition to the *in vitro* cytotoxic activity, the oil was also slightly active in the brine shrimp lethality test with an LC_{50} of 50 μg/mL. The probable odorous compounds in this oil are linalool, phenol, phytol (0.7%), eugenol, and α-cadinol.

2.1.14. *Ficus thonningii.*

Ficus thonningii Blume is commonly known as "strangler fig", and is common to riverine, upland forest, and rocky areas; this fig is also found in Nigeria [113]. The tree's bark embeds in it many medicinal uses, such as its use in treating colds, diarrhea, constipation, and stimulating lactation [188]. Methanol, ethyl acetate, and chloroform were used to extract the leaves of this plant. Of the three solvents, the ethyl acetate had the highest antimicrobial activity; the wound healing property of the ethyl acetate extract was also documented. The evaluation of wound contraction after post wounding days is close to what was observed for gentamicin, the drug used as the positive control [189]. The hydro-ethanol extract of the stem bark of *Ficus thonnigii* was reported to contain flavonoids, saponins, quinones, alkaloids, coumarins, catechic tannins, polyphenols, flavonoids, phlebotanins, and Antho cyanides; the extracts at 500 mg/kg were able to increase Catalase activity, glutathione and superoxide dismutase while inhibiting xanthine oxidase, malondialdehyde and pepsin concentration which led the authors to conclude that the extract has a promising therapeutic and pharmacologic activity for the management of ulcers [190].

The essential oil composition was determined by gas chromatography–mass spectrometry, and the following were found to be in high quantity: 6,10,14-trimethyl-2-pentadecanone (18.8%), phytol (14.7%), acorenone B (7.6%), and β-gurjunene (6.3%) [113]. Table 2 below shows the compounds present in the essential leaf oil of *Ficus thonningii* and their percentage composition. The presence of a high amount of phytol could mean that the oil might be useful in the cosmetics industry. Acorenone is also another abundant compound in this oil, and this compound has been reported to inhibit acetylcholinesterases and butyrylcholinesteras related to Alzheimer's disease [137]. Table 2 shows the constituents of the essential oils of different *Ficus* species alongside their percent abundance arranged in decreasing order.

3. Application of Compounds Found in the Essential Oil of the Plants under Review

The *Ficus* plants reviewed revealed a high content of the following compounds (some of these compounds are said to be biomarkers of Nigeria Figs): Phytol, Germacrene D-4-ol, α-Pinene, α-Humulene, Hexadecanoic acid, 6,10,14-trimethyl-2-pentadecanone, β-pinene, α-cadinol, *p*-cymene, α-copaene, carophyllene oxide, and β-carophyllene. Information on the application of these compounds will help infer the probable application of the essential oil that contains them. Some compounds have also been known to play important roles in various industries like food, pharmaceutical, and cosmetics.

3.1. (E)-phytol.

Having stated earlier that *(E)*-phytol is one of the markers of essential oil obtained from Nigerian *Ficus* species, we would look briefly into some of its uses and applications. Phytol is also known as 3, 7, 11, 15-tetramethyl-2-hexadecen-1-ol and is an isoprenoid component found in chlorophyll [191]. Phytol, acyclic diterpene alcohol, is used as a precursor to producing vitamin E, K1, and some other tocopherols [192–194]. It is also believed to be the most abundant acyclic isoprenoid compound present in the biosphere, and the products of its degradation are used as biogeochemical tracers in aquatic environments [195]. One of the uses of phytol is seen in its application in the cosmetic industries, in the production of soaps and detergents, largely due to its inviting fragrance [129]. This follows the information presented in Table 1 that alcohols as essential oils are used as antiseptics. Phytol can be used in the food industry to preserve foods susceptible to bacterial infection due to its ability to inhibit the growth of some bacteria like *Pseudomonas aeruginosa* and *Staphylococcus aureus* [128].

Some of the medical applications of this diterpene alcohol are seen in its ability to; act as an anti-inflammatory response drug as it was seen to reduce cytokine levels, neutrophil migration, and oxidative stress in models of acute inflammation [196]; alcohols as components of essential oils have been reported to be useful as an anesthetics and as an anti-inflammatory agent as presented in Table 1. It has also been used to treat Schistosomiasis in humans, as it was seen to reduce the worm load in a mouse infected with *Schistosomiasis mansoni* [194]. Although phytol is a natural product, it can be synthesized in the laboratory from acetone [197].

3.2. α-Pinene.

α-Pinene is bicyclic monoterpene [132] which is found in most of the *Ficus* species discussed in this review has myriads of medical usefulness. α-Pinene is made up of two enantiomers, the (−)-α-pinene and (+)-α-pinene, of which the positive enantiomer was found to possess antimicrobial activity [135]. It is known to have high potency as an anti-bacterial agent [16], although it's highly effective against yeasts and a group of bacteria classified as Gram-positive [132,172]. α-Pinene's ability to work against bacteria is by inducing toxicity on the membrane structure, thus hampering the function of the membrane [198], and Table 1 presents pinene as one of the hydrocarbons in essential oils with antibacterial and antiviral as some of the potential activities.

A research carried out showed that α-pinene is capable of inhibiting leukocyte migration which is necessary in an inflammatory response and, as such, can be used to treat cases with high leukocyte migration [199]. α-pinene has also been seen to show the anti-nociceptive property [200]. Furthermore, pinene has been reported to inhibit the Acetyl cholinesterase enzyme [136,137], an enzyme that has been deemed important in treating Alzheimer's disease.

3.3. Other compounds.

n-Hexadecanoic acid, a constituent of essential oil from the *Ficus* plant, is known to be used as a pesticide, as well as an antioxidant [97,155]. It is also implicated in an anti-inflammatory role, as it showed inhibitory activity in the enzyme kinetics of Phospholipase A2 [96].

Cymene is one of the compounds that fall under the hydrocarbon class of compounds in essential oils, as presented in Table 1. Among the biological properties of the hydrocarbon class in Table 1 is a decongestant. P-cymene medicinally is used to eradicate phlegm and prevent cough [134].

Germacrene-D, is known for its insecticidal property, as it is seen to be effective against mosquitoes [124]. It has also been found to possess cytotoxic attributes [125].

β-Caryophyllene, a volatile bicyclic sesquiterpene lactone compound [201] found in some of the *Ficus* species reviewed, has shown both anti-fungicidal and anti-bactericidal actions [72,131]. β- caryophyllene was also exhibited selective anti-proliferative effects against colorectal cancer cells and powerful antioxidant effects [72]. It is also added to foods as a preservative [202]. Due to its fine fragrance and safe use, it is added to cosmetics [203]. The therapeutic effects of β-caryophyllene in pain and inflammation, neurodegenerative diseases, gastrointestinal disorders, and many others have also been identified, and as a result of its safety when consumed, it has been used as a marker for quality control in some industries where it is widely used [201].

3.4. Odorous compounds in essential oils.

Extraction of essential oil is often followed by its analysis; most times, the essential oil is subjected to gas chromatography/mass spectrometry (GC/MS) and gas chromatography/ (GC/FID) for its characterization. One of the characteristics of essential oil is its odor (aroma) which is based on its components [83]. The essential oil can contain more than one odorous compound. The odor of a particular essential oil may be as a result of a large amount of a single compound, or in some others, trace elements are also important when it comes to essential oil odor, and that is why there is no easy overview when it comes to the major odorants in essential oils [110]. Often times the true odor is a manifestation of a complex mix of compounds. Knowing the odor of essential oil could be necessary in case imitation is required because of the scarce nature of essential oils [110]. Generally, the odor of essential oils can be classified into groups such as woody, herbaceous, minty, floral, spicy, camphorous, and earthy [83]. There are different techniques used in the determination of odor of essential oils, and the major one is the use of gas chromatography/olfactometry (GC/O); it could also be coupled with a mass spectrometer as GC-MS-O [50,110,204]. Odor intensity is ranked using CHARM analysis [110,205] and aroma extract dilution assay (AEDA) [110,206]; AEDA has proven to be better, and it can also be combined with stable isotopic dilution analysis (SIDA) [110,207] for another precise level of quantification.

The odor potency can be estimated using flavor dilution factor (FD); it is also possible to get the significant contribution of each odorant to the characteristic odor of the essential oil by getting the odor activity values (OAV) which is the ratio of the concentration to the odor threshold of the compound [50]. GC/O was used to identify the active odor compounds in the essential oil of *Eurya japonica* [109]. The active odor compounds were also identified in the essential oil of *Magnolia obovata* using GC/O and AEDA [50]. In this review, most of the analyses carried out on the essential oils of the *Ficus* species did not include the identification of odorous compounds. However, a list of previously confirmed odorous compounds gotten from literature and found in the essential oils of the *Ficus* species under review was presented in Table 3, alongside the bioactivities of these compounds. The bioactivities of the odorous compounds could give information on the probable potential of the oils that contain them. It is also worthy to note that the odor of a particular essential oil can also depend on the method by which the essential oil is extracted. For instance, the essential oil extracted from *Magnolia obovata* via hydrodistillation had a floral-sweet-spicy-woody odor, while the one extracted via Solvent assisted flavor evaporation (SAFE) had a spicy-woody-sweet-green odor [50].

4. Conclusion and Future Prospects

This review has pointed out that essential oils can be gotten from almost every part of the *Ficus* species and that there are diverse useful components in oils. There is a need to search for more bioactive compounds for the drug, food, and cosmetic industries. The following areas will need more attention.

The extraction of essential oils has been solely from leaves, as this review has pointed out. Extraction from other parts like root, stem can lead to more yield of essential oils. Attention also has to be given to extraction from fruits as this has received the least attention.

Other extraction methods ought to be investigated; this review has shown that the major extraction method has been hydrodistillation. Other methods may afford better yield as well as better quality.

Attention must also be paid to how method parameters such as distillation time, temperature, pressure, the time-lapse between extraction and analysis for the components affect the quality and quantity of essential oil.

The effect of maturity on the yield and chemical composition of essential oils from *Ficus* species, especially for the leaves and fruits, is also worthy of investigation.

There is also a need to investigate the quality and quantity of essential oil gotten from the plants related to how the sample is treated. In this review, essential oils were extracted majorly after air-drying the sample; essential oil quality and quantity of fresh samples and air-dried samples can be compared, especially since they are extremely volatile.

In this review, most of the works reported are basically on the extraction of essential oils, with few reports on the bioactivity of the oils even though essential oils have been playing a major role in managing diverse disease conditions and infections for decades. There is a need for a dedicated study on the pharmacological properties of these oils with the cases of drug resistance and a new strain of disease-causing organism evolution every day.

Isolation of phytochemical compounds often leads to possible synthesis in the laboratory and on the industrial scale. For example, the isolation of penicillin and its effectiveness against fungi led to its synthesis in the laboratory and industrially. There is a need to isolate compounds from the essential oils extracted, which will lead to their possible synthesis for our drug, food, and cosmetic-related industries.

Figs generally are very important plants as their use can be seen in diverse areas, which are not limited to anti-bacterial, anti-diabetic, anti-malarial, anti-cancer. This review has pointed out that *Ficus* species can be classified as essential oil-bearing plants. The essential oil can be obtained from all parts of the plants as already presented. Generally, essential oil contains numerous compounds that have proven useful in the cosmetics, drug, and food industries. The essential oil components from *Ficus* species have also shown that their essential oil can be useful in the chemical industries. These compounds can be a pilot in the synthesis of myriads of compounds for use by humanity.

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Conflicts of Interest

The authors declare no conflict of interest.

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