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Anti-malarial and Anti-bacterial properties of some selected species of Asteraceae family

Shehu Isah[1], Theresa Uchechukwu[2], James Akande[1]

[1]Caleb University, Lagos. [2]Alex Ekwueme Federal University, Abakaliki

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Abstract: **Bioactive natural plants, including the Asteraceae family have several therapeutic effects and antimicrobial properties. They are used in different cultures across the world as alternative medicine for treatments of several ailments including prevalent malaria infection, wound healing, diabetes, anti-ulcerative, anti-bacterial, treatment of liver disease, accelerates blood clotting, relieves muscle cramps during menstruation and treatment of common colds. In this review, some selected species of the Asteraceae families such as Vernonia amygdolina, artemisia annua and ageratum conyzoides amongst others were evaluated for their anti-malarial and antimicrobial properties. Major and minor bioactive chemical ingredients in each species were discussed, especially their chemical structures and inherent functional groups.**

This approach is intended to guide future research on drug development and drug discovery. This is especially important as we are set to finding lasting solution to multidrug resistance microbial infection and other life-threatening ailments, such as malaria, and cancer that confront our daily lives. Asteraceae family in general can be used as safe preservatives and food additives to improve the health role of food. This is attributed to their good flavor, antioxidant, and antimicrobial effect.

Keywords: **Bioactive plants; Asteraceae; therapeutic effects; antimicrobial effect; anti-malarial.**

1. INTRODUCTION

Bioactive plants extracts provide alternative therapy in combating and curtailing common ailments and diseases including multi-resistant pathogens encountered in our everyday lives. Bioactive plants are sources of various phytochemicals responsible for their biological activities. Some bioactive plants in Nigeria include guava, ginger, neem and moringa known to exhibit broad range of biological activities.

Globally, there are evidence-based studies to verify the efficacy of Bioactive plants and some of these shreds of evidence have provided insights into the syntheses of plant-based compounds with therapeutics application. The annual global market value of medicinal plant products has exceeded $100 billion.

The "traditional or herbal medicines" refer to treatment of diseases originating from bioactive plant sources and are generally regarded as safe (GRAS) at the concoction dosage, based on their historical usage in various cultures. Thus, plants remain the most abundant natural primary source of active drugs and are invaluable in the ethnomedical treatment of diverse ailments. World Health Organization (WHO) defined traditional medicine as the total of the knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness.

Studies show that there are 325 species and 95 families of medicinal plants being used by most of the people in Nigeria for treatment of various common diseases. *Fabaceae* has the largest number of species (42) followed by *Asteraceae* (22), *Euphorbiaaceae* (20), *Acanthaceae* (13) and *Apocynaceae* (12). The medicinal uses are varied, and the plant parts that are used ranged from their leaves, roots, stem, bark to fruits only, or a combination of two or more species.

Phytochemical screening of medicinal plants is usually done against broad spectrum of microorganisms to ascertain their biological or antimicrobial activities, based on the active constituents of the plants that are primarily secondary metabolites. The significant steps involve the extraction, primary screening, isolation, purification, and characterization as well as pharmacological and toxicological analyses.

Different techniques, which include varieties of column chromatography, gas chromatography-mass spectrometry (GC-MS), Fourier-transform infrared spectroscopy (FTIR), ultraviolet (UV) spectrophotometry, and nuclear magnetic resonance (NMR), are often used stepwise for purification, identification, and structural characterization of various groups of phytochemical compounds in plants extracts.

Phytochemicals are bioactive organic chemical compounds which play a defensive role against major chronic diseases in both host- metabolic or genetic dysfunctional disease and infectious diseases. These phytochemical constituents are present in different part of plant (leaves, roots, barks, fruits and seeds) and have led to the discovery of numerous biologically active drugs.

Phytochemicals are broadly classified into alkaloids, carotenoids, phenolics, Nitrogen-containing or organosulfur as shown on Fig. 1.

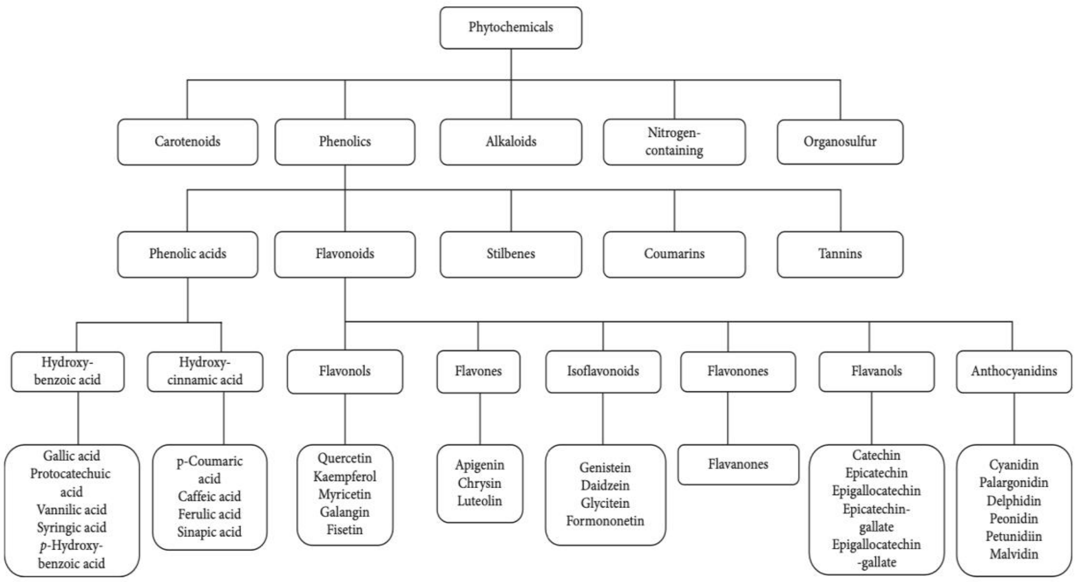

Fig.1 Classification of phytochemicals

The Asteraceae family is one of the largest families of flowering plants consisting of over 1600 *genera* and 2500 species globally with members having been used in dietary formulations and for medicinal purposes for centuries (Agata and Olas, 2017). Despite their wide diversity, most family members share a similar chemical composition: for example, all species are good sources of *inulin*, a natural polysaccharide with strong prebiotic properties (Nwafor *et al.*, 2017). They also demonstrate strong antioxidant, anti-inflammatory and antimicrobial activity, as well as diuretic and wound healing properties (Achika *et al.*, 2014). The pharmacological importance of *Asteraceae* can be attributed to the wide range of phytochemical compounds, including polyphenols, phenolic acids, flavonoids, acetylenes, and triterpenes. One such example is *arctiine*: a ligand with numerous antioxidants, antiproliferative and de-mutagenic activities. The family is also a source of sesquiterpene lactones: the secondary metabolites responsible for the bitter taste of many plants (Achika *et al.*, 2014). The *Asteraceae* family contains several bioactive natural products that are responsible for their physiological activities and their use in herbal medicine. These herbs are presently used in various products but understanding their mechanism of action and the ingredients involved can lead to the development of new industrial applications. The chemical structures of the main components of selected species of the *Asteraceae* family are listed under each specie. From available

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information in literature almost all *Asteraceae* family herbs have antimicrobial, antioxidant, anti-cancer, remedy effects and improve digestive disorders. Thus, herbs from the *Asteraceae* family can be used in traditional and modern medicine. Tea prepared from *Matricaria chamomilla* L. and *Artemisia persica* L. is recommended for the relief of pain. To reduce the volume of body mass, the use of *Artemisia aucheri*, *Arctium lappa*, *Polygonum bistorta*, *Artemisia annua* and *Cynara scolymus* is recommended. *Cichorium intybus*, chamomile, the use of *Arctium lappa*, *Polygonum bistorta*, *Artemisia annua*, and *Cynara scolymus* are effective in the treatment of diabetes. To improve inflammation, the use of *Achillea millefolium* L., *Arctium lappa* L., *Artemisia annua* L., *Artemisia aucheri* L., *Artemisia persica* L., *Matricaria chamomilla* L. and *Polygonum bistorta* L. are effective. For effective treatment of gastric ulcer, the use of *Polygonum bistorta* L. and *Arctium lappa* L. are effective. To improve asthma, the use of *Artemisia annua* L. and *Artemisia persica* L. are effective. To prevent flatulence, the use of *Matricaria chamomilla* L., *Artemisia persica* L., and *Achillea millefolium* L. are effective. To heal wounds, the use of *Polygonum bistorta* L., *Matricaria chamomilla* L., *Artemisia annua* L., *Arctium lappa* L. and *Achillea millefolium* L. are effective. The use of *Cynara scolymus* L., *Artemisia persica* L. and *Arctium lappa* L. are effective for the treatment of atherosclerosis. To improve kidney function, the use of *Polygonum bistorta* L., *Cynara scolymus* L. and *Cichorium intybus* L. are recommended. To improve hair growth stimulation and anti-dandruff, the use of *Achillea millefolium* L. and *Arctium lappa* L. are effective remedies. For proper relaxation therapy, the use of *Artemisia persica* L., *Artemisia aucheri* L., *Cichorium intybus* L., chamomile, and *Artemisia annua* L. are effective. *Cichorium intybus* L., chamomile, *Arctium lappa* L., *Polygonum bistorta* L., and *Artemisia annua* L. have antiviral activity, which *Artemisia annua* L. has an inhibitory effect on a wider range of viruses.

Some selected species of the *Asteraceae* family with important biological activities are discussed in detail:

(1) *Vernonia amygdalina* (Bitter leaf): *Vernonia amygdalina*, a member of the *Asteraceae* family is a small shrub that grows in tropical Africa. *V. amygdalina* typically grows to a height of 2–5 m (6.6–16.4 ft). The leaves are elliptical and up to 20 cm (7.9 in) long. Its bark is rough. *V. amygdalina* is commonly called 'bitter leaf' in English because of its bitter taste. Nigerian common names include ewuro (Yoruba), etidot (Efik), onugbu (Igbo), ityuna (Tiv), oriwo (Edo), chusar-doki or shuwaka (Hausa).

Fig. Image of *Vernonia amygdalina* (Bitter leaf) plant

Improved antimalarial activity of *Vernonia amygdalina* was reported by Elahe Tajbakhsh (2021) where he reported the enhanced effects of popular antimalarial drug (chloroquine) by aqueous *Vernonia amygdalina* leaf extract in mice infected with chloroquine resistant and sensitive Plasmodium berghei strains.

According to Ifedibaluchukwu *et al.* (2020), the methanol extract of the stem-bark of *V. amygdalina* has been reported to demonstrate antidiabetic and antihyperglycemic activities in alloxan-induced diabetes mellitus wistar rats where the active phytochemical in *V. amygdalina* responsible for the antidiabetic and antihyperglycemic activities was reported as **6β,10β,14β-Trimethylheptadecan-15α-olyl-15-O-β-D-glucopyranosyl-1,5β olide (*vernoniaolide* glucoside)** which belongs to the class of the novel sigmastane-type steroid glycosides - sesquiterpene lactones**.**

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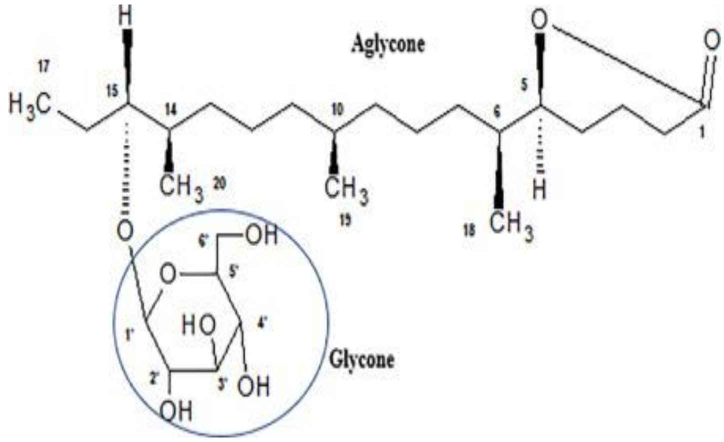

Fig 1. Structure of 6β,10β,14β-Trimethylheptadecan-15α-olyl-15-O-β-D-glucopyranosyl-1,5β-olide (*vernoniaolide* glucoside).

(2) *Artemisia annua* (sweet wormwood): *Artemisia annua* belongs to the plant family of *Asteraceae* and is an annual short-day plant. Its stem is brownish or violet-brown. The plant itself is hairless and naturally grows from 30 to 100 cm tall, although in cultivation, it is possible for plants to reach a height of 200 cm. The leaves of *A. annua* have a length of 3–5 cm and are divided by deep cuts into two or three small leaflets. The intensive aromatic scent of the leaves is a distinguishing characteristic. The artemisinin content in dried leaves is between 0% and 1.5%. New hybrids of *Artemisia annua* developed in Switzerland can reach a leaf artemisinin content of up to 2%. The small flowers have a diameter of 2–2.5 mm and are arranged in loose panicles. Their color is green- yellowish. The seeds are brown achenes with a diameter of only 0.6–0.8 mm. Common Nigerian names include tazargade (Hausa), Ewe Egbin (Yoruba), ocho-onye-ogwo (Igbo) and Mkpatat (Ibibio).

Leaf and stem-bark extract of *A. annua*, called artemisinin (or artesunate), (which is the active ingredient responsible for the *A. annua* antimalarial activity) is a medication used to treat malaria in Nigeria and other African countries (Ifedibaluchukwu *et al.*, 2020).

Fig. Picture of the artemisia annua plant

Ridder et al in 2008 reported self-reliant treatment of malaria in developing countries which includes the local production practices of A. annua followed by the possibilities for using traditional prepared teas from A. annua as an effective treatment for malaria. Discovery of artemisinin and its antimalarial properties by the Chinese Scientist, Tu Youyou led to the award of the 2011 Lasker Prize and 2015 Nobel Prize in Physiology or Medicine. Artemisinin is a sesquiterpene lactone with an endoperoxide bridge and has been produced as an antimalarial drug.

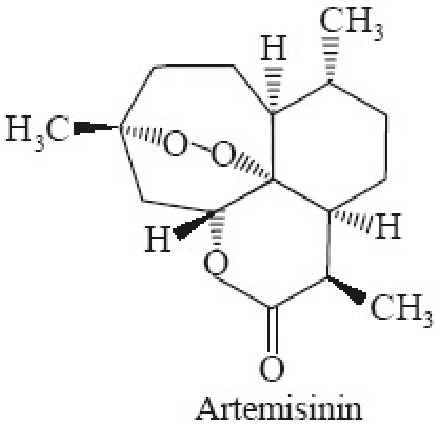

Fig. 2. Chemical structure of Artemisinin

(3) *Chromolaena odorata* (Siam weed): Synonym as *Eupatorium odoratum* is a traditional medicinal plant that is widely used for its antimalarial and wound healing property. Ileke and Olabimi in 2019 investigated the larvicidal, pupicidal and adulticidal activities of *Chromolaena odorata* extract against *An. gambiae* at room temperature of 28 ± 2 °C and 75 ± 5% relative humidity. Different concentrations of 20 mg/L, 40 mg/L, 80 mg/L, 120 mg/L and 160 mg/L were prepared for these experiments. Larval, pupal and adult mortality of *An. gambiae* were tested after 24 hours exposure. Results showed that *Chromolaena odorata* extract caused 32.5%, 60%, 82.5%, 92.5% and 100% mortality of *An. gambiae* larvae after 24 hours of treatment at concentrations of 20 mg/L, 40 mg/L, 80 mg/L, 120 mg/L and 160 mg/L, respectively.

In particular, the several parts of this herb (especially its leaves) have been used to treat wounds, burns and skin infections. The efficiency of healing wounds comes from the antioxidant property of the plant which enhances conserving the fibroblast and keratinocyte proliferation on those wounds.

Chromoleana odorata (Siam weed) has a minimum 10-year life span. *C. odorata* is a scrambling perennial shrub which grows 2–3 m in height with straight, pithy, brittle stems that branch readily. The arrowhead-shaped leaves are 6–12 cm in length and 3–7 cm in width, with three veins in a pitchfork appearance. The leaves grow in opposite pairs along the stems and branches. There are 15–25 tubular florets per head, each 10 mm long and several colors such as white, purple, pink, or blue. The color of seeds is brown-gray to black and is 4–5 mm long with a pale brown pappus that is 5 or 6 mm long. The roots are narrow and fibrous and generally reach 0.3 km in depth. *C. odorata* shows morphological in terms of flower color, leaf shape, odor of the crushed leaves, and plant architecture variable in its native environment. Common Nigerian names include obiarakaka/akwukwo Elizabeth (Igbo), ewe Akintola/ewe Awolowo (Yoruba), gautan kaji (Hausa).

Fig. Leafy plant of *C. odorata*

Hataichanok *et al.* (2013), established that the active phytochemicals responsible for the wound healing activities of *C. odorata* are stigmasterol (a steroid) and scutellarein tetramethyl ether (4',5,6,7-tetramethoxyflavone), a flavonoid**.**

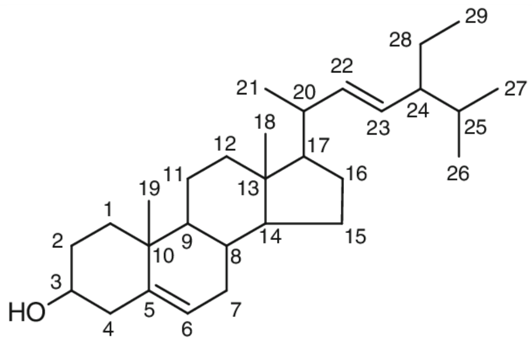

Fig. 3a. Structure of stigmasterol.

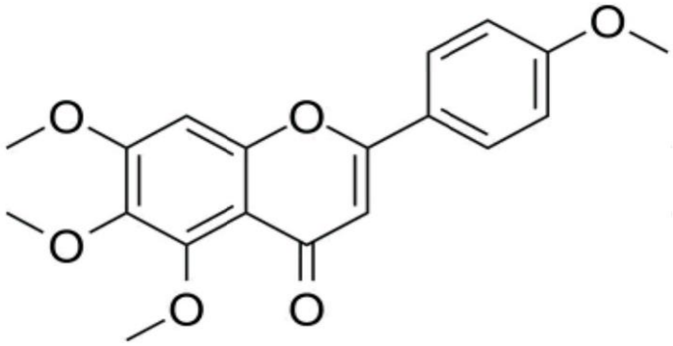

Fig. 3b. Structure of scutellarein tetramethyl ether (4',5,6,7-tetramethoxyflavone).

(4) *Emilia praetermissa* (yellow thistle): *Emilia praetermissa* which belongs to the family of *Asteraceae* is a useful plant of West tropical Africa used generally as food and medicine for general healing and antibacterial activity (Burkill, 1985). *E. praetermissa* leaves have been confirmed to possess potent and efficient anti-ulcerogenic activity, producing complete mucosal cytoprotection at a dose of 500 mg/kg. Common Nigerian names include Odundun (Yoruba), Banochi (Hausa), Nti ele (Igbo). The ethanolic extracts was reported by Gonemali et al, (2018) to exhibit both antibacterial and antifungal activities against tested microorganisms. Ethanolic roselle extract showed significant antibacterial activity ($P < 0.05$) against all tested bacterial strains, while no inhibitory effect on *Candida albicans* (CA).

Fig. Image of the *Emilia praetermissa* plant

Ilhan *et al.* (2005) established the active phytochemical responsible for the anti-ulcerogenic and cryoprotective properties of *Emilia praetermissa* as Hypolaetin-8-O-α-d-glucoside (a flavonoid).

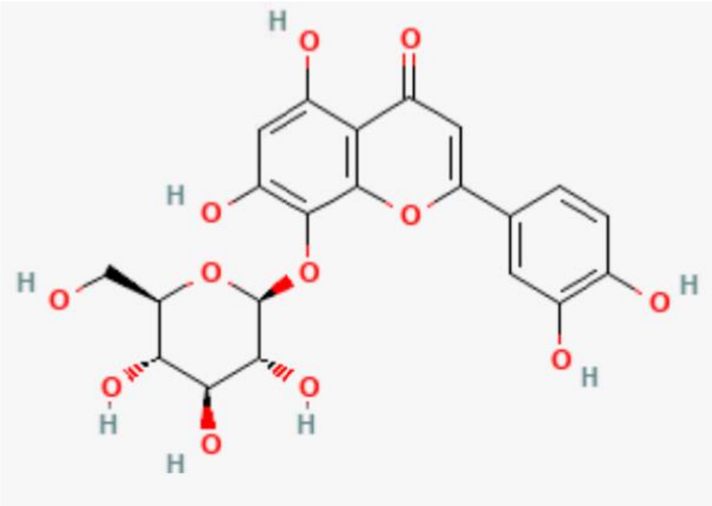

Fig. 4. Chemical structure of Hypolaetin-8-O-α-d-glucoside

(5) *Ageratum conyzoides* (Goat weed): *A. conyzoides* is an annual herb about 1m high, common throughout the tropical region, except in the driest situations in open spaces, distributed sites, distributed pan tropically and sub-tropically. Common Nigerian names include Agadi-isi-awo/akwukwo nwaosi n'aka (Igbo), Akoyunyun/imi-esu (Yoruba), Magarya (Hausa).

Fig: Image of flowering plant of Ageratum conyzoides

Ageratum conyzoides has bioactive activity that may have agricultural application, as shown by several research investigations in different countries. Dina and Olabode in 2006 investigated antibacterial activities of Ageratum conyzoides extracts on some bacterial pathogens. The susceptibility of Staphylococcus aureus, Yersinia enterocolitica, Salmonella gallinarum and Escherichia coli to the various extracts as well as the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were studied using standard methods. Results showed that the n-hexane extracts of the leaf, stem and root had 100% susceptibility to all the bacterial isolates investigated. The aqueous leaf extracts gave 75% susceptibility, while methanolic leaf extract gave 50%. The inhibition of the growth of bacterial isolates were dependent on concentration of leaves extracts.

Pereira in 1929 reported the use of the leaves as an insect (moth) repellent. The insecticide activity may be the most important biological activity of this species. The terpenic compounds, mainly precocenes, with their antijuvenile hormonal activity are probably responsible for the insecticide effects.

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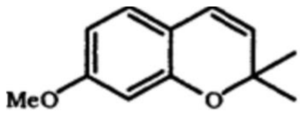
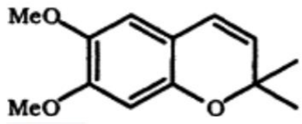


Precocene I



Precocene II

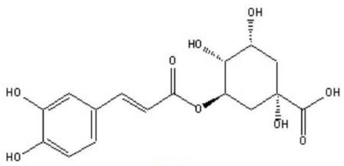
Fig. 5. Structure of precocene(I) and precocene(II)

6. ***Achillea millefolium* L.**

Therapeutic effects of *A. millefollium include* its application as a contraceptive agent (Innocenti *et al*., 2005). It facilitates labor by reduction in cervical adhesion and also controls uterine infection. It lowers premenstrual syndrome (Kalhor *et al*., 2019) and applied in the treatment of infectious diseases, treatment of liver disease, accelerates blood clotting, wounds healing, relieves muscle cramps during menstruation, treatment of colds, antioxidants (Mazaraie and Fahmideh, 2020), inhibition of cancer cell production, improvement of gall bladder function (Bozin *et al*., 2008), anti-inflammatory, antipyretic (Hegazy *et al*., 2008), antiparasitic, protection of red and white blood cells against free radicals (Karaalp *et al*., 2009), treatment of respiratory problems, treatment of oily hair, anti-dandruff, hair growth stimulation, local healing of the skin, anti-flatulence, improvement of digestive disorders, and use as a mouthwash due to its effect against opportunistic bacteria in the mouth (Atai *et al*., 2006).

Proven antimicrobial effects include *bacillus* (*subtilis, cereus* and *licheniformis*), *Staphylococcus* (*saprophyticus*, *aureus* and *epidermidis*), *Streptococcus* (*pyogenes*, *agalactiae*, *pneumoniae*, *sanguinis* and *salivarius*), *Salmonella* (*typhimurium* and *typhi*), *Proteus* (*vulgaris* and *mirabilis*), *Pseudomonas aeruginosa*, *Serratia marcescens*, *Klebsiella pneumoniae*, *Actinomyces viscosus*, *Enterobacter cloacae*, *Escherichia coli*, *Aspergillus niger*, and *Candida albicans* (Aljančić *et al*., 1999; Atai *et al*., 2006; Ghaderi *et al*., 2012).

Associated bioactive compounds in this species include 3-*O*-caffeoylquinic acid caffeic acid and chamazulene (Dias *et al*., 2013). Others are Sabinene, α-terpineol, cineole, chamazulene, borneol, caryophyllene, y-terpinene, and terpinene-4-ol. Chamazulene, 1,8-cineole, camphor and α-eudesmol (Farhadi *et al*., 2020). Guaiol, germacrene D, caryophyllene oxide, and spathulenol.



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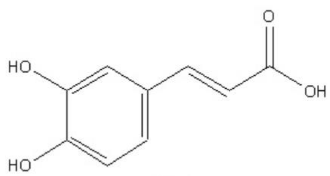

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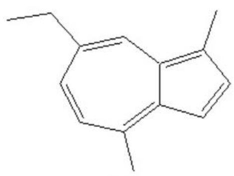


(3)

Fig. Chemical structures of isolated bioactive compounds from A. millifolium L: (1) 3-*O*-caffeoylquinic acid (2) caffeic acid and (3) chamazulene.

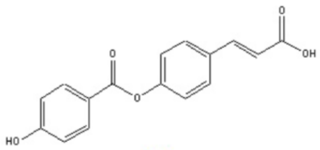
Chamazulene is known to stimulate leukotriene synthesis in neutrophilic granulocytes and reduces inflammation. Chamazulene also prevents inflammation by preventing the synthesis of prostaglandins and reducing the production of tumor necrosis factor-alpha and interleukins 6 and 8. It prevents the formation of leukotriene B-4 in healthy cells, and its anti-inflammatory activity may be related to the prevention of leukotriene production as well as its antioxidant activity (Carl and Emrich 1991). Terpineol on the other hand induces the process of programmed cell death and also plays a role in causing allergies and dermatitis (Murakami *et al*., 2002).

7. ***Arctium lappa* L**

This species improves calcium absorption, reduces the risk of osteoporosis and anti-obesity (de Moreno de LeBlanc *et al.*, 2011). It suppresses the growth of pathogenic bacteria and antiviral (Donohoe *et al.*, 2011; Chan *et al.*, 2011), antioxidant, diuretic, prevents dandruff and hair loss, treatment of gastric ulcer. It is an effective remedy for skin diseases such as laryngitis, ulcers, pimples, eczema and pneumonia, blood purification (Ferracane *et al.*, 2010), treatment of gout, hepatitis, and liver disease (Naeini *et al.*, 2010), blood pressure control (Eftekhar-Sadat *et al.*, 2016), prevention from atherosclerosis, treatment of heart disease, treatment of influenza, Alzheimer's, and cancer (Gao *et al.*, 2018), improvement of cachexia (severe weight loss) due to cancer, treatment of cerebral ischemia (complication due to lack of oxygen to the brain), treatment of tuberculosis, anti-constipation, wound healing, lowering of blood sugar, increase of tolerance to carbohydrates, treatment of diabetes, anti-allergy, anti-inflammatory and treatment of bacterial infections.

Arctium Lappa antimicrobial properties include *Brucellae* (*melitensis* and *abortus*), *Shigella* (*flexneri* and *sonnei*), *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Aeromonas hydrophila*, *Escherichia coli*, *Micrococcus luteus*, *Helicobacter pylori* and *Candida albicans* (Chan *et al*., 2011; Gao *et al*., 2018; Liu *et al*., 2021).

Bioactive compounds isolated from Arctium Lappa L. species include *p*-Coumaric acid/4-hydroxybenzoic acid (**4**), isoniazid (**5**) and rifampicin (**6**). Others are Quercetin-3-rutinoside hydrate, 3,4,5-trihydroxybenzoic acid, 5-*O*-caffeoylquinic acid, and 3,4-dihydroxybenzoic acid (De Souza *et al.*, 2019). Butanal, 2,3-pentanedione, 3-methylbutanal, β-selinene, α-selinene, 2-methylbutanal, methylene chloride, γ-curcumene, hexanal and furfural.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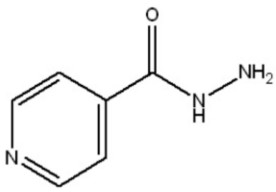
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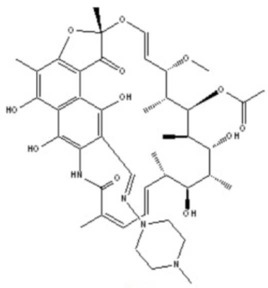
(6)

Fig. Chemical structures of (4) p-coumaric acid, (5) isoniazid and (6) rifampicin bioactive compounds.

8. **Matricaria chamomilla L.**

Therapeutic effects include treatment of diabetes, anti- flatulence, anti-inflammatory, lowering blood lipids, regulating blood pressure, antiviral, antioxidant activity and inhibiting tissue damage, improving sleep quality, sedative and anti-anxiety, analgesic, anticonvulsant, reduction of breast pain (periodic mastalgia), reduction of menstrual pain, reduction of bleeding intensity in menstruation (Modarres *et al.*, 2011), prevention of facial flushing in postmenopausal women, facilitating childbirth, diminish the symptoms of vomiting and nausea during gestation (Mirazi *et al.*, 2019; Abdullahzadeh and Naji, 2014; Ghanavati *et al.*, 2010; Ionita *et al.*, 2018; Modarres *et al.*, 2011; Kupfersztain *et al.*, 2003; Modares *et al.*, 2012), treatment of autoimmune disease (Abdanipour *et al.*, 2015), treatment of shortness of breath, burn treatment (Ebrahimi *et al.*, 2020), wound healing, inhibition of cancer cell production and use as mouthwash.

Bioactive ingredients in *matricaria chamomilla* specie include Quercetin, apigenin, luteolin, isorhamnetin, and kaempferol. Chamazulene, α-bisabolol oxide A, spathulenol, β-farnesene, α-bisabolol oxide B, *trans*-β- farnesene, β-cubebene, (*E*)-spiroether, α-bisabolol, and (*Z*)-γ-bisabolene. 6β-hydroxystigmast- 4-en-3- one, 7,22-diene-3,5,6-trihydroxyergosterol, 7,22-diene-3,5,6-trihydroxyergosterol, 5α-stigmasta-3,6- dione, 3β-hydroxy-5α,8α-epidioxyergosta-6,22-diene, stigmast-22-ene-3,6-dione, 7α-hydroxystigmasterol, 3β-hydroxy-(22E,24R)-ergosta-5,8,22-trien-7-one, 7α-hydroxysitosterol, 6β-hydroxystigmasta-4,22-dien-3- one, and 7β-hydroxystigmasterol. Galangin, 6-methoxykaempferol, eupafolin, 3-methylquercetin, scopoletin, ermanin, bracteoside, isochlorogenic acid B, 7-O-(β-D-glucopyranosyl)-galactin, 4-hydroxybenzoic acid, isochlorogenic acid C, hispidulin, 5,7,4′-trihydroxy-3,6- dimethoxyflavonone, and 5-pentadecylbenzene-1,3-diol.

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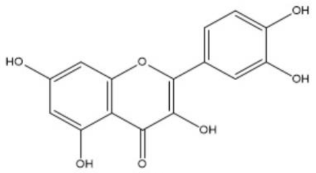
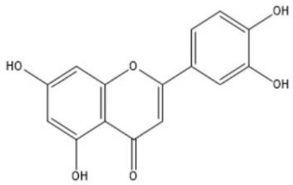
The chemical structures of some major bioactive compounds are shown as follows:



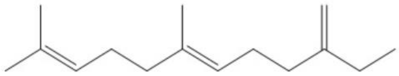
(22)

Quercetin



(23)

Luteolin



(24)

(*E*)-β-farnesene

Fig : Chemical structures of some bioactive natural compounds of *matricaria chamomilla L* species.

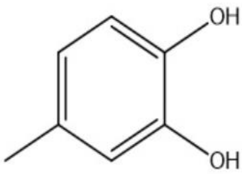
The matricaria chamomilla L. specie is widely grown in west Asia, Africa and North America. Chamomilla species applications in nutrition science and the food industry include its wide usage as herbal tea around the world. Reason for this widespread acceptance is attributed to its antioxidant, analgesic and anti-cancer effects. Its flavonoid compounds play an important role in creating antioxidant activity which is exploited as a preservative in the food industry (Asgary *et al*., 2002; McKay and Blumberg, 2006). It also finds useful application as a preservative in pasteurized milk with useful properties of functional food (Ahmadi *et al*., 2020). Chamomilla can be used to increase the maintainability of dairy products, particularly fermented products. Fermentation of chamomilla by *Lactobacillus plantarum* can help develop its antioxidant and anti-cancer function.

8.*Polygonum bistorta* L.

Polygonum bistorta L is a perennial herb consisting of 300 specie and characterized by a height of one meter. Sometimes its height varies and, in some cases, gets very short and going as low as 20 cm. This herb is called Snakeroot in English, Bijband in Hindi and Anjbar in Urdu. *Polygonum bistorta* usage in the nutrition science and food industry is attributed to the root as a powder in soup and bread production. The antimicrobial effect of *Polygonum bistorta* is related to gallic acid and benzenoid which inhibits the growth of pathogenic microbes such as MRSA. Due to its widespread antioxidant and antimicrobial effects, it is recommended to use it as a safe preservative in food (Demiray *et al*., 2009). As a member of the *Asteraceae* family, they are classified based on their therapeutic effect.

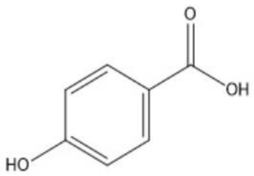
Such therapeutic effects of *Polygonum bistorta* include anti-obesity, anti-HIV virus, anti-diarrhea, treatment of plague, anti-inflammatory, treatment of kidney stones, anti-diabetes, anti-tumor, treatment of bronchitis, pulmonary disorders, purulent skin lesions, prevention of urinary tract irritation and abortion (Chen *et al*., 2006), soothing, stimulant, blood clotting, wound healing (Mirbehbahani *et al*., 2020), treatment of bladder inflammation, irritable bowel syndrome, ulcerative colitis and excessive menstruation, treatment of gastric ulcer, treatment of breast cancer and inhibition of cancer cell production. Antimicrobial effect has been reported as effective against *Bacillus subtilis*, *Staphylococcus aureus Pseudomonas aeruginosa* and *Escherichia coli* (Datta *et al*., 2007).

Bioactive compounds reported for these species include 4-Methyl catechol (**25**), *p*-hydroxy benzoic acid (**26**) and protocatechuic acid (**27**) (Intisar *et al*., 2012). Others are Arborinone, adianenone, 3β-acetoxy-dammara-20, arborinol, 24-diene, and isoarborinol (Mazid *et al*., 2011). 24(E)-ethylidenecycloartan-3α-ol and 24(*E*)- ethylidenecycloartanone. 3,7,3-Trihydroxy-5,6-dimethoxyflavone, kaempferol, quercetin, baicalin, 3-methyl quercetin, myricetin, and isoquercetin. The chemical structures of some reported phytochemicals are shown below:



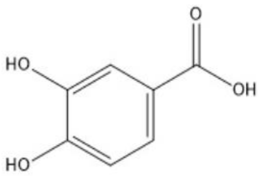
(25)

4-methyl catechol



(26)

p-hydroxybenzoic acid



(27)

protocatechuic acid

Fig: Chemical structures of some phytochemicals reported for *Polygonum bistorta* L species

Asteraceae family is widely used as a safe and natural seasoning ingredients and preservative in a variety of foods and nutrition due to their antimicrobial, antioxidant, and flavor effects and the presence of different effective phytochemicals in their roots, leaves and stems. Typical phytochemicals include 1-8-cineol, α-pinene, β-pinene, camphor, sabinene and kaempferol which are used in the remedy of different diseases or illnesses, but it should be noted that herbs such as yarrow, chamomile, and artichoke in high doses have reported toxic effects on consumer health, and caution must be exercised when using these plants. The presence of growth-promoting compounds (Phytohormones) of probiotics in *Asteraceae* family herbs makes their use in symbiotic food applications. This review provided the scientific basis for the ethnopharmacological usage of these plants, since different products derived from them (isolated compounds, oils, and extracts) are effective in the models of healing *in vitro* and *in vivo*. Silibinin (from *S. marianum*) and jaceosidin (from *A. princeps*) were identified as promising compounds for the development of healing agents. Furthermore, the results obtained in clinical trials with *A. pichinchensis* and *C. ocinalis* are exciting and highlight their importance for the treatment of wounds. These evidences suggest that Asteraceae plants are important sources for the development of new efficient drugs for healing.

Due to the emergence of the COVID-19 disease in recent years and the antiviral performance of *Asteraceae* family herbs such as chicory, chamomile, *Polygonum bistorta* and sweet wormwood, it is recommended that the antiviral activity of these herbs against coronavirus be evaluated in future studies. Also, with its antimicrobial, antifungal and antioxidant effects, there is a need for further investigation on the mechanism of action in food and nutrition. The outcome of this review is intended to highlight the physiological importance of the plants of *Asteraceae* family for applications in the food, nutrition, and drug formulation.

9.Sunflower (Helianthus annuus L.)

Sunflower seed and sprout contain high concentrations of niacin and vitamins A, B and C. They are also rich in minerals, specifically calcium, iron, magnesium, phosphorus, potassium, selenium, and zinc as well as cholesterol-lowering phytosterols and phytochemicals active ingredients, such as flavonoids, alkaloids and tannins. Sunflower seeds are especially high in vitamin E and selenium which function as antioxidants to protect body cells against damage by free radicals. Sunflower is commonly called Orangila in Igbo, Tozalin in Hausa and Yunyun in Yoruba.

The chemical structure of Nicotinic acid (niacin) with molecular formular C_5H_4NCOOH is shown below:

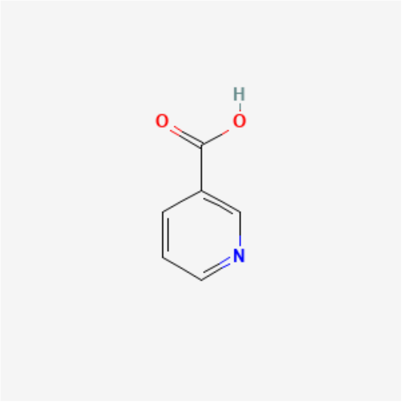


Fig: Pyridine-3-carboxylic acid (3-pyridinecarboxylic acid)

Fig: Picture of Sunflower

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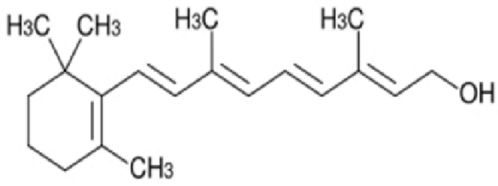
Chemical Structure of vitamin A (Retinol).

Molecular formula $C_{20}H_{30}O$. The IUPAC name is 3, 7-dimethyl-9-(2, 6, 6-trimethylcyclohex-1-yl) nona-2, 4, 6, 8-tetraen-1-ol.



10. ASPILA AFRICANA Heamorrhage plant.

English: wild sunflower, Yoruba: yunyun. Igbo: Orangila. Hausa: Tozalin.

Aspilia africana plant is used in alternative medicine for the perceived presence of some bioactive components in the leaves.

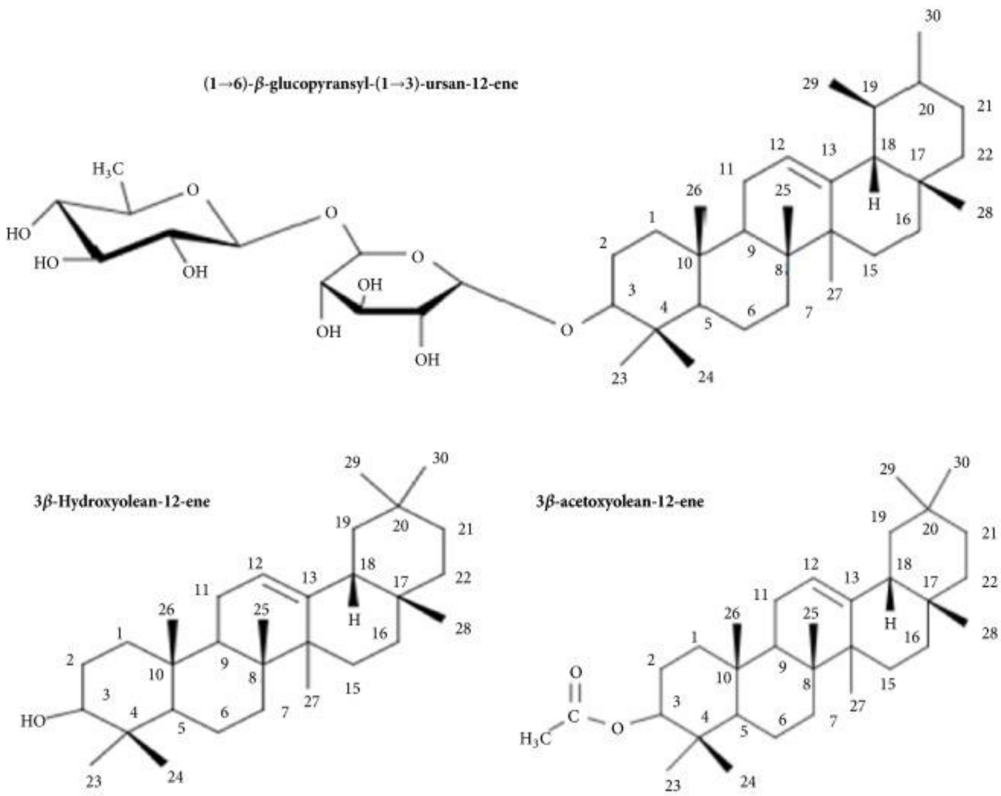
The anti-microbial activity of samples of A. *Africana* were tested on 9 micro-organisms (6 bacteria and 3 fungal strains) using the agar well diffusion technique.

Phytochemical screening revealed the presence of high amount of some bioactive compounds such as saponins, tannins, alkaloids, flavonoids, terpenoid and phenol.

Natural products have been used over the years for treatment and management of wounds. A. *africana* is one of the plants with immense attributes to enhance wound healing.

Aspilla *Africana* contains Terpenoids known to promote wound healing process, mainly due to their astringent and antimicrobial properties, which seem to be responsible for wound contraction and an increased rate of epithelialization

Antimicrobials, *Aspilia africana* leaf, Crude extracts, Phytochemistry



2. CONCLUSION

Selected species of Asteraceae family were reviewed for their therapeutic and antimicrobial activities. Each specie was also evaluated for their peculiar bioactive compounds, chemical structures, and inherent functional groups. In particular, the selected species include *Aspilla Africana*, Sunflower, *Polygonium Historia, Matricaria Chamomilla, Atrium Lappa, Archillea Millefolium, Ageratum Conyzoides, Chromolaena Adorate, Emilia Pratermissa, Artemisia Annua* and *Vernonia Amygdalina*.

Identified bioactive natural compound in these plants include some terpenoids, flavonoids, coumarin and catechins. The chemical structures of 3β-Hydroxyolean-12-ene, pyridine-3-carboxylic acid, 4-methyl catechol, p-hydroxybenzoic acid, protocatechuic, quercetin, luteolin, rifampicin, p-coumaric and sesquiterpene lactone were examined for their specific stereochemistry and functional groups. This will provide a guide for retrosynthesis and total synthesis of these compounds in the course of drug development.

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