ISSN 2955-1226 (Print)
ISSN 2955-1234 (Electronic)

Tropical Journal of Phytochemistry & Pharmaceutical Sciences

Available online at https://www.tjpps.org

Review Article

Nutraceuticals: A Remedy to Various Maladies

Joseph A. Dauda[a,*], Muluh E. Khan[b], Alifa D. Jacob[a], Friday Oteno[a], Saadatu Haruna[c], Rotimi A. Larayetan[a], Lucky Ekwoba[a], Gabriel W. Ocheme[a], Olufunke L. Idowu[a], Comfort T. Are[a], Aminu S. Abdullahi[a], Samaila Isiya[d]

[a]*Department of Pure and Industrial Chemistry, Kogi State University, Anyigba, Nigeria.*
[b]*Department of Pure and Industrial Chemistry, Federal University Lokoja, Nigeria.*
[c]Zonal Advanced Space Technology Applications Laboratory (ZASTAL) Gombe State.
[d]*Department of Chemistry, Zamfara State College of Education, Maru.*

ABSRTACT

Nutraceuticals are bioactive substances of natural origin. They are products derived from food sources with the capacity to provide extra health benefits in addition to the basic nutritional value found in foods. It encompasses dietary supplements, herbal products, probiotics and prebiotics, and functional foods meant for the prevention and treatment of diseases. Depending on the chemical composition, nutraceutical products may prevent chronic diseases, improve health, delay aging, increase life expectancy, and boost the immune system. They are used as an alternative to synthetic drugs to promote health quality and boost the nutritional values of diets. They are accepted universally by all age groups because of their safety, quality, purity, efficacy, health-promoting potential, and therapeutic potential. However, this review article is aimed at discussing the history, classification, health benefits, and disease prevention potentials of nutraceuticals.

Keywords: Nutraceuticals, Dietary supplement, Health promotion, Disease prevention, Herbal.

Received 30 August 2023
Revised 12 October 2023
Accepted 03 November 2023
Published online 02 December 2023

Introduction

The last 50 years have seen a significant shift in human lifestyles as a result of urbanization, industrialization, hectic schedules, and shifting cultural norms. Due to these factors, people now eat junk food and fast food, which are both quick and tasty. These practices have adversely impacted food's nutritional value and gradually reduced both the quantity and quality of its nutrients. Immune dysfunction, metabolic diseases, and degenerative diseases have all increased as a result of these dietary changes. People are now more aware of their health than ever before, and they are deeply concerned with how to manage it.1 The health sector has, however, received a lot of attention as a result of recent developments in medicine, phytomedicine, nutritional science, the food industry, and health care. The areas of nutraceuticals, foods, and phytonutrients have seen the most recent advancements.[1]

Any nontoxic food ingredient that has been used to promote health, including the prevention and treatment of diseases, is referred to as a nutraceutical. The term nutraceuticals was derived from nutrition and pharmaceuticals by Stephen Defelice, who is the founder and chairman of foundation for innovative medicine.[2] A food or component of a food that offers medicinal or health benefits, including the prevention and treatment of diseases, is referred to as a nutraceutical.[3] Isolated nutrients, herbal products, dietary supplements, genetically modified foods, and processed food products are all examples of nutraceuticals.

*Corresponding author. E mail: dauda.ja@ksu.edu.ng
Tel: +2348062422941

Citation: Dauda JA, Khan ME, Jacob AD, Oteno F, Haruna S, Larayetan RA, Ekwoba L, Ocheme GW, Idowu OL, Are CT, Abdullahi AS, Isiya S. Nutraceuticals: A Remedy to Various Maladies. Trop J Phytochem Pharm. Sci. 2023; 2(4):92-99. http://www.doi.org/10.26538/tjpps/v2i4.1

Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria.

Vitamins, lipids, proteins, carbohydrates, minerals, and other essential nutrients are typically found in nutraceuticals.[4]

Nutraceuticals

A nutraceutical is a product that is isolated or purified from natural sources (plants or animals) and sold in medicinal form (or as a food supplement) to provide pharmacological or health benefits, such as disease prevention and treatment.[3] The concept of Nutraceuticals went back three thousand years ago when Hippocrates emphasized that, 'let food be your medicine and medicine be your food.[2]

Nutraceuticals are food-derived products that are claimed to provide additional health benefits in addition to the basic nutritional value found in foods. Products may prevent chronic diseases, improve health, delay the aging process, increase life expectancy, or support the structure or function of the body, depending on their chemical composition.[5]

Nutraceuticals creates a new era of research to promote quality of life. It can reduce the risk of disease onset by retaining normal health condition, and improving immunity.[4] Treatment approaches of disease in modern medicines seek complementary or alternative beneficial products, and nutraceuticals filled into this gap.[5]

Classification of Nutraceuticals

Nutraceuticals or functional foods can be classified on the basis of their natural sources (plants, animals, minerals or microbial), pharmacological conditions or chemical constitution of the products (Figure 1).[6]

Dietary supplement

A dietary supplement is a product that contains dietary nutrients derived from food products with the intention of adding further nutritional value to the diet. They could be in powder, liquid, capsule, pills or tablet form.[8] A dietary supplement is a product taken orally, and contains dietary ingredient (vitamins, minerals, amino acids and antioxidants) with the intention of supplementing the diet. Dietary

supplements can also be extracts or concentrates, which could be found in forms of softgels, gelcaps, or powder.[9]

Nutrients: Substances such as vitamins, minerals, amino acids and fatty acids are basic examples of nutrients (Table 1). They play vital roles in the metabolic function of the body systems. For example, vitamins play an important role in metabolism and enzyme systems. Minerals are important for immunity, reproduction, and growth. Amino acids serve as building blocks for proteins to help the body, break down food and repair body tissue. Fatty acids are responsible for healthy cell membrane, skin and hairs and proper functioning of nervous system, immune system and hormones.[10, 11]

Herbals: With the aid of herbs (plants), nutraceuticals have a great deal of potential to enhance health and prevent chronic diseases. Before the use of modern clinical drugs, plants were and are still used for the treatment of diseases. These healing plants are known to have therapeutic benefits or act as building blocks for the synthesis of useful drugs.[12,49,50,51] Examples of common herbs used as nutraceuticals are presented in Table 2.

Phytochemicals: Phytochemicals are chemical compounds produced by plants, which also acts as nutraceuticals. These are chemicals found in plants and have disease protective or pharmacological properties.[6] Examples of phytochemicals (Figure 1) include; alkaloids, flavonoids, tannins, phenolic compounds, steroids, terpenoids, carotenoids, saponins, and so on.
Dietary intake of phytochemicals may promote health benefits, and could also aid in protection against chronic degenerative disorders such as cancer, diabetes, inflammation, coronary heart diseases, ulcer, viral and parasitic infections. For example, carotenoids found in various fruits and vegetables are anticarcinogenic, boost immune cells and protect cornea against ultraviolet light.[1] Examples some phytochemicals and their health benefits are presented in Table 3.

Antioxidants: They are compounds that helps prevent or defend the body against free radical damage, and are critical for maintaining optimum health and well-being. Damage to cells caused by free radicals is believed to play a vital role in aging process and disease progression. Free radicals are capable of attacking the healthy cells of the body, causing them to lose their structure and function. Antioxidants are capable of stabilizing or deactivating free radicals that are capable of attacking healthy cells. Antioxidants are very important for maintaining optimal cellular and systemic health and well-being.[13] Examples of antioxidants (Figure 3) include; ascorbic acid, anthocyanin, tocopherol and β-carotene.

Probiotics: These are microbial feed supplements that help the balance of bacteria in the intestines. Lactose intolerance, irritable bowel syndrome, inflammatory bowel disease, acute diarrhea, and gastrointestinal disorders are all treated with some probiotics. They aid in the synthesis of a particular enzyme called galactosidase, which hydrolyzes the problematic lactose into its constituent sugar. Probiotics commonly include the bacteria Lactobacillus and Bifidobacterium.[13]

Prebiotics: These are substances that stimulate the activity or growth of microorganisms (like bacteria and fungi) in an effort to benefit their host. The most typical instance is in the digestive system, where prebiotics can change the makeup of the bacteria in the gut microbiome. Prebiotics are fiber-based substances that have laxative effects. Prebiotics can improve the bioavailability and uptake of minerals, promote satiety, and aid in weight loss, among other health advantages.[13]

Nutraceutical enzymes: Enzymes play a crucial role in numerous biological processes and are a vital component of the body. Many signs of obesity, digestive issues, hyperglycemia, and hypoglycemia disappear when enzyme supplements are added to diets.[14]

Dietary fiber: Dietary fibers are foods or plant materials that are digested by gut microflora rather than being hydrolyzed by digestive tract enzymes. Dietary fibers are carbohydrate polymers that are neither digested nor absorbed in the small intestine and have a degree of polymerization not lower than three. Non-starchy polysaccharides like cellulose, hemicellulose, gum, pectin, lignin, and resistant dextrin are examples of dietary fiber.[2]

Table 1: Nutrients and their benefits[3, 9]

Nutrients	Potential Benefits
Vitamin A	Antioxidant, needed for vision and treatment of certain skin disorder
Vitamin E	Helps in formation of blood cells, muscle, lungs and nerve tissue, boosts immune system.
Vitamin C	Beneficial for bones, gums, teeth and skin, wound healing and also prevent common cold.
Vitamin K	Vital for blood clotting
Vitamin B1	Essential in neurologic functions and helps to convert food into energy
Vitamin B2	Helps in energy production and other chemical processes in the body, helps maintain healthy eyes, skin and nerve functions.
Vitamin B3	Maintain proper brain functions.
Vitamin B6	Synthesize amino acids and metabolism of fats, protein and carbohydrate, helps to produce the genetic material of cells, RBCs formation, maintain CNS system.
Vitamin B7	Part of an enzyme needed for energy metabolism.
Vitamin B12	Part of an enzyme needed for making new cells, essential for nerve functions.
Vitamin D	Needed for proper absorption of calcium.
Vitamin E	Helps in the protection of cell walls and also, as an antioxidant.
Folic acid	RBCs formation and protection against cardiovascular diseases.
Calcium	Fortify bones and teeth, important in functioning of nerve, muscle and glands
Iron	Helps to produce energy, carry and transfer oxygen to tissues
Magnesium	Maintain a healthy nerve and muscle function, useful in bone formation, may help to prevent premenstrual syndrome.

Phosphorus	Strong bones and teeth, helps in the formation of genetic material, energy production and storage.
Chromium	Helps to convert carbohydrates and fats into energy.
Cobalt	Essential component of vitamin B12, but ingested cobalt is metabolized in vivo to form the B12 coenzymes.
Copper	Vital for production of hemoglobin and collagen, healthy functioning of the heart, energy production, absorption of iron from digestive tract.
Fatty acids	Reduces cancer and also improve body composition.
Mono saturated fatty acids	Reduce risk of coronary heart diseases.
Omega 3	Reduce risk of cardiovascular diseases.
Phenylalanine	It plays an integral role in the structure and function of proteins and enzymes and the production of other amino acids.
Tryptophan	A neurotransmitter that regulates your appetite, sleep, and mood.
Histidine	A neurotransmitter that is vital to immune response, digestion, sexual function, and sleep-wake cycles.
Leucine	Essential for protein synthesis and muscle repair. It also helps regulate blood sugar levels, stimulates wound healing, and produces growth hormones.
Methionine	This amino acid plays an important role in metabolism and detoxification. It's also necessary for tissue growth and the absorption of zinc and selenium.
Isoleucine	It helps in muscle metabolism and is heavily concentrated in muscle tissue. It's also important for immune function, hemoglobin production, and energy regulation.
Lysine	Lysine plays major role in protein synthesis, calcium absorption, and the production of hormones and enzymes. It's also important for energy production, immune function, and the production of collagen and elastin.
Valine	Valine helps stimulate muscle growth and regeneration and is involved in energy production.

Table 2: Common herbals as nutraceuticals[6]

Name	Constituents	Health benefits
Garlic (*Allium sativum*)	Alliin and allicin	Anti-inflammatory, antibacterial
Ginger (*Zingiber officinale*)	Zingiberene and gingerols	Stimulants, hyperglycemia, throat ache and chronic bronchitis
Turmeric (*Curcuma longa*)	Curcumin	Anti-inflammatory, anticancer, antiarthritic and antiseptic
Onion (*Allium cepa*)	Allicin and alliin	Hypoglycemic, antibiotic and anti-atherosclerosis
Ginseng (*Panax ginseng*)	Ginsenosides and panaxosides	Stimulating immune and nervous system and adaptogenic properties.
Aloes (*Aloe barbadensis*)	Aloins and aloesin	Anti-inflammatory and wound healing properties
Ginkgo (*Ginkgo biloba*)	Ginkgolide and bilobalide	Memory enhancer and antioxidant

Fortified nutraceuticals

Nutraceuticals that have been fortified with additional ingredients can serve a specific medical or physiological purpose in addition to their nutritional value. It is food that has been fortified with additional nutrients or ingredients. Examples include orange juice fortified with calcium, milk fortified with vitamin D, and cereal flour fortified with folic acid and fiber. Nutraceuticals that have been fortified during processing are then released or given to consumers with additional nutritional or therapeutic benefits.[15]

Farmaceuticals or recombinant nutraceuticals

The term "farmaceutical" combines the words "farm" and "pharmaceuticals." A pharmaceutical is a substance with high medical value that is made from altered plants or animals, typically through biotechnology. It includes foods that provide energy, such as bread, alcohol, fermented starches, yogurt, cheese, vinegar, and other biotech-produced goods. Biotechnology, for instance, is used to produce probiotics, extract bioactive components through fermentation or enzyme processes, and create genetically modified products.[15]

Health Benefits of Nutraceuticals

There are numerous advantages of nutraceuticals for disease prevention and health promotion (Figure 4). It protects against non-communicable diseases, slows down the aging process, increases lifespan, and enhances the body's metabolic processes.[16] Nutraceuticals have numerous bioactivities, which make them a potent therapeutic agent with a lot of health benefits.

Antioxidant activity

Free radical scavenging properties in several nutraceuticals have been reported. Onions, garlic, grapes, rosemary, spinach, turmeric, and parsley all have significant antioxidant properties, according to research.[18] Numerous neurodegenerative diseases, including Parkinson's and Alzheimer's, are prevented by dietary supplements with antioxidant potential.[19]

Gastro-intestinal health

Many people around the world experience different digestive disorders, including diverticulitis, ulcerative colitis, food allergies, and irritable bowel syndrome. However, nutraceuticals have the capacity

 ISSN 2955-1226 (Print)
ISSN 2955-1234 (Electronic)

to lessen oxidative and antigenic insults in a person's gastrointestinal tract. For instance, flavonoids and polyphenols have been linked to cytoprotective and gastroprotective effects as well as antioxidant activity. A neurotransmitter called glutamate, which is found in the gut, contributes significantly to the development of infant gastric mucosa as well as improved neonatal gastrointestinal function and gastric emptying.[20] Probiotics and other herbal nutraceuticals have a special place in maintaining a healthy digestive system. It strengthens the body's natural gut defense mechanisms, encourages the growth of beneficial microflora, and slows the growth of dangerous bacteria. Additionally, it lessens lactose intolerance and guards against gastrointestinal issues.[21]

Reproductive health

The ability of both men and women to reproduce is significantly influenced by nutraceuticals. Nutraceutical food supplements improve sperm quality, treat sperm dysfunction, and increase sperm count by 60 % in men. Nutraceuticals increase sperm mobility and also shield sperm from oxidative damage.[22] It lowers the chance of preterm labor in the case of female reproduction and affects steroid production at the cellular level. Women suffering from menstrual pain are relieved by nutraceuticals. It also corrects the improper sex hormone metabolism brought on by nutritional deficiencies. Nutraceuticals may have an impact on reproductive function, ovarian pathology, and hormone functions.[23]

Stem cell growth

By stimulating and attracting endogenous stem cells to the site of injury, certain nutraceuticals have significant effects on stem cell growth and proliferation and contribute significantly to tissue regeneration and healing. Our immune system is strengthened by nutraceuticals like green tea, catechins, carnosine, vitamin D, polyunsaturated fatty acids (PUFA), and essential amino acids.[22]

Prolonging life span

Citrus fruits and soybeans both contain nutrients that have an impact on autophagy, necrosis, and epigenetic modifications.[24, 25] According to studies, spermidine and its derivatives increase autophagy, which extends human lifespan. In addition to being antimicrobial, antioxidant, anti-rheumatic, and carcinogenic, fruits, vegetables, and herbs also contain caffeine and rosmarinic acid. They could lengthen a healthy life span.[21]

Renal and excretory health

The excretory system is significantly influenced by nutrients like magnesium citrate, potassium citrate, lutein, lycopene, and xeaxanthin. These roles, for instance, include promoting healthy oxalate excretion in the urine, protecting the kidneys, enhancing urinary bladder health, balancing calcium accumulation, crystallization of calcium and oxalate, and maintaining normal microbial flora in the bladder and urinary tract.[22]

Significance of Nutraceuticals on Disease Prevention

The use of nutritional supplements is essential in the fight against disease and illness. It aids in preventing non-communicable diseases, slowing down the aging process, extending life expectancy, and enhancing the body's metabolic processes.[26]

Cancer

Cancer can be prevented by using nutraceuticals that are high in bioactive dietary components.[27] The anti-mutagenic and anti-carcinogenic properties of herbal nutraceuticals was reported by Dutta *et al*.[26] Lycopene and carotenoids both have antioxidant properties that are useful in the treatment of cancer. Antioxidants reduce oxidative stress by quenching oxygen. Nutraceuticals inhibit DNA transcription in tumors and regulate DNA-damaging factors in cells.28 Fruits and vegetables contain chemopreventive elements that may have anti-carcinogenic properties.

Table 3: Some phytochemicals and their health benefits[3]

Phytochemicals	Sources	Health benefits
Flavonols	Onions, apples	Antioxidant
Anthocyanins	Blueberries, blackberries	Antioxidants, anti-inflammation and antidiabetic
Phenolic acids	Berries, legumes, whole wheat bran	Reduce oxidation of LDL cholesterol, reduce cancer, strong antioxidant
Curcumin	Turmeric root	Anti-inflammatory, antioxidant and anti-clotting agent
Saponins	Soy beans, vegetables	Anticancer (effective against colon cancer), lowers cholesterol
Isoflavonones	Soy beans, maize, legumes, lentil seed	Lowers cholesterol, antioxidants, prostate, breast, bowel and other cancers
β-carotene	Oat, vegetables, fruits, carrots	Antioxidant, protect cornea against UV light
Lutein and Zeoxanthine	Corn, avocado, egg yolk, spinach, citrus, rice bran	Improves vision, cataracts, anticancer (colon)
Lycopene	Tomatoes, watermelon, grape fruit, guava, pawpaw	Antioxidant, anticancer (prostate, bladder, cervical, leukemia), lowers cholesterol level

Table 4: List of marketed nutraceutical products [6]

Products	Category	Contents
Calcirol D-3	Calcium supplement	Calcium and vitamins
GRD	Nutritional supplement	Proteins, vitamins, minerals and carbohydrates
Proteinex	Protein supplement	Predigested proteins, vitamins, minerals and carbohydrates
Omega woman	Immune supplement	Antioxidants, vitamins and phytochemicals
Coral calcium	Calcium supplement	Calcium and trace minerals
Brahmi	Brain supplement	Protein, minerals, vitamins, fibre, carbohydrate and nicotinic acid
		Bitter orange

ISSN 2955-1226 (Print)
ISSN 2955-1234 (Electronic)

Phenorex	Fat burner	*Ginkgo biloba* and ginseng
BrainShiner	Memory booster	

For instance, the antioxidant beta-carotene in yellow and orange fruits has anticancer properties. They aid in preventing the action of tumor-promoting enzymes. Garlic contains sulfur compounds that strengthen the immune system, lower atherosclerosis, and stop platelet aggregation.29 Recent research has demonstrated that herbal nutraceuticals can affect the metastatic spread of cancer.[30]

Diabetes

Herbal nutraceuticals have proven to offer effective therapeutic benefits on type 2 diabetes. Isoflavones and omega 3 fatty acids lowers mortality and incidence of diabetes, promote insulin sensitivity, reduce glucose tolerance and reduce the sugar level in blood to normal. Antioxidants such as lipoic acid, catechins, fenugreek and cinnamon are used to treat diabetic neuropathy, nephropathy and retinopathy.[31] Nutrients such as magnesium, calcium, chromium and vitamin D promotes insulin sensitivity and also improves glycemic control.[31] Furthermore, caffeic acid reduces elevated plasma glucose in insulin resistant patients, green tea and epicatechin 3 gallate reduces fasting and postprandial glucose and improves insulin resistance. Bitter melon and pomegranates are good for diabetes because, it regulates the metabolism and aid the transportation of glucose from the blood into the cells.[31]

Obesity

A medical condition known as obesity is characterized by the buildup of excess body fat. Excellent anti-obesity properties can be found in nutraceuticals like psyllium, capsaicin, and conjugated linoleic acid. Chitosan, caffeine, fenugreek, vitamin C, green tea, curcumin, and bottle gourd are herbal nutraceuticals that aid in body weight reduction.[32, 33] Leptin and other cytokines that they secrete help lower LDL and total cholesterol and control food intake.[34, 35]

Cardiovascular diseases (CVDs)

In addition to quercetin found in apples, berries, cherries, and onions, dietary supplements such as flavonoids, flavones, and flavanones, as well as other antioxidant vitamins and minerals, may help lower CVD-related mortality. They work by blocking the cyclooxygenase pathway and stopping the angiotensin-converting enzyme (ACE), which raises blood pressure, from doing its job. By using lipid-lowering nutraceutical supplements and maintaining a healthy nutritional lifestyle, CVDs may be controlled.[36, 37]

Oral diseases

Odontonutraceuticals are a recent development in the nutraceutical industry. In dentistry, it serves as a phytotherapeutic agent.[38, 39] It is important for the treatment of oral disorders. Green tea, grape, and cocoa seed extracts, which are high in polyphenols, flavonoids, and proanthocyanidins, are examples of odontonutraceuticals.40 Aloe vera gel helps patients with oral lichen planus disease by healing mucosal wounds and reducing pain. Additionally, probiotics are a type of nutraceutical that aids in the prevention of halitosis, malodor, dental caries, and gingivitis.[41]

Osteoarthritis

All joint tissues are impacted by osteoarthritis. The cartilage is degraded by a combination of biochemical and mechanical factors.[42] Joint pain makes it harder to exercise, which leads to an energy imbalance and weight gain. The complications are treated with nutraceuticals like chondroitin sulfate, glucosamine, banana, ginger, green tea, curcumin, avocado, and soybean.[43] Antioxidant nutritional supplements are very effective in treating joint damage, pain, and inflammation.[44] Olive oil application also lessens swelling, stiffness, and pain.[45]

Parkinson's disease

Parkinson's disease is known as brain damage which occurs due to neurodegeneration. It is the second most common age related disorder in the world.[46] Herbal nutraceutical of Indian origin (Brahmi) is a natural brain tonic that helps in mental peace and relaxation, migraine, headache, insomnia, depression, anxiety, brain cell rejuvenation, blood circulation in the brain, memory function improvement and hormone secretion.[47] Researches have shown the potent use of dietary supplement (inosine) in slowing the progression of Parkinson's disease.[48]

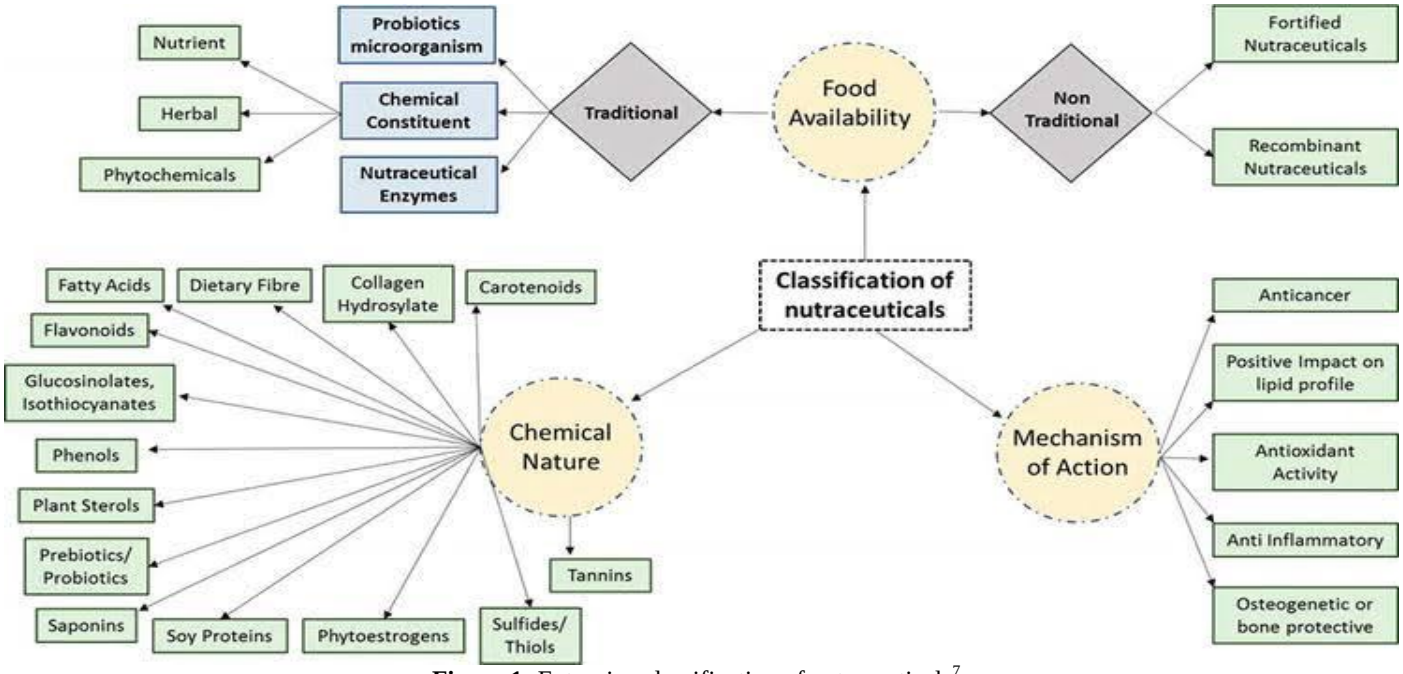

Figure 1: Extensive classification of nutraceuticals[7]

ISSN 2955-1226 (Print)
ISSN 2955-1234 (Electronic)

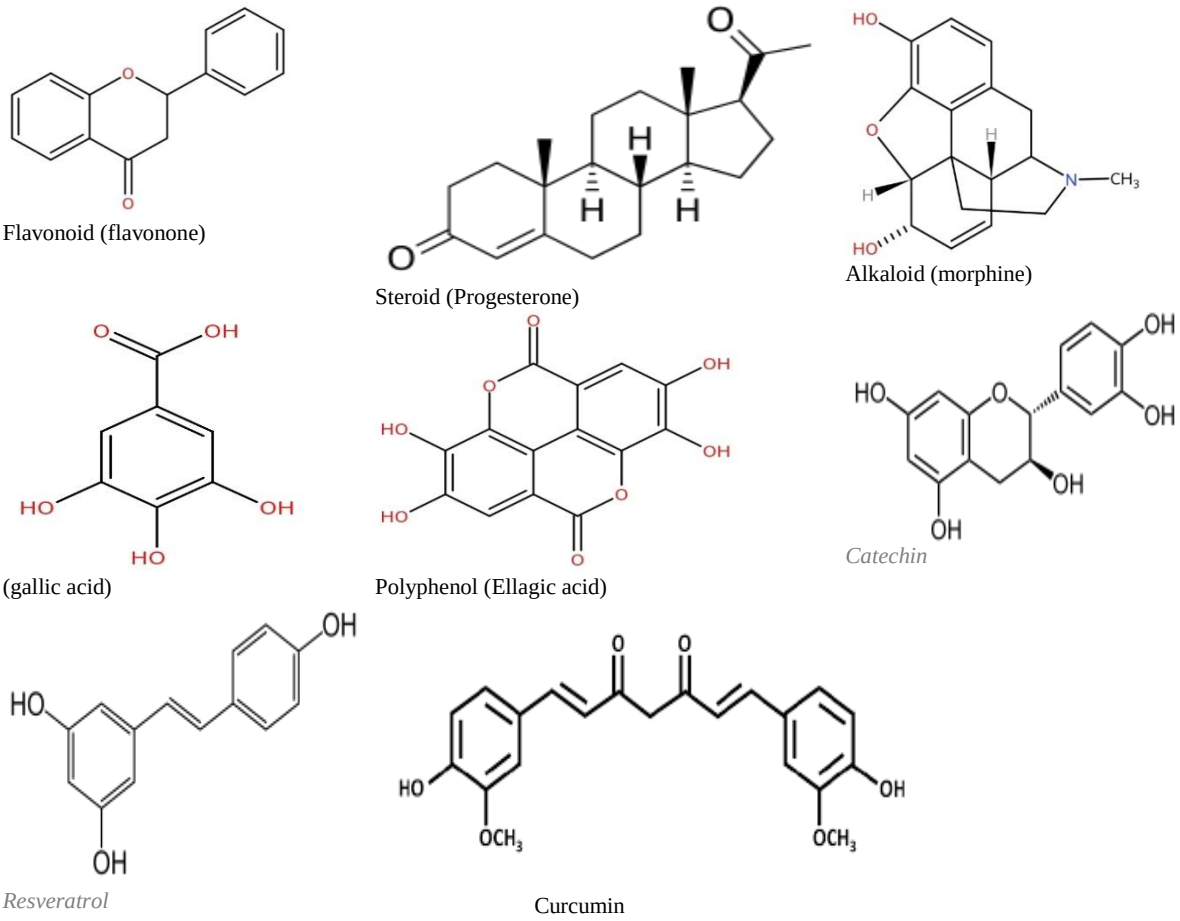

Figure 2: Examples of plant phytochemicals

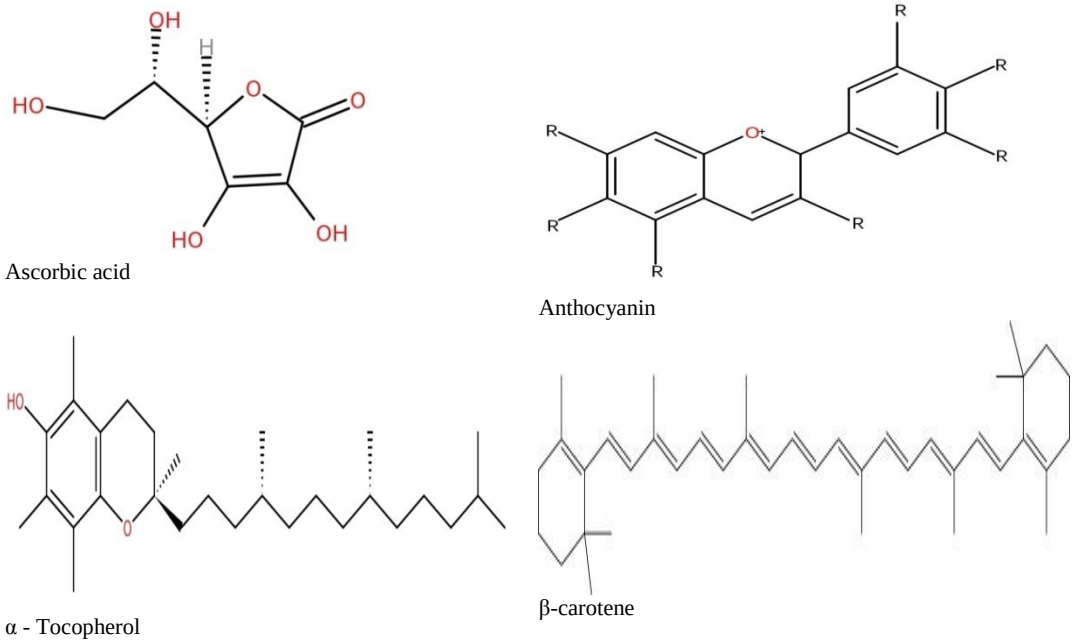

Figure 3: Examples of plant antioxidants

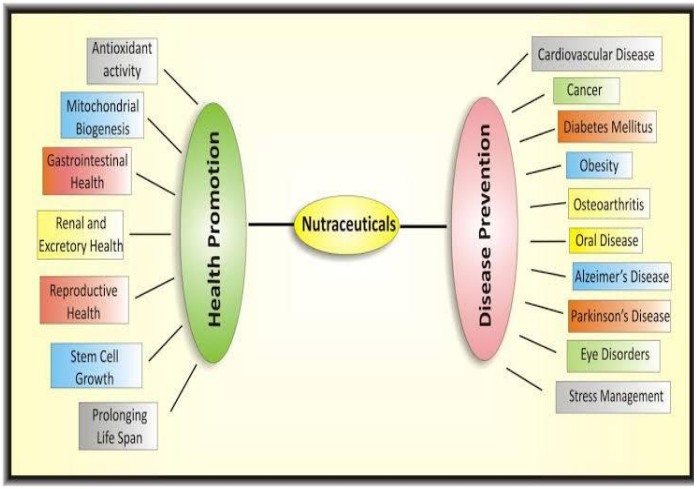

Figure 4: Role of nutraceuticals in health promotion and disease prevention[17]

Commercial Nutraceuticals

Nutraceuticals are used to treat a wide range of medical conditions, including arthritis, colds and coughs, sleeping disorders, digestion, the prevention of certain cancers, osteoporosis, blood pressure, cholesterol control, pain relievers, depression, and diabetes. However, various companies have branded nutraceuticals as therapeutic agents for boosting the immune system and preventing disease. Table 4 contains a list of some commercially available nutraceuticals.

Conclusion

Nature has been, and is still a source of medicinal agents for thousands of years. Currently, research is being done on medicinal plants worldwide. Plants have been used for the healing of diseases before the use of recent clinical drugs. Such medicinal plants are also recognized to have nutraceutical potential. Nutraceuticals are products derived from food sources, with the capability of providing extra health benefits, in addition to the basic nutritional value found in foods. Depending on the chemical composition, products may prevent chronic diseases, improve health, delay aging process, increase life expectancy, or support the structure or function of the body. They are universally accepted by all age groups due to their safety, quality, purity, efficacy, health promoting and disease curing efficacies.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

References

1. Nistha N, Anil K, Pillewan MB, Praveen KM, Sonali B. Improtance of nutraceuticals in various diseases and human health – A literature review. Wrld J. Pharm and Med Res. 2018; 4(9):104-110.
2. Riyaz AK, Gamal OE, Kamal AQ. Nutraceuticals: In the treatment and prevention of diseases - an overview. Pharma Innov J. 2014; 3(10):47-50.
3. Ravinder K, Gagandeep S, Gaurav S, Pawan K, Pratima K, Saeed IR, Surya PG. Nutraceuticals. A boom to medical industry. Pharm. Sci. 2013; 2:1-8.
4. Rajasekaran A, Sivagnanam G, Xavier R. Nutraceuticals as therapeutic agents. Res J. Pharm and Tech. 2008; 1(4):328-340.
5. Das L, Bhaumik E, Raychaudhuri U, Chakraborty R. Role of nutraceuticals in human health. J. Food Sci and Tech. 2012; 49(2):173-183.
6. Chauhan B, Kumar G, Kalam N, Ansari SH. Current concepts and prospects of herbal nutraceutical: A review. J. Adv Pharm Tech and Res. 2013; 4(1):4-8.
7. Chavarri M. Introductory Chapter: Nutraceuticals as an Alternative to maintain a Healthy Lifestyle. In (Ed.), Nutraceticals – Past, Present and Future. IntechOpen. https://doi.org/10.5772/intechopen.89875, (2020).
8. Diane EJ. What You Should Know About Nutraceuticals. The Female Patient. 2006; 51-52.
9. Bishop WM, Zubeek HM. Evaluation of microalgae for use as nutraceuticals and nutritional supplements. Nutr and Food Sci. 2012; 2(5):1-6.
10. Sumeet G, Devesh C, Kritika M, Preeti S, Anroop N. An Overview of Nutraceuticals: Current Scenario. J. Basic and Clin Pharma. 2010; 1(2):55-62.
11. Singh F, Kumar MS, Mahadevan N. Nutraceuticals: Uplift in Health. Int J. Recent Adv. Pharm Res. 2012; 2(2):17-28.
12. Shubhreet K, Saurabh G, Priyae BG. Phytochemical analysis of Eucalyptus leaves extract. J. Pharma and Phyt. 2019; 8(1):24422446.
13. Garima V, Manoj KM. A review on nutraceuticals: classification and its role in various diseases. Int J. Pharm and Therapeutics. 2016; 7(4):152-160.
14. Kalia AN. Textbook of Industrial Pharmacognosy. CBS Publisher and Distributor, New Delhi. 2005; 204-208.
15. Singh J, Sinha S. Classification, Regulatory Acts and Applications of Nutraceutical for Health. Int J. Pharm and Bio Sci. 2012; 2(1):177-187.
16. Nasri H, Baradaran A, Shirzad H, Kopaei MR, New Concepts in Nutraceuticals as Alternative for Pharmaceuticals. Int J. Prev Med. 2014; 5(12):1487-1499.
17. Sajan M, Nisha S, Mamta T, Anju S, Snehil SY. A review article on nutraceuticals. Int Res J. Mod. Eng Tech and Sci. 2022; 4(5):4329-4342.
18. Kaur S. Free radicals and antioxidants (nutraceuticals). Book to human health. Int J. Nat Pro Sci. 2012; 1:175.
19. Kesley NA, Wilkins HM, Linseman DA, Nutraceuticals antioxidant as novel neuroprotective agents. Molecules. 2010; 15:7792-7814.
20. Ostojic SM, Mitochondria-targeted nutraceuticals in sports medicine: a new perspective. Res. Sports Med. 2017; 25:91-100.
21. Pietsch K, Saul N, Chakrabarti S, Sturzenbaum SR, Menzel R, Steinberg CE. Hormetins, antioxidants and prooxidants: defining quercetin, caffeic acid and rosmarinic acid-mediated life extension in *C. elegans.* Biogerontology. 2011; 12(4):329-347.
22. Sarin R, Sharma M, Singh R, Kumar S. Nutraceuticals: Review. Int Res J. Pharm. 2012; 3(4):95-99.
23. Biesalski HK. Nutraceuticals: the link between nutrition and medicine. In (Ed.), Nutraceuticals in health and disease prevention. New York: Marcel Deckker Inc. 2001; 1-26.
24. Eisenberg T, Knauer H, Schauer A, Büttner S, Ruckenstuhl C, Carmona-Gutierrez D. Induction of autophagy by spermidine promotes longevity. Nat Cell Bio. 2009; 11:1305-1314.
25. Morselli E, Mariño G, Bennetzen MV, Eisenberg T, Megalou E, Schroeder S. Spermidine and resveratrol induce autophagy by distinct pathways converging on the acetylproteome. J. Cell Bio. 2011; 192(4):615-629.
26. Dutta S, Ali KM, Dash SK, Giri B. Role of nutraceuticals on health promotion and disease prevention: A review. J. Drug Deliv and Ther. 2018; 8(4):42-47.
27. Cencic A, Chingwaru W. Antimicrobial agents deriving from indigenous plants. RPFNA. 2010: 2:83-92.

28. Balsano C, Alisi A. Antioxidant effects of natural bioactive compounds. Cur Pharm Des. 2009; 15(26):3063-3073.
29. Sabita NS, Trygve OT. The role of nutraceuticals in chemoprevention and chemotherapy and their clinical outcomes. J. Onco. 2012; 64:1-23.
30. Wargovich MJ, Morris J, Brown V, Ellis J, Logothetis B, Weber R. Nutraceutical use in late-stage cancer. Can and Meta Rev. 2010; 29(3):503-510.
31. Stephen DA. A report of national nutraceutical centre. Nutraceutical India, 2012. Webinar. 2012:1-22.
32. Kasbia GS. Functional foods and nutraceuticals in the management of obesity. Nutr and Food Sci. 2005: 35:344-351.
33. Dev R, Kumar S, Singh J, Chauhan B. Potential role of nutraceuticals in present scenerio: A review. J. Appl Pharm Sci. 2011: 1(4):26-28.
34. Kaur G, Mukundan S, Wani V, Kumar MS. Nutraceuticals in the management and prevention of metabolic syndrome. Austin J. Pharm and Ther. 2015; 3:1-6.
35. Conroy KP, Davidson IM, Warnock M. Pathogenic obesity and nutraceuticals. The Proceedings of the Nutrition Society. 2011; 70(4):426-438.
36. Cicero AF, Colletti A. Combination of phytomedicines with different lipid lowering activity for dyslipidemia management: the available clinical data. Phytomed. 2016: 23:1113-1118.
37. Cicero AFG, Colletti A, Bajraktari G, Descamps O, Djuric DM, Ezhov M. Lipid-lowering nutraceuticals in clinical practice: position paper from international lipid expert panel. Arch. Med Sci. 2017; 13(5):9651005.
38. Gonzalez-Vallinas M, Gonzalez-Castejon M, Rodriguez-Casado A, Ramirez de Molina A. Dietary phytochemicals in cancer prevention and therapy: a complementary approach with promising perspectives. Nutr Rev. 2013; 71(9):585-599.
39. Varani EM, Iriti M. Odonto nutraceuticals: pleioyropic photo therapeutic agents for oral health. Pharmaceuticals. 2016; 9(1):10-13.
40. Gaur S, Agnihotri R. Green tea: a novel functional food for the oral health of older adults. Geriat and Geront Intl. 2014; 14:238-250.
41. Janczarek M, Bachanek T, Mazur E, Chalas R. The role of probiotics in prevention of oral diseases. Postepy Hig Med Dows. 2016; 70:850-857.
42. Wildman REC. Nutraceuticals and functional foods. In: Wildman Handbook of Nutraceuticals and Functional foods. New York: CRC press. 2006; 1-9.
43. Sacco SM, Horcajada MN, Offord E. Phytonutrients for bone health during ageing. British J. Clin Pharm. 2013; 75(3):697-707.
44. Akhtar N, Haqqi TM. Current nutraceuticals in the management of osteoarthritis: a review. Ther Adv Musculoskel Dis. 2012; 4(3):181-207.
45. Ruchi S, Amanjot K, Sourav T, Keerti B, Sujit B. Role of nutraceuticals in health care: a review. Intl J. Green Pharm. 2017; 11(3):386-394.
46. Mythri RB, Joshi AK, Mukunda M, Bharath S. Bioactive nutraceuticals and dietary supplements in neurological and brain disease. Academic Press, 2015; 421-431.
47. Agarwwal S. Leading pharmaceutical consultant. Nutraceuticals and osteoarthritis. Retrieved from http://www.drsanjayagrawal.com, (2017).
48. Michael J. Fox foundation nutraceuticals world. New hope for Parkinson's disease. Retrieved from https://www.michaeljfox.org/understanding-parkinsons, (2018).
49. Falodun A. Herbal Medicine in Africa-Distribution, Standardization and Prospects. Res J. Phyt. 2010; 4 (3):154-161.
50. Dauda JA, Jacob AD, Ogaji OD, Haruna, S, Idowu, OL, Are, CT, Abdullahi, AS, Ocheme, GW, Olupinyo, O, Oteno, F. Synergetic Assessment of the Elemental Profile, Phytoconstituents, Antioxidant and Antibacterial Efficacy of the Methanolic Extracts of *Persea americana* and *Daucus carota* Fruits. FUDMA J. of Sci. (FJS). 2022; 6(6):97-104.
51. Dauda JA, Ameh EM, Adaji MU, Ocheme GW, Nayo RO. (2020). Nutritional Composition and Antioxidant Analyses of *Ageratum conyzoides* Whole Plant. Intl J. Sci and Res Pub. 2020; 10(8):922-928.