An overview of the relevance of phytochemicals to the Nigerian health sector

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Abstract
The human body produces antioxidants which are essential for preventing oxidative stress. Oxidative stress can result from the effects of free radicals like singlet oxygen, super oxide, peroxyl radicals, hydroxyl radicals and peroxynite, and can lead to cellular damage. Phytochemicals are antioxidants from plants that protect cells against the damaging effects of free radicals. Free radicals generated in the body can be removed by the body's own natural antioxidant defences such as glutathione or catalases. This mechanism of combating oxidative stress which nature has already provided in the body can find useful supplements in natural products derived from plants. This paper reviews the health benefits of phytochemicals, highlights the key role played by natural antioxidants in health maintenance and prevention of diseases, and synthesizes recent research works on the usefulness of phytochemicals especially with respect to the Nigerian health sector. Phytochemicals quickly enough scavenge the metastable chemical species of free radicals in order to prevent any damages crucial to bio molecules like lipids and proteins, including those present in all membranes, mitochondria and the DNA, so as to forestall any abnormalities leading to disease conditions. The paper while outlining the significant antioxidant properties that are necessary for the reduction in the occurrence of many diseases also reveals the biochemistry behind these findings.
Keywords: phytochemicals, antioxidant, free radicals, oxidative stress.

Introduction

A huge number of bioactive phytochemicals capable of improving anti-cancer therapy and reducing chemotherapy induced toxicity are available according to Luzbetak, Subenguth, Werner, and Mayer (2019), stating that 50% of the cancer patients in Europe are using them. In the third world and developing countries (including Nigeria) the continuous exposure to, and consumption of, food substances containing some toxicants arising from the use of inorganic fertilizers and improper food processing techniques, and the increasing microbial resistance of pathogenic microorganisms against antibiotics have led to the consideration of these natural substances extracted from plants known to

have beneficial effects in medical procedures and applications in the cosmetic, pharmaceutical and food industries. Ogunmefun (2018) also promotes the belief that God's endowment of curative power in plants might have led to the increasing popularity of traditional medicine in West Africa. Earlier studies recorded that approximately 20% of known plants have been used in pharmaceutical studies, impacting the healthcare system in positive ways such as in the treatment of cancer and harmful diseases and that more than 80% of Nigerians use herbs for the treatment of common ailments due to their relative availability, significant high cost of primary health care, the poor healthcare system in the country and the relative safety of herbal medicines, (Awosika, 1993; Iwu, Duncan & Okunji, 1999). This discovery of high concentrations of phytochemicals in fruits and vegetables according to Elujoba, Odeleye and Ogunyemi (2004) has boosted their significance in global primary healthcare, leading to a tendency to choose herbal remedies over synthetic drugs.

In line with the foregoing Luzbetak *et al.*, (2019), Singh, Sharma, Ghosh, Park and Jeong (2016), Einali, Azizian-Shermeh and Ghasemi (2018), Liu (2004) affirm that phytochemicals are bioactive, non-nutrient plant chemicals naturally occurring in fruits, vegetables, legumes, grains and other plant foods that give plants their colour, flavour, smell and are part of a plant's natural defence system of disease resistance, and have been linked to reducing the risk of major degenerative diseases in humans following their consumption or application. Plants containing beneficial phytochemicals, medicinal properties and high nutritional value, may supplement the needs of the human body by acting as natural antioxidants, providing several health benefits. Increasing the consumption of fruits and vegetables has been recommended by many agencies and health care systems throughout the world (Webb, 2013). This paper discusses the role, contributions and usefulness of medicinal plants in tackling the diseases of public health importance, with particular emphasis on the current strategic approaches to disease prevention in Nigeria.

Overview of Phytochemicals

Phytochemicals (from Greek phyto, meaning "plant") are chemicals produced by plants through primary or secondary metabolism. They generally have biological activity in the plant host and play a role in plant growth or defence against competitors, pathogens, or predators. Plants use phytochemicals as a defence against potential threats which may include bacteria, viruses, and fungi. When we consume these plants as fruits and vegetables, these defences are passed along to humans to help boost our immune system. Brightly coloured fruits and vegetables contain the highest concentrations of phytochemicals, and may help us fight off diseases such as cancer by preventing the formation of carcinogens, which are cancer-causing agents, diabetes, hypertension and heart disease. It is currently hypothesized that phytochemicals interfere with the processes that cause chronic diseases. Some examples of foods containing phytochemicals are Red, orange and yellow vegetables and fruit (such as tomatoes, carrots, peppers, squash, sweet potatoes, peaches, mangos, melons, citrus fruits, and berries), dark green leafy vegetables (such as spinach, kale, bok choy, broccoli, Swiss chard, and romaine lettuce), garlic, onions, chives and leeks . The actions of phytochemicals vary by the type of the food and the colour. They may act as antioxidants or nutrient protectors or prevent carcinogens from forming. They are anticarsinogenic, antimutagenic, antiinflamatory and antioxidants. The term phytochemical refers to a wide variety of compounds made by plants but is mainly used to describe those compounds that may affect human health. Scientists have identified thousands of phytochemicals, although only a small fraction has been studied closely. Some common examples of phytochemicals include beta-carotene (with other carotenoids), vitamin C, vitamin E, and folic acid (Glaser, Doss & Shih 2015).

Classes of Phytochemicals

Phytochemicals are classified into different groups based on their biosynthetic origin and structural characteristics. They include:

Alkaloids

These are the largest group of secondary chemical constituents made largely of ammonia compounds comprising basically of nitrogen bases synthesized from amino acid building blocks with various radicals replacing one or more of the hydrogen atoms in the peptide ring, most containing oxygen. According to Awosika (1993) over 12,000 alkaloids exist in about 20% of plant species and only few have been exploited for medicinal purposes. Alkaloids have pharmacological applications as anaesthetics (Kokate, Purohit & Gokhale, 2002) and CNS and respiratory systems stimulants (Madziga, Sanni & Sandabe, 2010). Plant-derived alkaloids in clinical use include morphine and codeine (analgesics), tubocurarine (muscle relaxant), sanguinafine and berberine (antibiotics), vinblastine (anticancer agent), ajmaline (antiarrhythmic), atropine (pupil dilator and used widely as antidote to organophosphate poisoning), scopolamine (sedative agent) and the addictive stimulants caffeine (serves also as an antidote to barbiturate and morphine poisoning) including nicotine, codeine, morphine, ergotamine, cocaine, nicotine ephedrine. Firn (2010) maintains that some basic properties of alkaloids include that the compounds are alkaline in reaction, turning red litmus paper blue. They react with acids to form crystalline salts without the production of water. Majority of alkaloids exist in solid such as atropine, some as liquids containing carbon, hydrogen, and nitrogen. Most alkaloids are readily soluble in alcohol and though they are sparingly soluble in water, their salts are usually soluble. The solutions of alkaloids are intensely bitter and their nitrogenous compounds function in the defence of plants against herbivores and pathogens, and are widely exploited as pharmaceuticals, stimulants, narcotics, and poisons due to their potent biological activities. Alkaloids exist in large proportions in the seeds and roots of plants and often in combination with vegetable acids.

Glycosides

Glycosides in general, are defined as the condensation products of sugars (including polysaccharides) with a host of different varieties of organic hydroxy (occasionally thiol) compounds (invariably monohydrate in character), in such a manner that the hemiacetal entity of the carbohydrate must essentially take part in the condensation. Glycosides are colorless, crystalline carbon, hydrogen and oxygen-containing (some contain nitrogen and sulfur) water-soluble phytoconstituents, found in the cell sap. Kar (2007) and Firn (2010) independently reported that glycosides chemically contain a carbohydrate (glucose) and a non-carbohydrate part (aglycone or genin). Glycosides are purely bitter extracts that are commonly found in plants of the Genitiaceae family and though they are chemically unrelated but possess the common property of an intensely bitter taste. The bitters act on gustatory nerves, which results in increased flow of saliva and gastric juices. Chemically, the bitter principles contain the lactone group that may be diterpene lactones (e.g. *andrographolide*) or triterpenoids (e.g. *amarogentin*). Some of the bitter extracts are either used as astringents due to the presence of tannic acid, as antiprotozoan, or to reduce thyroxine and metabolism. Examples include alcohol glycosides, anthraquinone glycorides, coumarin glycosides, cyanogenic glycosides, etc. Sarker & Nahar (2007) reported that extracts of plants that contain cyanogenic glycosides are used as flavouring agents in many pharmaceutical preparations. Anthraquinones are derivatives of phenolic and glycosidic compounds. They are solely derived from anthracene giving variable oxidized derivatives such as anthrones and anthranols (Maurya *et al.,* 2008; Firn, 2010). Glycosides have been used in the treatment of cancer (HCN liberated in stomach kills malignant cells), and also as a cough suppressant in various preparations. Excessive ingestion of cyanogenic glycosides can be fatal. Some foodstuffs containing cyanogenic glycosides can cause poisoning (severe gastric irritations and damage) if not properly handled (Sarker & Nahar, 2007; Kokate, Purohit & Gokhale, 2002).

There are specifically amphipathic glycosides that are grouped phenomenologically by their production of soap-like foaming when shaken in aqueous solutions. They are grouped structurally by possession of one or more hydrophilic glycoside moieties combined with a lipophilic triterpene derivative (Hostettmann & Marson, 2008).

Phenolics

Phenolics, phenols or polyphenolics (or polyphenol extracts) are chemical components that occur ubiquitously as natural colour pigments responsible for the colour of fruits of plants. Phenolics in plants are mostly synthesized from phenylalanine via the action of phenylalanine ammonia lyase (PAL). They are very important to plants and have multiple functions. The most important role may be in plant defence against pathogens and herbivore predators, and thus are applied in the control of human pathogenic infections. Kar (2007) classifies them into:

(i) phenolic acids

(ii) flavonoid polyphenolics (flavonones, flavones, xanthones and catechins)

(iii) non-flavonoid polyphenolies.

Caffeic acid is regarded as the most common of phenolic compounds distributed in the plant flora followed by chlorogenic acid known to cause allergic dermatitis among humans. Phenolics essentially represent a host of natural antioxidants, used as nutraceuticals, and found in apples, green-tea, and red-wine for their enormous ability to combat cancer and are also thought to prevent heart ailments to an appreciable degree and sometimes are anti-inflammatory agents. Other examples include flavones, rutin, naringin, hesperidin and chlorogenic. Phenolic compounds are commonly found in both edible and non-edible plants, and they have been reported to have multiple biological effects, including antioxidant activity. Phenols contribute to the prevention of various degenerative diseases that act as an antioxidant (Rice-Evans, Miller & Paganga, 1996; and, Puupponen-Pimiä, Nohynek, Alakomi, & Oksman-Caldentey, 2008). The most common of phenolic compounds widespread in plants is caffeic

acid which is followed by chlorogenic acid, the causal agent of excessively sensitive inflammation of the skin (dermatitis) among humans (Kar, 2007). Phenolics are natural antioxidants functioning as nutraceuticals and available in red wine, apples, and green tea. They serve as anticancer and anti-inflammatory agents as well as prevent heart diseases. Crude extracts of fruits, herbs, vegetables, cereals, and other plant materials rich in phenolics are increasingly being used in the food industry because they retard oxidative degradation of lipids and improve the quality and nutritional value of food. Phenolic compounds are considered secondary metabolites and are synthesized by plants during normal development, and in response to infections, wounding, ultra-violet (UV) radiation, and insects. These phytochemical compounds derived from phenylalanine and tyrosine occur ubiquitously in plants and are very diversified (Naczk & Shahidi, 2004). Phenolic plant compounds fall into several categories; simple phenolics, phenolic acids (derivatives of cinnamic and benzoic acids), coumarins, flavonoids, stilbenes, tannins, lignans and lignins. Chief among these are the flavonoids which have potent antioxidant activities.

Saponin

Two major groups of saponins exist which are steroid and triterpene saponins. Saponins are insoluble in ether but soluble in water, and on hydrolysis, they give aglycones like glycosides. They cause haemolysis of blood and cattle poisoning as they are known to be extremely poisonous (Kar, 2007). Apart from causing irritation to mucous membranes, they have a bitter and acrid taste. They are soluble in alcohol and water but insoluble in solvents like benzene and n-hexane that are organic and nonpolar; therefore, they are mostly amorphous in nature. Saponins are therapeutically important because they lower bad fats in the body (hypolipidemic) and have anticancer potentials. Saponins work in synergy with the cardiac glycosides (Sarker & Nahar, 2007). Saponins are regarded as high molecular weight compounds in which, a sugar molecule is combined with triterpene or steroid aglycone. Saponins are also important therapeutically as they are shown to have hypolipidemic and anticancer activity.

Terpenes

The terpenes, also known as isoprenoids, form the largest class of phytonutrients in green foods and grains. These compounds are found in higher plants, mosses, liverworts, algae and lichens, as well as in insects, microbes or marine organisms. Terpenoids are derived from a common biosynthetic pathway based on mevalonate as parent, and are named terpenoids, terpenes or isoprenoids, with the subgroup of steroids among them as a class (Tholl, 2006; Bohlmann & Keeling, 2008). Their importance to plants relates to their necessity to fix carbon through photosynthetic reactions using photosensitizing pigments. Animals have evolved to utilize these compounds for hormonal and growth regulatory functions (vitamin A) and, as it is now being understood, the presence of these molecules in animal tissues also provides a measure of protection from certain diseases, especially those related to chronic damage and growth deregulation.

The diverse functional roles of some of the terpenoids are characterized as hormones (gibberellins), photosynthetic pigments (phytol, carotenoids), electron carriers (ubiquinone, plastoquinone), and mediators of polysaccharide assembly, as well as communication and defence mechanisms (Langenheim, 1994). Several biological actions have been reported for diterpenes including antibacterial, antifungal, anti-inflammatory, antileishmanial, cytotoxic and antitumour activities (Singh *et al.*, 1999). Currently, a broad range of biological responses can be elicited in humans through various terpenoids that are applicable to human health care (Paduch *et al.*, 2007). Different terpenoid molecules have antimicrobial, antifungal, antiparasitic, antiviral, anti-allergenic, antispasmodic, antihyperglycaemic, antiinflammatory, chemotherapeutic and immunomodulatory properties (Hammer *et al.*, 2003; Wagner and Elmadfa, 2003; Paduch *et al.*, 2007). Terpenes are also used as skin penetration enhancers as well as natural insecticides, and can be of use as protective substances in storing agriculture products (Lee *et al.*, 2003). Terpenes have a unique antioxidant activity in their interaction with free radicals. They react with free radicals by partitioning themselves into fatty membranes by

virtue of their long carbon side chain. The most studied terpene antioxidants are the tocotrienols and tocopherols. They are found naturally in whole grains and have effects on cancer cells. The tocotrienols are effective apoptotic inducers for human breast cancer cells. The impact of a diet of fruits, vegetables and grains on reduction of cancer risk may be explained by the actions of terpenes *in vivo* (Ikeda *et al.*, 2002; Prakash & Gupta, 2009; Prakash & Kumar, 2011). Terpenes are among the most widespread and chemically diverse groups of natural products. They are flammable unsaturated hydrocarbons, existing in liquid form commonly found in essential oils, resins or oleoresins (Firn, 2010). Terpenoids includes hydrocarbons of plant origin of general formula (C5H8)n and are classified as mono-, di-, tri- and sesquiterpenoids depending on the number of carbon atoms. Examples of commonly important terpenes include terpinen-4-ol, thujone, camphor, eugenol and menthol. *Diterpenes (C20)* are classically considered to be resins and taxol, the anticancer agent, is the common example. The t*riterpenes (C30)* include steroids, sterols, and cardiac glycosides with anti-inflammatory, sedative, insecticidal or cytotoxic activity. Common triterpenes: amyrins, ursolic acid and oleanic acid s*esquiterpene (C15*) like monoterpenes, are major components many essential oils (Martinez *et al.*, 2008). The sesquiterpene acts as irritants when applied externally and when consumed internally their action resembles that of gastrointestinal tract irritant. A number of sesquiterpene lactones have been extracted and broadly they have antimicrobial (particularly antiprotozoal) and neurotoxic action. The sesquiterpene lactone, palasonin, extracted from *Butea monosperma* has anthelmintic activity, inhibits glucose uptake and depletes the glycogen content in *Ascaridia galli*.

Carotenoids

Carotenoids protect lipids against peroxidative damage by inactivating singlet oxygen (without degradation) reacting with hydroxyl, superoxide, and peroxyl radicals. Relative to phenolics and other antioxidants, carotenoids are not particularly good quenchers of peroxyl radicals, but they are exceptional at quenching singlet oxygen, at which most other phenolics and antioxidants are relatively

ineffective. The antioxidant activity of carotenoids is due to the ability to delocalize unpaired electrons through their structure of conjugated double bonds. Much of our present knowledge comes from epidemiological studies and indicates that the incidence of some forms of cancer and cardiovascular disease appear to be lower in populations with large relative intakes of antioxidant nutrients such as vitamins C, and E, and the various carotenoids (Haslam, 1996). The β-carotene is the most abundant of the carotenoids and widely used in therapies. It is almost completely insoluble in water but readily soluble in hydrophobic environments, and slightly polar solvents. β-carotene is highly reactive with electrophiles and oxidants. While many studies have shown β-carotene inhibition of lipid auto-oxidation in biological tissues and food, few details of the kinetics or mechanism of these reactions have been revealed (Alves, David, Bahia & Aguiar, 2010). The most common carotenoids in a Western diet are alpha-carotene, beta-carotene, beta-cryptoxanthin, lutein, zeaxanthin and lycopene. Premkumar listed carrots, yams, sweet potatoes, papaya, watermelon, cantaloupe, mangos, spinach, kale, tomatoes, bell peppers and oranges among the fruits and vegetables in which carotenoids can be found.

Essential oils

Essential oils are the odorous and volatile products of various plant and animal species. Essential oils have a tendency to evaporate on exposure to air even at ambient conditions and are therefore also referred to as volatile oils or ethereal oils**.** They mostly contribute to the odoriferous constituents or *'essences'* of the aromatic plants that are used abundantly in enhancing the aroma of some spices (Martinez *et al.,* 2008). Essential oils are either secreted either directly by the plant protoplasm or by the hydrolysis of some glycosides and structures such as directly Plant structures associated with the secretion of essential oils include: Glandular hairs (Lamiaceae e.g. *Lavandula angustifolia*), Oil tubes (or vittae) (Apiaceae eg. *Foeniculum vulgare,* and *Pimpinella anisum* (Aniseed), modified parenchymal cells (Piperaceae e.g. *Piper nigrum* - Black pepper), Schizogenous or *lysigenum passages* (Rutaceae e.g. *Pinus palustris* - Pine oil. Essential oils have been associated with different plant parts including

leaves, stems, flowers, roots or rhizomes. Chemically, a single volatile oil comprises of more than 200 different chemical components, and mostly the trace constituents are solely responsible for attributing its characteristic flavour and odour (Firn, 2010). Essential oils can be prepared from various plant sources either by direct steam distillation, expression, extraction or by enzymatic hydrolysis.

Steroids

Plant steroids also known as cardiac or steroid glycosides are one of the most naturally occurring plant phytoconstituents that are applied therapeutically as cardiac drugs or arrow poisons (Firn, 2010). The cardiac glycosides are majorly steroids having a natural ability to exert specific and powerful action on the cardiac muscle mainly when injected into animal or man. Steroids (anabolic steroids) have the ability to promote nitrogen retention in osteoporosis (a disease following menopause in women causing bones to be porous and subjected to fracture) and in animals with wasting illness (Maurya, Singh & Yadav, 2008; Madziga, Sanni & Sandabe, 2010). Steroids have the ability to exhibit activities such as antifungal, antiviral, antileukemic, hypnotic, antipyretic, and muscle-relaxant activities and are found in large quantities in many plants (Kokpol, Chittawong & Mills, 1984).

Plant steroids (or steroid glycosides) also referred to as ‘cardiac glycosides’ are one of the most naturally occurring plant phytoconstituents that have found therapeutic applications as arrow poisons or cardiac drugs (Firn, 2010). The cardiac glycosides are basically steroids with an inherent ability to afford a very specific and powerful action mainly on the cardiac muscle when administered through injection into man or animal. Steroids (anabolic steroids) have been observed to promote nitrogen retention in osteoporosis and in animals with wasting illness (Maurya *et al.,* 2008; Madziga *et al.,* 2010). Caution should be taken when using steroidal glycosides as small amounts would exhibit the much needed stimulation on a diseased heart, whereas excessive dose may cause even death. Diosgenin and cevadine (from *Veratrum veride*) are examples of plant steroids.

Emerging relevance and biochemistry of phytochemicals in Nigeria

Scientists, food manufacturers, and consumers are gaining interest in the antioxidant constituents of plants due to the future trends toward functional food with specific health effects for the maintenance of health, protection from coronary heart disease, and cancer (Kähkönen *et al*., 1999). *Readers Digest* (2013) reports that antioxidants control and reduce the oxidative damage in foods by delaying or inhibiting oxidation caused by reactive oxygen species (ROS), ultimately increasing the shelf life and quality of foods. In plants, phytochemicals attract beneficial and repel harmful organisms, serve as photoprotectants, and respond to environmental changes. For instance, isoflavones, anthocyanin and flavonoids do function as phytoalexins, substances that assist a plant to resist pathogens (Luzbetak *et al*, 2019). Carotenoids help in light collection under conditions of low light or help to dissipate excess absorbed energy as heat under conditions of high sun exposure.

Nigerian Government agencies and several other health organizations around the world seem to agree, and encourage people to eat more fruits and vegetables and take advantage of the potential benefits from these foods. Several herbal remedies in Nigeria have already received licence from the National Food and Drug Administration and Control, NAFDAC. A number of phytonutrients which have antioxidant properties have been shown to reduce the risk of cancer, heart disease, stroke, Alzheimer's and Parkinson's disease. Experts believe that eating plenty of phytonutrient-rich foods promotes healthy aging. Phytonutrients may have other bioactive functions for promoting health. Some may have positive effects on the immune system and hormones. Phytonutrients may also act as antibacterial or antiviral agent. Phytonutrients are responsible for the vibrant colours found in vegetables and fruit. For example, the phytonutrient lycopene helps give tomatoes and watermelon their red colour. By enjoying a rainbow of vegetables and fruit everyday, you can make the most of many of the phytonutrients nature has to offer**.** Plants are natural reservoir of medicinal agents almost free from the side effects normally caused by synthetic chemicals (Fennel *et al*., 2004). The World Health Organization estimates that

herbal medicine is still the main stay of about 75-80% of the world population, mainly in the developing countries for primary health care because of better cultural acceptability, better compatibility with the human body, and lesser side-effects (Kamboj, 2000; Yadav & Dixit, 2008). The over use of synthetic drugs with impurities resulting in higher incidence of adverse drug reactions, has motivated mankind to go back to nature for safer remedies. Due to varied locations where these plants grow, coupled with the problem of different vanacular names, the World Health Organization published standards for herbal safety tominimize adultartion and abuse (WHO, 1999).

A number of modern drugs have been extracted from natural sources and many of these extracts were based on the uses of the agents in traditional medicine (Rizvi *et al*., 2009). Antimicrobial properties of crude extracts prepared from plants have been described and such reports had attracted the attention of scientists worldwide (Falodun *et al*., 2006; El-Mahmood & Amey, 2007; El-Mahmood, 2009). Herbs have been used for food and medicinal purposes for centuries and this knowledge have been passed on from generation to generation (Adedapo *et al*., 2005). This is particularly evident in the rural areas where infectious diseases are endemic and modern health care facilities are few and far thus, compelling the people to nurse their ailments using local herbs. Herbal treatments have been adjudged to be relatively safe (WHO, 1999).

Conclusion

Phytochemicals are antioxidants from plants that protect cells against the damaging effects of reactive oxygen species otherwise called, free radicals such as singlet oxygen, super oxide, peroxyl radicals, hydroxyl radicals and peroxynite which results in oxidative stress leading to cellular damage. Though there are few disadvantages associated with natural products research. These include difficulties in access and supply, complexities of natural product chemistry and inherent slowness of working with natural products. In addition, there are concerns about intellectual property rights, and the hopes associated with the use of collections of compounds prepared by combinatorial chemistry methods.

Despite these limitations, over a 100 natural-product-derived compounds are currently undergoing clinical trials and at least 100 similar projects are in preclinical development. Among these products the highest number are from plant origin. Most are derived from plants and microbial. Despite the recent advancement in herbal medicine, one of the most difficult issues to contend with in translating traditional herbal practices into conventional 'western' medicine is the individualization of prescriptions containing multiple herbal and other ingredients. Also, industries in developing countries face challenges in the development of the medicinal plant.

One of these problems is lack of information on the social, biochemical and economic benefits that could be derived from the industrial utilization of medicinal plants. In addition, there are little incentives for standardization of products, little information on the market potential and trading possibilities of these medicinal plants. This results in under use or less exploitation in the real potential of these plants. Natural products derived from plants for the treatment of diseases have proved that nature stands a golden mark to show the relationship between the interrelationship between man and his environment. Natural antioxidants play a key role in health maintenance and prevention of the chronic and degenerative diseases, such as atherosclerosis, cardiac and cerebral ischema, carcinogenesis, neurodegenerative disorders, diabetic pregnancy, rheumatic disorder, DNA damage and ageing. Antioxidants exert their activity by scavenging the 'free-oxygen radicals' thereby giving rise to a fairly 'stable radical'. The free radicals are metastable chemical species, which tend to trap electrons from the molecules in the immediate surroundings. These radicals if not scavenged effectively in time, they may damage crucial bio molecules like lipids, proteins including those present in all membranes, mitochondria and, the DNA resulting in abnormalities leading to disease conditions. When it is stressed, the human body produces insufficient amount of antioxidants which are essential for preventing oxidative stress. Free radicals generated in the body can be removed by the body's own natural antioxidant defences such as glutathione or catalases**.** Insufficient supply of natural antioxidants is a

deficiency that has to be compensated by making use of natural exogenous antioxidants, such as vitamin C, vitamin E, flavones, β-carotene and natural products in plants. Plants contain a wide variety of free radicals scavenging molecules including phenols, flavonoids, vitamins, terpenoids that are rich in antioxidant activites. Antioxidants are often added to foods to prevent the radical chain reactions of oxidation, and they act by inhibiting the initiation and propagation step leading to the termination of the reaction and delay the oxidation process. It is important to note that phytonutrients may prevent or delay developing diseases however once a disease has manifested, the recommended option is to consult with a physician and take appropriate medications that have been proven to be effective in large clinical trials.

References

Adedapo, A.A., Shabi, O.O. & Adedokun, O. A. (2005). Antihelminthic efficacy of the aqueous extract of *Euphorbia hirta* (Linn.) in Nigerian dogs. *Veterinary Archives*. 75(1): 39-47.

Alves, C.Q., David, J.M., David, J.P., Bahia, M.V., & Aguiar, R.M. (2010). Methods for determination of *in vitro* antioxidant activity for extracts and organic compounds.

Awosika, F. (1993). Traditional medicine as the solution to Nigerian health problems. In *Clinical Pharmacology and Herbal Medicine,* 9, 26–31.

Burkill HM. The Useful Plants of West Tropical Africa. 2nd ed. Royal Botanic Gardens: Kew, UK; 1985. 960p. http://plants.jstor.org/upwta/2_580

Dharmananda, S. (2003). Gall nuts and the uses of tannins in Chinese medicine. *Proceedings of Institute for Traditional Medicine*. Portland: Oregon.

El-Mahmood, M. A. & Ameh, J. M. (2007). *In-vitro* antibacterial activity of *Parkia biglobosa* (Jacq) root, bark extract against some microorganisms associated with Urinary tract infections. *African Journal of Biotechnology*. 6(11): 195-200.

El-Mahmood, M. A. (2009). Efficacy of crude extracts of garlic (*Allium sativum* Linn.) against nosocomial *Escherichia coli, Staphylococcus aureus, Streptococcus pneumoniea* and *Pseudomonas aeruginosa. Journal of Medicinal Plants Research*. 3(4): 179-185.

Elujoba, A. A., Odeleye, O. M., & Ogunyemi, C. M. (2004). Traditional Medical Development for medical and dental primary health care delivery system in Africa. *African Journal of Traditional, Complementary and Alternative Medicines*, 2 (1): 46–61.

Falodun, A.; Okunrobe, L.O. & Uzoamaka N (2006). Phytochemical screening and antiinflammatory evaluation of methanolic and aqueous extracts of *Euphorbia heterophylla* Linn. (Euphorbiaceae). *African Journal of Biotechnology*. 5(6):529-531

Fennell, C.W., Lindsey, K.L., McGaw, L.J., Sparg, S.G., Stafford, G.I., Elgorashi, E.E., Grace, O.M. & van Staden, J. (2004). Assessing African medicinal plants for efficacy and safety: Pharmacological screening and toxicology. *Journal of Ethnopharmacoly*.94: 205-217.

Firn, R. (2010). *Nature's Chemicals*. Oxford: Oxford University Press.

Glaser, T. S., Doss, L. E. & Shih, G. (2015). The Association of Dietary Lutein plus Zeaxanthin and B vitamins with cataracts in the age-related eye disease study AREDS report no.37. *Ophtalmology*. 122 (7): 1471-1479.

Harborne JB. Phytochemical Methods – A Guide to Modern Techniques of Plant Analysis. London: Chapman and Hall; 1998. pp. 182-190

Haslam, E. (1996). Natural polyphenols (vegetable tannins) as drugs: possible modes of action. *Journal of Natural Products,* 59 (2), 205-215.

Hostettmann K, Marson A. Chemistry and Pharmacology of Natural Products: Saponins. Cambridge: Cambridge University press; 2008. 562p

Houghton, P. J., Hylands, P. J., Mensah, A. Y., Hensel, A. & Deters, A. M. (2005). In vitro tests and ethnopharmacological investigations: Wound healing as an example. *Journal of Ethnopharmacology*.;100:100-107

Iwu, M., Duncan, R. A., & Okunji, C. O. (1999). New antimicrobials of plant origin. In J. Janick, (Ed.) *Perspectives on New Crops and New Uses*. Alexandria, Va, USA: ASHS Press.

Kamboj, V.P. (2000). Herbal medicine. *Current Science*. 78 (1): 35-39.

Kar, A. (2007). *Pharmacognosy and Pharmacobiotechnology* (Revised-Expanded Second Edition). New Delhi, India: New Age International Limted Publishers.

Kathie, E., Ferrelli, T. & Richard, W. (2006). *Squirrels: The Animal Answer Guide*. Baltimore: Johns Hopkins University press.

Kokpol, U., Chittawong, V. & Mills, H.D. (1984). Chemical constituents of the roots of *Acanthus illicifolius. Journal of Natural Product.*;49:355-356.

Liu, R. H. (2004). Potential synergy of phytochemicals in cancer prevention: mechanism of Action. *Journal of Nutrition*. 134 (12 Suppl): 3479S-3485S.

Luzbetak, M., Sußenguth, N., Werner, J. & Mayer, B. (2019). The phytochemicals *Curcumin* and *Vitamin C* act as immunosensitizer. *European Journal of Cancer,* 110: S1-S34.

Madziga, H. A., Sanni, S. & Sandabe, U. K. (2010). Phytochemical and Elemental Analysis of *Acalypha wilkesiana* Leaf. *Journal of American Science.* 6 (11): 510-514.

Maurya, R.; Singh G. & Yadav, P.P. (2008). Antiosteoporotic agents from natural sources. In Atta-ur-Rahman (Ed.) *Studies in Natural Products Chemistry*, 35 (Elsevier): 517-545.

McGee, H. (2004). *On Food and Cooking? The Science and Lore of the Kitchen*. NewYork: Scribner.

Ogunmefun, O. T. (2018). Phytochemicals: God's Endowment of Curative Power in Plants. In T. Asao & M. Asaduzzaman, *Phytochemicals - Source of Antioxidants and Role in Disease Prevention*. IntechOpen: DOI: 10.5772/intechopen.77423.

Philipson, J.D. (2007). Phytochemistry and pharmacognosy. *Phytochemistry*. 68: 2960-2972.

Rice-Evans, C. A., Miller, N. J., & Paganga, G. (1996). Structure–antioxidant activity relationships of flavonoids and phenolic acids. *Free Radical Biology and Medicine*, 20(7): 933-938.

Rizvi, M.M.A., Irshad, M., Hassadi, G.E. & Younis, S.B. (2009). Bioefficacies of *Cassia fistula:* An Indian labrum (Review). *African Journal of Pharmacy and Pharmacology*. 3(6): 287-292.

Sarker, S. D. & Nahar, L. (2007). *Chemistry for Pharmacy Students: General, Organic and Natural Product Chemistry.* England: John Wiley and Sons.

Scalbert, A. (1991). Antimicrobial properties of tannin. *Phytochemistry*;30(12): 3875-3883

Trease ,GE, Evans WC. A Text Book of Pharmacognosy. 16th ed. London: Saunders Ltd; 2009. 616p

World Health Organisation, W.H.O. (1999). *WHO Monographs on Selected Medicinal Plants*. 1: 1-295.

Yadav, N.P. & Dixit, V.K. (2008). Recent approaches in herbal drug standardization. *International Journal of Intergrative Biology*.2(3): 195-203.