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Bioactive Agents, Nutraceuticals Potentials, Phytochemistry, and Food Value of *Emilia coccinea* Leaf: A Review

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Authors' contributions

This work was carried out in collaboration between all authors. Author VAN wrote the first draft of the manuscript. Authors BICB and SCU assisted in literature searches. Authors SCU, FCE and GNE supervised the review. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Emilia coccinea (Sims) G. Don belongs to the family *Asteraceae*. The members of this family are largely woody herbs or shrubs, a few trees and climbing herbs. *Emilia coccinea* leaf extracts can play major roles by improving nutritional livelihood especially in the rural areas. *E. coccinea* extracts have also been implicated as possible control against chronic diseases such as cancer, obesity and cardiovascular conditions all over the world. *E. coccinea* as a lesser known indigenous

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plant in Nigeria can be refined to serve as either as health supplements or medicinal herbal formula targeted at treatment of diseases. It is reportedly used in folkloric medicine for the treatment of tumor, inflammation, cough, rheumatism, fever, dysentery, wounds and in preventing miscarriage. The juice of the edible leaves is reportedly used in treating eye inflammations, night blindness, and ear-aches. In terms of Doctrines of signature, its resemblance to the spleen could imply that it may have immune-modulatory potentials for people with defective immune system. It also resembles the pancreas which is responsible for production of insulin which breaks down glucose. Thus the *E. coccinea* leaf extracts could have potentials to regulate blood sugar. Previous studies have revealed the presence of some secondary metabolites in the plant (*E. coccinea*) which are alkaloids, tannin, saponin, steroid, terpenoid, flavonoid, cardiac glycoside and lignin and are known as therapeutic agents. Quantitative estimation of the percentage of crude chemical constituents in the Nigerian *E. coccinea* was 0.92±0.22% of alkaloids, 0.81±0.10% of phenols, 0.96±0.10% of flavonoid, 2.30±0.20% of saponin and 11.85±0.31% of tannin by previous workers. These components are known to be medicinal as well as exhibiting physiological activities in humans. Isolation of pyrrolizidine alkaloid as natural product in *Emilia coccinea*, has been reported for the first time. The global resurgence of interest in the use of medicinal plants for the treatment of human diseases fuelled with rising cost of orthodox drugs, and this is a comparative advantage of natural products to synthetic products, which incentivizes researches on lesser known plants such as *E. coccinea*. Advance research work on *E. coccinea* leaf will open an avenue for industrialization in Nigeria through development of different natural/herbal products, functional foods and beverages from the plant that will be easily available and accessible throughout the year. In addition, it will provide a cleaner environment through re-cultivation of such plant and maintenance of greener environment.

Keywords: Food value; nutraceuticals potentials; medicinal plants; Emilia coccinea; phytochemicals.

1. INTRODUCTION

The World Health Organization [1], defined traditional medicine as the sum 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, improving treatment of physical and social imbalance and relying exclusively in practical experience and observation handed down from generation to generation whether verbally or in writing. According to previous records about 80 percent of the world population relies on traditional medicine for primary health care [2]. Natural products research remains one of the main means of discovering bioactive compounds as a potential to new drug discovery. The medicinal value of plants lies in some chemical substances that produce a definite physiological action on the human body [3]. According to Ezeonu [4], there are two classes of medicinal plants; those that contain health supplements and are regularly incorporated in our diets as spices and those with bioactivity, which are more popularly acclaimed as medicinal herbs targeted at treatment of diseases or as pain relieving decoctions. However, reports have shown the effectiveness of traditional herbs against microorganisms, and as a result, plants are one of the bedrock of modern medicine [5]. The major hindrance to the use of traditional herbal preparations is the lack of scientific and clinical data in support of better understanding of the efficacy and safety of the bioactive compounds present in these plants. This is due largely to the negligence of the evaluation of the toxicity and adverse drug reactions of herbal medicines, as they are considered natural and thus, erroneously, safe. Some plant extracts could be inherently dangerous, containing naturally occurring toxins, which may be cytotoxic or carcinogenic [6]. Accordingly, most of the herbal preparations do not have drug regulatory approval to demonstrate their safety and efficacy [7].

]It is therefore pertinent to establish the safety of these preparations through toxicological assessments. Liver, being the primary organ for the detoxification and distribution of drugs could be assessed in terms of pathology and associated enzymes to establish the safety of a natural product [8]. A number of plants with acclaimed anti-diabetic, anti-obesity and antioxidant properties have been studied in different laboratories throughout the world,

especially in developing countries. This became more apparent following WHO [9] recommendations regarding the need to develop and evaluate better pharmacological agents to tackle emerging and re-emerging diseases of the world.

This topic reviewed the bioactive agents, nutraceuticals potentials, phytochemistry, and food value of a plant leaf botanically recognized as *Emila coccinea* in which the leaf was observed to have potentials for new drugs development. Thus, the method adopted was to consider the general research works done by different research scientists on the plant and more than seventy published articles gathered were useful to this review paper in which some were from PubMed, Google scholar and other science research search engines. The Keywords used were Food value, Nutraceuticals potentials, Medicinal plants, *Emilia coccinea*, and phytochemicals. Information from symposiums and posters were not considered. In addition, the references were chosen into a specific range of publication years, from 1937 to February 2017.

However, the plant was selected based on its local medicinal uses in Eastern part of Nigeria.

This information will help in advance research on the wild *Emilia coccinea* plant for development and production of many health care products.

2. *Emilia coccinea*

Emilia coccinea (Sims) G. Don belongs to the family *Asteraceae*. The members of this family are largely woody herbs or shrubs, a few trees and climbing herbs [10]. *E. coccinea* is also known as “tassel flower”. It is an erect bushy herb of up to 120cm in height. It is a ubiquitous weed of waste place and fallow land. *Emilia coccinea* (Sims) G. Don is commonly found throughout the plain of the Central Africa and in dry areas up to 2000 m altitude in the eastern Africa. This species belongs to the genus *Emilia* represented by about 115 species (as shown in Table 1), with 50 of them found in Africa [11]. It is a flowering plant with green leaves attached to the plant stalk. It is harvested from the root prior to herbal preparation or other uses.

2.1 The Botany and Ethnobotanical History of *Emilia coccinea*

Emilia coccinea (Sims) G. Don is called “Cupids shaving brush”, or “Tassel flower” in English, and *“Mmiri-akọnigwe or Ire-ejụna”* by the Igbos of Anambra State South Eastern, Nigeria. It is reportedly used in folkloric medicine for the treatment of tumor, inflammation, cough, rheumatism, fever, dysentery, wounds and in preventing miscarriage. The juice of the edible leaves is reportedly used in treating eye inflammations, night blindness, and ear-aches. The root is used in the treatment of diarrhea. The high medicinal properties of such plants used by traditional medicine practitioners may be due to one or more of the many arrays of chemical constituents of such plant material. These phytochemicals include complex carbohydrates, alkaloids, glycopeptides, terpenoids, tannins, cyanogens, peptides and amines, steroids, flavonoids, lipids, coumarins, sulphur compounds and inorganic ions among numerous others [8]. Some of these compounds may be toxic and thus the plants containing them, when consumed for a long term could confer varied levels of toxicity to the individual. Some plants are therefore inherently dangerous, containing naturally occurring toxins, often with cytotoxic, carcinogenic effects or some other toxic properties [6].

There is a global resurgence of interest in medicinal plants for the treatment of human diseases fuelled by the rising cost of prescription drugs. These rising costs of already existing drugs have necessitated the further search for newer drugs from plants. Secondly, the comparative advantages of natural products over synthetic products which have inundated the human drug market have necessitated the search for pharmacologically bioactive compounds of *Emilia coccinea*.

Ethnobotanical history has revealed the wide use of the leave extracts of *Emilia coccinea* for treatment of various ailments especially obesity among women. Thus there is need to scientifically investigate the plant with the view to having better understanding of its potentials, evaluate its proximate composition, isolate and characterize the phytochemicals and assess its bioactive potential.

2.2 Doctrine of Signatures in the Case of *Emilia coccinea*

Dating from the time of Dioscurides and Galen, state that herbs that resemble various parts of the body can be used by herbalists to treat ailments of those parts of the body. Doctrine of signatures explains that the shape of plant leaf, root, organ etc. is symbolic to the organ in the human body that it exerts pharmacological

Table 1. Species of the genus Emilia [12]

Emilia abyssinica	*Emilia graminea*	*Emilia petitiana*
Emilia adamagibaensis	*Emilia guineensis*	*Emilia pinnatifida*
Emilia adscendens	*Emilia hantamensis*	*Emilia praetermissa*
Emilia alstonii	*Emilia helianthella*	*Emilia prenanthoidea*
Emilia ambifaria	*Emilia herbacea*	*Emilia protracta*
Emilia arvensis	*Emilia hiernii*	*Emilia pseudactis*
Emilia aurita	*Emilia hockii*	*Emilia pumila*
Emilia baberka	*Emilia homblei*	*Emilia ramulosa*
Emilia baldwinii	*Emilia humifusa*	*Emilia rehmanniana*
Emilia bampsiana	*Emilia infralignosa*	*Emilia rigida*
Emilia basifolia	*Emilia integrifolia*	*Emilia robynsiana*
Emilia bathiei	*Emilia irregularibracteata*	*Emilia scabra*
Emilia baumii	*Emilia jeffreyana*	*Emilia schmitzii*
Emilia bellioides	*Emilia juncea*	*Emilia serpentina*
Emilia bianoensis	*Emilia kasaiensis*	*Emilia serpentinus*
Emilia brachycephala	*Emilia khaopawtaensis*	*Emilia serrata*
Emilia caespitosa	*Emilia kilwensis*	*Emilia shabensis*
Emilia capillaris	*Emilia kivuensis*	*Emilia simulans*
Emilia cenioides	*Emilia lejolyana*	*Emilia somalensis*
Emilia chiovendeana	*Emilia leptocephala*	*Emilia sonchifolia*
Emilia citrina	*Emilia leucantha*	*Emilia speeseae*
Emilia coccinea	*Emilia libeniana*	*Emilia subscaposa*
Emilia coloniaria	*Emilia limosa*	*Emilia tenellula*
Emilia crepidioides	*Emilia lisowskiana*	*Emilia tenera*
Emilia crispata	*Emilia longifolia*	*Emilia tenuipes*
Emilia cryptantha	*Emilia longipes*	*Emilia tenuis*
Emilia debilis	*Emilia longiramea*	*Emilia tessmannii*
Emilia decaryi	*Emilia lopollensis*	*Emilia transvaalensis*
Emilia decipiens	*Emilia lubumbashiensis*	*Emilia tricholepis*
Emilia discifolia	*Emilia lyrata*	*Emilia ukambensis*
Emilia djalonensis	*Emilia malaisseana*	*Emilia ukingensis*
Emilia duvigneaudii	*Emilia marlothiana*	*Emilia vanmeelii*
Emilia emilioides	*Emilia mbagoi*	*Emilia violacea*
Emilia exserta	*Emilia micrura*	*Emilia zairensis*
Emilia fallax	*Emilia moutsamboteana*	*Emilia zeylanica*
Emilia flaccida	*Emilia myriocephala*	
Emilia fosbergii	*Emilia negellensis*	
Emilia fugax	*Emilia pammicrocephala*	
Emilia gaudichaudii	*Emilia parnassiifolia*	
Emilia gossweileri	*Emilia perrieri*	

effects in terms of disease correction. In the consideration of *Emilia coccinea* leaf in terms of shape is identical to spleen and pancreas. The spleen is the machine housing lymphocytes which are indispensable for production of antibodies which fight infectious agent, and protects the host from disease. In terms of Doctrines of signature, its resemblance to the spleen could imply that it may have immune-modulatory potentials for people with defective immune system. Pancreas is responsible for production of insulin which breaks down glucose. Thus the *Emilia coccinea* leaf could have potentials to regulate blood sugar.

2.3 Natural product Chemistry

Natural products from medicinal plants, either as pure compounds or as standardized extracts, provide unlimited opportunities for new drug leads because of the unmatched availability of chemical diversity [13]. A natural product is a chemical compound or substance produced by a living organism that is, found in nature [14,15]. In the broadest sense, natural products include any substance produced by life [16]. The term natural product has also been extended for commercial purposes to refer to cosmetics, dietary supplements, and foods produced from natural

sources without added artificial ingredients [17]. Within the field of organic chemistry, the definition of natural products is usually restricted to mean purified organic compounds isolated from natural sources that are produced by the pathways of primary or secondary metabolism [18]. Within the field of medicinal chemistry, the definition is often further restricted to secondary metabolites [19]. Secondary metabolites are not essential for survival, but nevertheless provide organisms that produce them an evolutionary advantage [20]. Many secondary metabolites are cytotoxic and have been selected and optimized through evolution for use as "chemical warfare" agents against prey, predators, and competing organisms [21]. Natural products sometimes have pharmacological or biological activity that can be of therapeutic benefit in treating diseases. As such, natural products are the active components not only of most traditional medicines but also of many modern medicines. Natural products from *E. coccinea* can make substantial combinations to health care delivery and general wellness.

2.3.1 Food value, bioactive agents of *Emilia coccinea* and their possible biological activities

Plants are chemical factories, very efficient in biosynthesis and specific in production of nutrients and secondary metabolites. The proximate value has been reported [22]. The leaf was reported to be low in protein and fat. Crude fibre and carbohydrate were in high amount [22]. High fibre consumption can result in increased removal of carcinogens, potential mutagens, steroids, bile acids and xenobiotics by binding or absorbing to dietary fibre components which can be rapidly excreted, hence having health promoting benefits. Previous studies have revealed the presence of some secondary metabolites in the plant (*Emilia coccinea*) which are alkaloids, tannin, saponin, steroid, terpenoid, flavonoid, cardiac glycoside and lignin and are known as therapeutic agents [23-26]. Quantitative estimation of the percentage of crude chemical constituents in the Nigerian *E. coccinea* was 0.92±0.22% of alkaloids, 0.81±0.10% of phenols, 0.96±0.10% of flavonoid, 2.30±0.20% of saponin and 11.85±0.31% of tannin [24]. Another phytochemical composition study of the leaves (mg/100 g dry weight) of *Emilia coccinea* reported [26]: Alkaloids 1.71, Flavonoids 1.87, Phenols 1.55, Tannins 0.37, Saponins 0.37. Mineral element composition of the leaves (mg/100 g dry weight) of *Emilia coccinea* reported by Faleye et al. [15]: Potassium 12.23, Sodium 1.88, Calcium 6.85, Magnesium 1.94, Manganese 0.63, Phosphorous 0.74, Iron 2.51 and Zinc 1.24. These components are known to be medicinal as well as exhibiting physiological activities in humans [27]. The importance of these components in various antibiotics used in treating common pathogenic strains has been reported. The medicinal importance of tannins, saponins, flavonoids, alkaloids, steroids and cardiac glycoside which are components of traditional herbal preparation used in managing various common ailments has been reported [28-30]. Shyamai et al. [31] reported that alkaloids can be used in the management of cold, fever and chronic catarrh. The antibacterial properties of tannins have been reported [32]. Saponins have also been reported as anti-fungi agent. Flavonoids are known for their antioxidant activity, they help to protect the body against cancer and other degenerative disease such as Arthritis and Type 1 diabetes mellitus [33]. Herbal preparations containing cardiac glycosides are used for the treatment of congestive heart failure and cardiac arrhythmia Steroids are taken by humans (mostly athletes) to increase muscles and bone synthesis [34]. Thus *Emilia coccinea* can be seen as a potential source of useful drugs for the treatment of ailments since it contains those bioactive phytochemicals. This plant is a good source of ascorbic acid, riboflavin, thiamin and niacin and natural ascorbic acid is vital for the body performance [35]. Lack of ascorbic acid impairs the normal formation of intercellular substances throughout the body, including tooth dentine, bone matrix and collagen [36]. A striking pathological change resulting from this defect is the weakening of the endothelial wall of the capillaries due to a reduction in the amount of intercellular substance [30]. Therefore, the clinical manifestation of scurvy haemorrhage from mucous membrane of the mouth and gastro intestinal tract, anaemia, pains in the joints can be related to the association of ascorbic acid and normal connective tissue metabolism [30]. This function of ascorbic acid also accounts for its requirement for normal wound healing [37]. As a result of the availability of ascorbic acid in *E. coccinea*, the plant is used as herbal medicine for the treatment of cold, colic in babies and as chest medicine [26]. Riboflavin (vit.B2), thiamine (vit.B1), niacin (vit. B3) are three of the eight B-complex vitamins including vitamins B5, B6, B7, B9 and B12. These three vitamins present in *E. coccinea* work closely with each other to break

the carbohydrates, fats, and proteins in food down [35,38].

Thus, *Emilia coccinea* can be seen as a potential source of useful drugs for the treatment of ailments since it contains those bioactive phytochemicals. Most of these bioactive agents can be extracted (see Fig. 1), isolated and purified (see Fig. 2), following extraction theory and chromatographic spectroscopies. Recovery of bioactive compounds from plant materials is typically accomplished through different extraction techniques taking into account their phytochemistry and uneven distribution in the plant matrix. For example, soluble phenolics are present in higher concentrations in the outer tissues (epidermal and sub-epidermal layers) of fruits and grains than in the inner tissues (mesocarp and pulp) [39]. Solvent extraction is most frequently used technique for isolation of plant antioxidant and other bioactive compounds. However, the extract yields and resulting biological activities of the plant materials are strongly dependent on the nature of extracting solvent, due to the presence of different bioactive compounds of varied chemical characteristics and polarities that may or may not be soluble in a particular solvent. Polar solvents are frequently employed for the recovery of polyphenols from a plant matrix. The most suitable of these solvents are (hot or cold) aqueous mixtures containing ethanol, methanol, acetone, and ethyl acetate [40]. Methanol and ethanol have been extensively used to extract antioxidant compounds from various plants and plant-based foods (fruits, vegetables etc.) such as plum, strawberry, pomegranate, broccoli, rosemary, sage, sumac, rice bran, wheat grain and bran, mango seed kernel, citrus peel, and many other fruit peels. Other studies have also demonstrated the efficacy of ethyl acetate to extract phenolic compounds from onion and citrus peel [41,42].

Isolation of pyrrolizidine alkaloid in *Emilia coccinea* Sims., family *Compositae* has been reported for the first time [43]. The isolation technique reported was performed a newly elaborated RP-HPLC ion trap MS method with atmospheric pressure chemical ionization (APCI) interface and different PAs (N-oxides, free bases, otonecine alkaloids) isolated were separated on Waters XTerra C18 column using a gradient elution [32]. From the report, it was observed that in *E. coccinea*, the following types of PAs were found: platyphylline-N-oxide, platyphylline (three stereoisomers with the same MS(n) spectrum), ligularidine, neoligularidine, neosenkirkine and also previously reported senkirkine [43].

Bioactive compounds produced by medicinal plants are used mainly for medicinal purposes. These compounds either act on different systems of animals including man, and/or act through interfering in the metabolism of microbes infecting them. The microbes may be pathogenic or symbiotic. In either way the bioactive compounds from medicinal plants play a determining role in regulating host-microbe interaction in favour of the host. So the identification of bioactive compound in plants, their isolation, purification and characterization of active ingredients in crude extracts by various analytical methods is important (Fig. 2). The bioactivities of *Emilia coccinea* have been confirmed in various laboratories, these include anti-diarrhoeral, antimicrobial and fungicidal activities [44,24]. The antimicrobial properties of *Emilia coccinea* and its use for therapeutic treatment have been investigated and reported [25]. *Emilia coccinea* was reported to possess antidiarrhoeal and antimicrobial activities [25]. The antidiarrhoeal effects of both methanol and aqueous extracts of the leaves of *Emilia coccinea* in rats against castor oil-induced diarrhoea at the doses of 200, 400 and 600 mg/kg body weight were reported [25]. The methanol extract and, to a lesser extent, the aqueous extract, were reported to significantly prolong the time for diarrhoeal induction [25]. However, the frequency of diarrhoea episodes was reduced and decreased the propulsion of charcoal meal through the gastrointestinal tract in a dose dependent manner was reported [25]. The aqueous extract was reported not to have any antimicrobial activity at the tested concentration (5 mg/ml), but the methanol extract was most active on *Escherichia coli* [25]. There are increasing incidences of infectious agents becoming resistant to orthodox antibacterial drugs [45-48] and therefore, it has become exigent to develop alternative antibacterial drugs in order to mitigate these and other related health care challenges. The increasing quest for antibacterial agents has shifted to plant materials and studies have shown that phytomedicine is reliable, sustainable and a rewarding prospect in this regard [49-51].

The effort towards the search for medicinal plants capable of ameliorating hyperlipidemia was reported [53]. Their study investigated the capacity of ethanolic leaf extracts of *Emilia coccinea*, *Hibiscus rose-sinesis*, *Acanthus*

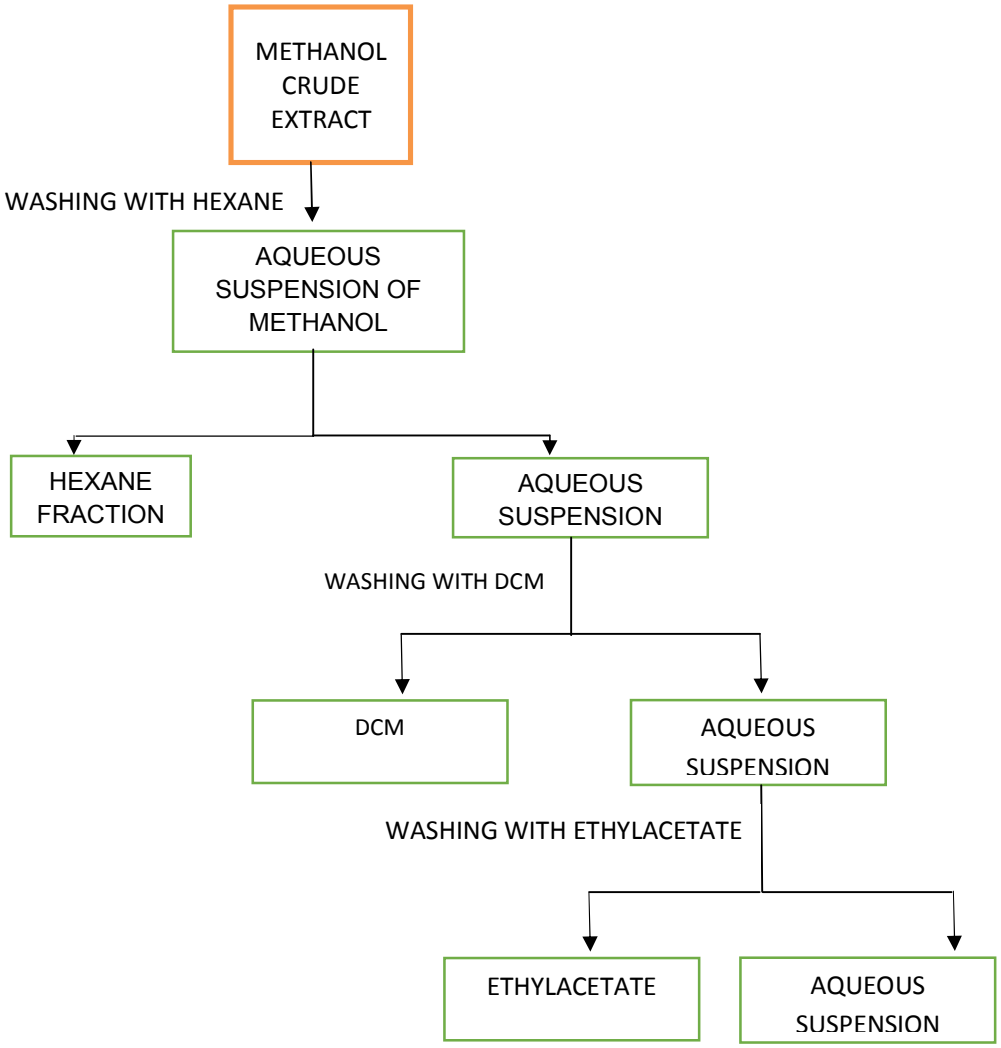

Fig. 1. Sequential Extraction (Solvent partitioning) of methanol crude extract [52]

montanus and *Asystasia gangetica* to ameliorate hyperlipidemia in hyperlipidemia animal model [53]. Hyperlipidemia was induced in animals using lipogenic diet containing 2.5% cholesterol, 20% sunflower oil and 0.5% sodium cholate [53]. Separate leaf extracts of the four plants (dose = 400 mg/kg) were administered to various groups of the experimental animals by intra peritoneal injection at regular time intervals of 12 h for 14 days. However treatment of hyperlipidemic rabbits (HyL-Rs) with the four plant extracts caused different levels of lowered serum lipid components with concomitant elevation of HDL-C concentration.

Report had shown the capacities of crude aqueous and ethanolic leaf extracts of *Acanthus montanus* (ACMO), *Asystasia gangetica* (ASGA), *Emilia coccinea* (EMCO), and *Hibiscus rosasinensis* (HIRO), as well as their combinatorial formulations to ameliorate hyperglycemia in Type I diabetic rats [58]. Hyperglycemia was reported to be induced by single intraperitoneal injection of alloxan monohydrate in phosphate buffer saline (PBS) solution (pH = 7.4) dosage = 120 mg/kg; bw, in which the individual hyperglycemic rats (HyGR) received separate doses of either 20 mg/kg bw/24 h of *Acanthus montanus, Asystasia gangetica, Emilia coccinea* and *Hibiscus rosasinensi*s, as well as their combinatorial formulations for 14 days [54]. The ethanol extract of *Acanthus montanus, Asystasia gangetica, Emilia coccinea and Hibiscus rosasinensis* was reported to exhibit the highest capacity to lower fasting blood glucose concentration by

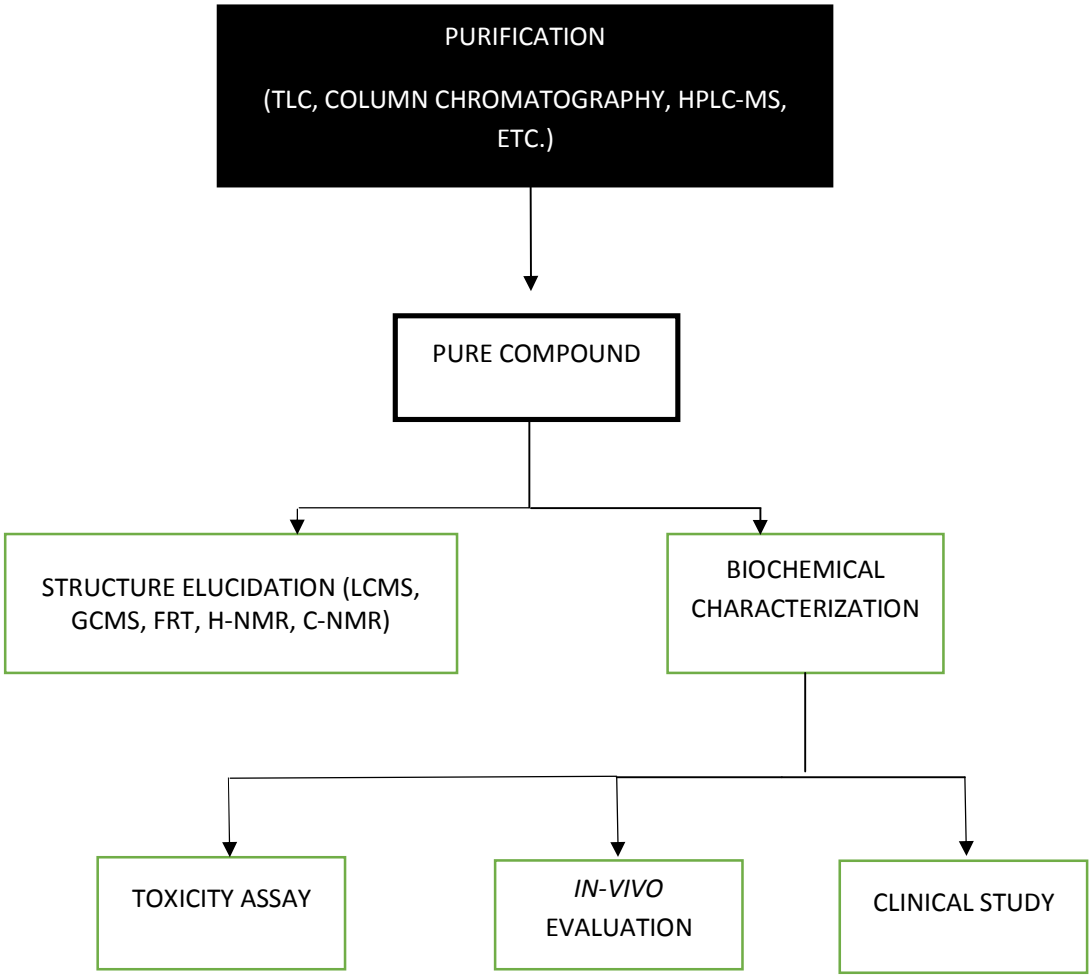

Fig. 2. A brief summary of the general approaches in extraction, isolation/purification and structure elucidation and characterization of bioactive compound from plant extract [55]

53.55 ± 1.04% than that of aqueous extract of the combined medicinal plants, the combination of the herbal extracts synergistically improved the therapeutic potentials of the individual herbal extracts [54].

Another study reported the effects on memory of the hydroalcoholic extract of *Emilia coccinea* in scopolamine treated rats and proposed possible mechanisms of action [56].

The study demonstrated the beneficial effect of the hydroalcoholic extract of *E. coccinae* on scopolamine-induced cognitive impairment [56]. *E. coccinea* protected from memory deficiency induced by scopolamine, by the behavioral tests using the Y-maze and Novel object recognition tests [56]. Also, based on their results of the biochemical studies, the researchers observed that *E. coccinae* is an antioxidant; suggesting that its protective effects are possibly related to its antioxidant effects. Their results also indicated that the extract can ameliorate scopolamine induced acetylcholinesterase (AChE) activity increment [56].

2.4 *E. coccinea* in Ethnomedical Practices in Africa

Generally, plants serve various purposes and their usefulness can be in the form of food, textile, and shelter, as medicine and as a relic in religious practices. The use of this plant (*E. coccinea*) particularly as a medicinal plant and traditional medicine in most developing countries for the maintenance of good health has been widely observed [57]. Medicinal plants constitute the base of the health care systems in

many societies. Globally, about 85% of the traditional medicines used for primary health care are derived from plants [39]. It has also been observed that the rising costs of prescription drugs in the maintenance of personal health and well-being, and the bioprospecting of new plant-derived drugs had fuelled the interest in medicinal plants as a re-emerging health aid [58]. The increasing failure of chemotherapeutics and antibiotic resistance exhibited by pathogenic microbial infectious agents led to the screening of several medicinal plants including *E. coccinea* for potential antimicrobial activity. Phytomedicines have shown great promise in the treatment of intractable infectious diseases [59]. *Emilia coccinea* is one medicinal plant that has been widely used traditionally for medicinal purposes to treat a variety of ailments. The plant is used for the treatment of fever, convulsions and epilepsy in children [59]. Ethnomedicinal reports reveal that in Nigeria, the leaf is used to manage or cover sores [60]. The dry leaves are used for the treatment of wounds, sores, sinusitis, ulcer, ringworm and also to treat jaundice, abdominal pains, and gastritis [60]. The leaf sap is used to treat vertigo [61]. The leaf sap can also be used in treating epilepsy in Ivory Coast [62] and in Congo for managing gonococcal infection, hernia and syphilis [60]. The leaf decoction is also reported to be used as a febrifuge and has a mild laxative effect [63]. *E. coccinea* have also been reportedly effective in treating ulcers, lice, ringworm, gonorrhea, measles, cough and convulsion in children [24,64]. In some tribe in the western part of Cameroon, the infusion of the dry leaves of this plant is used as a potent sedative, restorative [65] for the treatment of some neurological disorders. In Tanzania, the leaves mixed with Ipomoea eriocarps are used as eye drop for eye infections, the crushed green leaves are used to treat wounds, sores and sinusitis while the dried powdered leaves are used to manage sores [11]. Various activities of the entire herb, including antibacterial, antioxidant and anti-inflammatory activities have been reported [66]. Some of the bioactivities of the plant have been confirmed in the laboratory which include antidiarrhoeal, antimicrobial and antifungal activity [66,67,24]. In Nigeria, the leaves are eaten cooked or raw as salad or spinach and the fresh juice of the leaves is a remedy for sore eyes [68]. The leaves are also eaten raw and can be mixed with guinea corn and lime juice to serve as a remedy for sore throat [68,67]. Most studies on such medicinal plants pertain to their organic contents, viz. essential oils, glycosides, vitamins, alkaloids and other active components and their pharmacological/therapeutic effects. The presence of flavonoids and phenolic compounds in the leaves of *E. coccinea* [66] suggests that this plant possesses antioxidant properties and can have neuroprotective propensity. In the search for new therapeutic products for the treatment of neurological disorders, research on *E. coccinea* has also contributed significantly by demonstrating pharmacological effectiveness of it in animal models [65]. Besides, several organic compounds play a vital role in general well-being as well as in the cure of diseases [69,70].

2.5 Nutraceutical Applications of *E. coccinea*

Virtually in all the country, there is a great deal of interest in and support for the search for new and useful drugs from higher plants [71]. About 250,000 to 150,000 estimate of the number of higher plants have been described on the face of the Earth [72] which could have potential for new drugs development targeting diseases such as arthritis, high blood pressure, acquired immune deficiency syndrome (AIDS), cancer and etc. The active compounds can be extracted from most of these plants and their structures determined (Figs. 1-2) for better understanding of their functions.

Nutraceutical is a modern invention and a blend of two words 'nutrition and pharmaceutical' which was coined by Dr. Stephen DeFelice in 1989 [72]. It therefore refers to extracts of foods claimed to have medicinal effects on human health or a food (or part of a food) that provides medical or health benefits, including the prevention and/or treatment of a disease [72]; or a natural bioactive chemical compound that has health promoting, disease preventing or medicinal properties [73].

However, not all plants chemical compounds are nutraceuticals.

There are eight broad Nutraceutical categories:

- Vitamins and mineral elements
- Amino acids, peptides, proteins and derivatives
- Fibres, special carbohydrates, and pre-biotics (i.e. non-digestible materials that promote growth of beneficial micro-organisms in the gastrointestinal (GI) tract)
- Carotenoids (i.e. natural coloured compounds - typically red, orange or yellow- that are fat-soluble)

- Pro-biotics (i.e. living bacteria)
- Special fatty acids and derivatives
- Polyphenols and flavonoids (i.e. natural pigments that are water-soluble)
- Sterols and stanols (which are structurally very similar to each other and to cholesterol)

Nigeria has huge medicinal plants needed for social development in which *E. coccinea* is not far from it. Many non-communicable diseases such as cancer, malaria, typhoid, obesity, diabetes and cardiovascular problems and their complications can be treated and managed by the use of nutraceuticals from plants.

Based on the essential nutrients and phytochemicals present in *E. coccinea* leaf, the leaf can be used in the development and production of nutraceuticals, functional foods/beverages and Nutracosmetics. An illustration of the possible Nutraceutical applications of *E. coccinea* leaf is shown in Fig. 3.

Classification of *Emilia coccinea* [74]

Plant name : *Emilia coccinea*
Kingdom : Plantae
Phylum : Magnoliophyta
Class : Magnoliopsida
Order : Asterales
Family : *Asteraceae*
Genus : *Emilia*

Vernacular names:

English: Tassel flower;

Nigeria

Alor, Idemili South LGA, Anambra State: *Mmiliakon'igwe*;
Awka, Awka South LGA, Anambra State: *Ile-ejuna*
Umunachi, Obowo LGA, Anambra State: *Anya-kirikiri*

Fig. 1 shows sequential extraction (solvent partitioning) of methanol crude extract which involved both non-polar and polar organic solvents.

Fig. 2 shows a brief summary of the general approaches in extraction, isolation/purification, structure elucidation and characterization of bioactive compound from plant extract.

Fig. 3 shows an illustration of Nutraceutical applications of *Emilia coccinea* leaf.

Plate 1. *Emilia coccinea* whole plant growing in the soil

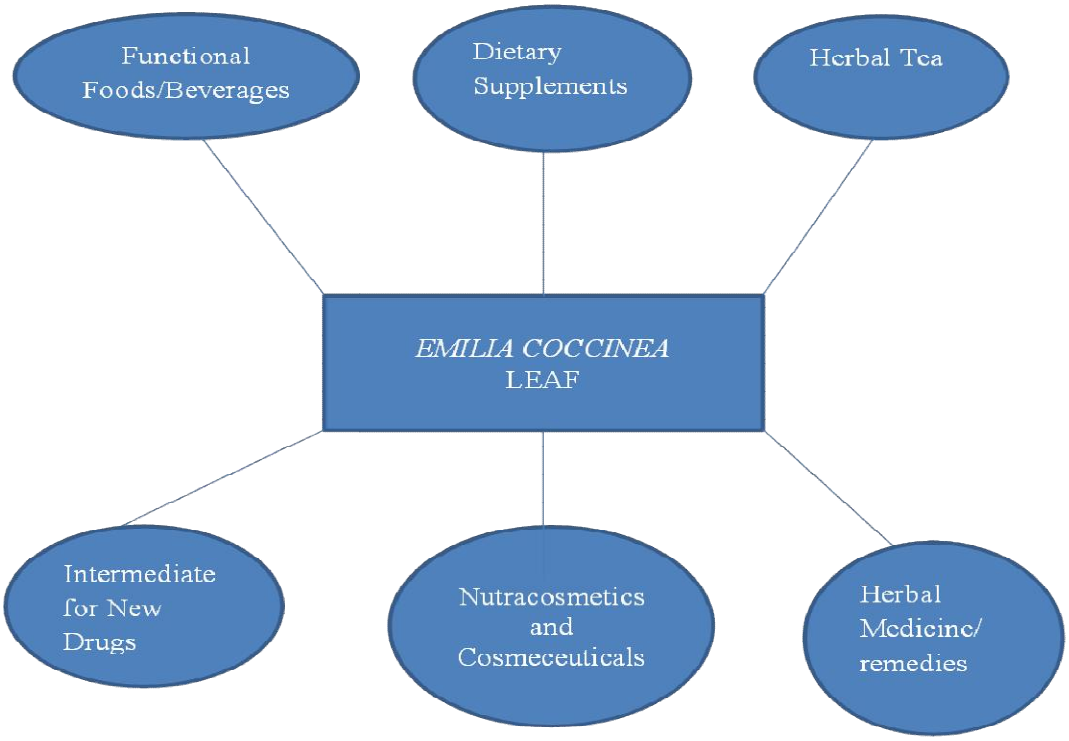

Fig. 3. An Illustration of Nutraceutical applications of *Emilia coccinea* leaf

3. CONCLUSION

Nigeria is endowed with vast resources of medicinal and aromatic plants which have been used over the millennia for human welfare in the promotion of health and as drugs and fragrance materials. The traditional health practices and formulations play a significant role in tackling health challenges as well as in bridging health inequalities. This is especially in Sub-Saharan Africa which has the highest poverty level coupled with struggling national healthcare delivery systems amidst very rich biodiversity ecosystems.

E. coccinea leaf can be used in development and production of nutraceuticals, herbal teas, health foods, nutracosmetics and among others. Its medicinal effects aredue to its bioactive agents reported such as, flavonoid, alkaloid, steroid, tannins, terpenoid, saponin, cardiac glycoside and phenols. These compounds are known for their therapeutic effects. This plant as reported is also a good source of ascorbic acid, riboflavin, thiamin and niacin which are vital for the body performance.

The bioactivities of *Emilia coccinea* have been confirmed in various laboratories, these include anti-diarrhoeral, antioxidant, antimicrobial, hypo/anti-lipidemicand fungicidal activities. The leaf could serve as an alternative antibacterial agent for resistant bacterial strains, could salvage the situation of cardiovascular problem and also used in new drug formulation for antiabortifacient drug, apparently, the leaf could contain calcium channel blockers which have been advocated as potential therapeutic agents in the management of premature labor, making the traditionalists to use the leaf in folkloric medicine to prevent miscarriage. The plant leaf in synergy with other plants' leaves (*Acanthus montanus, Asystasia gangetica, and Hibiscus rosasinensis*) was reported to exhibit the highest capacity to lower fasting blood glucose concentration by 53.55 ± 1.04%. New drugs for the treatment of eye inflammations, night blindness and ear-aches could also emanate from the leaf.

The Isolated compound, pyrrolizidine alkaloid as natural product in *Emilia coccinea*, has been reported for the first time. Thus, there is need for advance phytochemical screening and isolation of known and novel bioactive compounds from this plant leaf that will have high pharmacological effect in treatment of deteriorating diseases.

Nutraceuticals have come to stay. The market will probably increase in the world, notwithstanding this rich array of the plant species, Nigeria, like most other African countries, play very insignificant roles in the estimated herbal medicine global trade worth over USD$100b.Nutraceuticals, functional foods and supplements will have marginal impact on public health, especially disease vulnerable groups that may benefit from selected substances. Therefore, *E. coccinea* can be seen as a potential source of useful drugs for the treatment of ailments since it contains potent bioactive compounds.

This review is geared towards stimulating the research scientists' minds to embark on natural product research on this ornamental plant for development of novel effective phytomedicines for treatment of diseases. Such developed technologies could be transferred to potential bio-business industrialists to improve the economy and health sector in Nigeria.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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