The Nutraceuticals: A Voluminous Torrent in Pharmaceuticals-coupling Health & Drugs

Vijay Sharma¹, Lalit Singh¹ and Navneet Verma²

¹Department of Pharmaceutics, SRMSCET, Bareilly, U.P., India.
²Faculty of Pharmacy, IFTM University, Moradabad, U.P., India.

Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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(1) Dongdong Wang, Department of Pharmacognosy, West China College of Pharmacy, Sichuan University, China.
(2) Francesco Marotta, Texas Women University, USA.
(3) Jose Luis Montaner Soto, Instituto Politécnico Nacional, Mexico.
(3) Josephine Ezekwesili-Otilli, Nnamdi Azikiwe University, Nigeria.
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ABSTRACT

The present review is focused on the nutraceuticals which are present in our surroundings having an excellent impact over the health of humans but are not known for their pharmaceutical use. Nutraceuticals include vitamins, minerals and other dietary supplements, which may be herbs, enzymes, animal extracts etc. Various researchers have proved that nutraceuticals are having an important role in reducing the risk of various diseases such as diabetes, cardiovascular diseases, Parkinson’s disease etc. with very few or negligible side effects.

Keywords: Nutraceuticals; drugs; dietary supplements; functional foods.

1. INTRODUCTION

“Let food be your medicine and medicine be your food” this great line said by the great scientist, Hippocrates, is related to the chemicals in food having both nutritional and therapeutic values i.e. Nutraceuticals [1].

*Corresponding author: E-mail: vijaysrampur@gmail.com;
Nutraceuticals are a heterogeneous product category which has a number of synonyms that are used internationally. The term "Nutraceutical" was given by Stephen De Felice who was the founder and chairman of the Foundation for Innovation in Medicine. This term has been part of the industry lexicon for almost a decade [2]. The term "Nutraceutical" is derived from the combination of two words, “nutrient” which means a nourishing food or food component and second “pharmaceutical” which means a medical drug. Nutraceuticals may contain substances that are “natural”, intended to treat or prevent a number of diseases, but may not be generally recognized as safe. Hence these are the food products intended for health and medical benefit [3,4]. It has been proved by research that nutraceuticals are useful in providing protection from a number of diseases like diabetes, cancer, cardiac disease, hypertension etc., for example, carotenoids and anti-oxidants found in carrots help in protection against chronic diseases, by preventing free radical damage [5]. Nutraceuticals have become more popular in the modern society due to the belief of reduced chances of adverse effects, being natural, the ease of self-medication and the positive effects on the aging-population.

2. TYPES OF NUTRACEUTICALS

2.1 Dietary Supplements

Dietary supplements (DS) include herbs, minerals, vitamins, or products obtained from plant sources, animal sources such as yeasts, fungus, algae, seafood and many more, for example, energy bars, amino acids, and liquid supplements. They are not consumed in large quantities but have the basic objective to provide nutrition. The United States authorities state that dietary supplements may be regarded as foods, while elsewhere they are classified as drugs or other products [6,7].

2.2 Functional Foods

Japan introduced the concept of functional food in 1980s, to promote health or reduce the risk of diseases. The functional foods include those food items which are advised to be consumed as part of the normal diet, they contain biologically active constituents offering the potential to enhance health or reduce risk of various diseases. Among these foods are those that contain fatty acids, vitamins, specific minerals or dietary fibers, foods with added biologically active substances such as phytochemicals or other antioxidants and probiotics that have beneficial live cultures [8]. Some examples of functional food products are; milk, cheese and eggs (enriched with omega-3 fatty acids); yogurt enhanced with live active cultures (probiotics); fruit juices and drinks (having antioxidant properties or containing antioxidants); cereals and grains such as wheat, oat, barley (having enriched amounts of dietary fibre); modified fatty acid vegetable oils; soy, canola and hemp (vegetable proteins) and legumes [9,10].

In accordance with the established requirement for the functional food in Japan, the functional food should be consumed:

a). In its natural form, rather than a prepared dosage form like capsule, tablet, or powder;

b). Daily, in sufficient quantity; and

c). In the correct way such that it can regulate a biological process, in order to prevent or cure a disease [11].

2.3 Dietary Supplements and Food Additives

Dietary supplements provide nutrients that may otherwise not be consumed in sufficient quantities. Generally, dietary supplements include vitamins, minerals, fatty acids, fiber or amino acids etc., which according to United State authorities are regarded as foods [12].

Food additives like the dietary supplements, are any substances that are either deliberately added to food to enhance its shelf-life, nutrition, texture, or other quality aspect, or which unintentionally contaminates food (indirect additive) (Fig. 1) [13].

Nutrients are the nutritive constituents present in food that a person consumes for his/her survival and growth. Macronutrients provide the bulk energy required for functioning of metabolic system, whereas micronutrients are helpful in providing the necessary co-factors for metabolism. Plenty of these nutrients are available in the environment [14]. Inorganic chemical compounds like water, minerals, and oxygen should also be considered as nutrients [15].

2.4 Herbals

In ancient times, a large number of herbs were used to prevent and treat many diseases. A plant
containing non-nutritive phytochemicals, provides health benefits if included in diet [16-18]. Nutraceuticals as herbals are big boon to human beings in the aspect of improving their health and to protect them from chronic diseases e.g. willow bark (*Salix Nigra*) helps as anti-inflammatory, analgesic, anti-arthritic, astringent as well as antipyretic [19].

### 2.4.1 Phytochemicals

Phytochemicals are the plant components having bioactivities which are used to get health benefits, but their use always requires to be backed up with some scientific rationale for being present in food as potential nutraceutical. Phytochemical have following health benefits:

1. These are used as substrates for biochemical reactions.
2. These are used as cofactors of enzymatic reactions.
3. These act as ligands which agonize or antagonize cell surface or intracellular receptors.
4. These are used as scavengers of various reactive or toxic chemicals.
5. These are used as compounds to increase the absorption and or improve stability of many essential nutrients.
6. These work as selective growth factors for gut friendly bacteria.
7. Fermented phytochemicals are beneficial for non-pathogenic bacteria found in gastrointestinal tract.
8. These are selective inhibitors of deleterious intestinal bacteria. Phytochemicals like terpenoids, phenolics, alkaloids and fiber, are extensively examined and used for their ability to provide health benefits [20].

### 2.5 Probiotic/Prebiotics

Probiotic bacteria are “living microorganisms that taken in tolerable quantity, provide a variety of benefits to host health”. These may interact with commensal bacteria to have a direct impact on the host [21]. Metchinkoff was the first person who successfully revamped the toxic flora of the large intestine into a host-sympathetic colony of *Bacillus bulgaricus*, found by Hord [22;23]. Hence probiotics are gut friendly bacteria which aid in digestion and absorption of some nutrients. They act by eliminating the disease causing pathogens, like yeasts, other bacteria and viruses which mutually develop advantageous symbiosis within gastrointestinal tract (Table 1) [24]. The Japanese were the first to recognize the value of non-digestible oligosaccharides, and added these in feed of piglets to relieve and

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**Fig. 1. Diagrammatic representation of nutraceuticals**
prevent diarrhoea. It was observed that fructo-oligosaccharides and galacto-oligosaccharides cause an increase in intestinal bifido-bacteria which stimulated their growth in the human gut. Hence a prebiotic is “a selectively fermented ingredient that causes changes in the activity of the gastrointestinal microbiota that is beneficial for human health” [25]. Some people use lactobacillus for irritable bowel syndrome, Crohn’s disease, inflammation of the colon, necrotizing enterocolitis in babies born prematurely, infection with Helicobacter pylori, urinary tract infections, vaginal yeast infections, in prevention of common cold in adults and to prevent respiratory infections in children attending daycare centers. It is also being tested to prevent serious infections in people on ventilators [26-31].

A number of commercial/commercially prepared nutraceuticals are available in market as mentioned in Table 2.

### Table 1. Different species of microbes used as probiotic

| Genus       | Species                                                                 |
|-------------|-------------------------------------------------------------------------|
| Lactobacillus | Acidophilus, Delbrueckia, Brevis, Fermentum, Gasseri Johnsonii, Paracasei, Plantarum, Reuteri, Rhamnosus, Salivarrius |
| Bifidobacterium | Adolescentis, Animalisb, Breve, Bifidum, Infantis, Longum              |
| Streptococcus | Therophilus, Salivarrius                                                |
| Saccharomyces | Cerevisiae                                                              |
| Escherichia   | Coli                                                                    |
| Enterococcus  | Faecium                                                                 |
| Bacillus      | Coagulans, Clausii                                                      |

### Table 2. List of marketed nutraceuticals

| Products          | Category                        | Contents                                          | Manufacturer                        |
|-------------------|---------------------------------|---------------------------------------------------|-------------------------------------|
| Alamin SE         | Protein supplement              | L-Arginine & other Protein                        | Albert David Ltd., India            |
| Albumen Care      | Protein supplement              | L-Arginine, multivitamins & minerals              | B.V. Bio-Corp Pvt. Ltd., India      |
| Arginine          | Protein supplement              | L-Arginine, proanthocyanid                        | Manikind Pharma Pvt. Ltd, India     |
| Appetite Intercept™ | Appetite Suppressant            | Caffeine, tyrosine and Phenylalanine              | Natrol, Chatsworth, CA, USA         |
| Betafactor™       | Immune supplement               | Beta glycan                                       | Ameridan International Inc. USA     |
| Brainspeed Memory® | Brain Health supplement         | Vitamin and minerals                              | Natrol, Chatsworth, CA, USA         |
| Biovinca™         | Neurotonic                      | Vinpocetine                                       | Cyvex nutrition, Irvine, USA        |
| Coral calcium     | Calcium supplement              | Calcium and trace minerals                        | Nature’s answer, Hauppauge, NY, USA  |
| Calcirol D-3®     | Calcium supplement              | Calcium and vitamins                              | Cadilla Healthcare, India           |
| Chaser™           | Hangover Supplement             | Activated calcium carbonate, and vegetable carbon | Living Essentials, Walled Lake MI, USA |
| GRD®              | Nutritional Supplement          | Proteins, vitamins, minerals and carbohydrates   | Zydus Cadila Ltd. Ahmedabad, India  |
| Weight smart™     | Nutritional supplement          | Vitamins and trace elements                       | Bayer Corporation, Morristown, NL, USA |
| Yakult            | Probiotic                       | Skimmed milk, Lactobacilli                        | Danone India Ltd. India             |
| Products          | Category                      | Contents                                      | Manufacturer                  |
|------------------|-------------------------------|-----------------------------------------------|-------------------------------|
| ImmunAge         | Fermented papaya Preparation | Papaya, yeast, dextrose                      | Osato laboratory Inc. USA     |
| Glowelle®        | Beauty drink                  | Antioxidants, vitamins and fruit extracts     | Nestle, India                 |
| HiOwna           | Nutritional supplement        | Protein, multivitamins, minerals and antioxidant | Himalaya herbal ltd, India    |
| PediaSure®       | Nutritional supplement        | Protein, multivitamins and antioxidant        | Abbott India ltd, India       |
| Revital®         | Health supplement             | Ginseng, vitamin and minerals                 | Ranbaxy, India                |
| Proteinex®       | Protein Supplement            | Predigested proteins, vitamins, minerals and carbohydrates | Pfizer Ltd., Mumbai, India |
| Rox® Glucon-D    | Energy drink                  | Taurine, caffeine and glucuronolactone        | Rox America, Spartanburg, SA, USA |
| Glucose-D        |                               | Glucose                                       | Dabur                         |
| Omega woman      | Immune supplement             | Antioxidants, vitamins and phytochemicals (eg. Lycopene, and resveratrol) | Wassen, Surrey, U.K |
| Mushroom optimizer™ | Immune Supplement          | Mushrooms polysaccharides and Folic acid | Jarrow formulas, Los Angeles, CA, USA |
| Proplus®         | Nutritional Supplement        | Soy proteins                                  | Campbell soup company, Camden, NJ, USA |
| Snapple-aday™    | Meal replacement Beverage     | Vitamins and minerals                         | Snapple beverage group, White Plains, NY, USA |
| WelLife®         | Amino acid Supplement         | Granulated-L-glutamine                       | Daesang America Inc., Hackensach, NJ, USA |
| Olivenol™        | Dietary Supplement            | Natural antioxidant, Hydroxytyrosol          | CreAgri, Hayward, CA, USA     |
| Threptin®        | Diskettes Protein supplements | Proteins and vitamin B                       | Raptakos, Brett & Co. Ltd., Mumbai, India |
| Red bull®        | Energy drink                  | Taurine, Caffeine, Glucuronolactone, b- group vitamins | Austrian red bull GmbH |

3. PHARMACOLOGICAL USE OF NUTRACEUTICALS

Better life quality is achieved with food items filled with nutrient values and remarkably potent in preventing diseases which may be cancer, diabetes, heart diseases, hypertension etc (Table 3 & Fig. 2). Such products may be dietary supplements, food additives, phytochemicals, prebiotics, probiotics, genetically modified food, processed food and plant products.

3.1 In Cardiovascular Disease

It is not easy to set up a clear impact of nutrition/physical exercise on major cardiovascular diseases because history of cardiovascular diseases is too long [32]. The effect of calcium on hypertension and pre-eclampsia (a condition in pregnancy characterized by high blood pressure, sometimes with fluid retention and proteinuria) is unpredictable as well as ambiguous. It is
supposed that high levels of intracellular calcium may increase vascular smooth muscle tone, peripheral vascular resistance, and responsiveness to blood pressure. Treatment with vitamin C and selenium need further study to observe its effect on mortality [33-34].

It has been observed that some nutraceuticals may be useful to prevent the risk of thrombosis in women with thrombophilic gene mutations like vitamin E which causes inhibition of platelet aggregation by a protein kinase C-dependent pathway [35-36]. Nutraceuticals like vitamins, minerals, omega-3 poly-unsaturated fatty acids (n-3 PUFAs), dietary fibers and antioxidants, in addition to physical exercise, are recommended to prevent and treat cardiovascular diseases. Researchers have proved that polyphenols found in grapes and in wine are helpful in reducing arterial disease by altering cellular metabolism and signalling [37].

Onion, black grapes, cherries, cruciferous vegetables, grapefruits, red wine, apples and berries are good sources of flavonoids [38] and also available as flavones and flavonols which are beneficial for the treatment of cardiovascular diseases [39-41]. Flavonoids block the angiotensin-converting enzyme, a key moiety that causes raising in blood pressure [42]. Antioxidant activity of ascorbic acid, alpha-tocopherol, and beta-carotene as has been studied and reviewed [43].

3.2 In the Management of Diabetes

Various in-vitro and in-vivo studies (animal) have proved that plant polyphenols including phenolic acids, stilbenes, lignans and flavonoids are effective nutraceuticals in diabetes and its prevention, although human clinical trials are required to check the efficacy of poly-phenol compounds in treatment of diabetes [44].

Vitamin C (ascorbic acid) is a chain-breaking antioxidant which prevents the propagation of chain reactions that may lead to a reduction in protein glycation. It has been reported that ascorbic acid helps in reducing diabetes-induced sorbitol in animals [16]. Ascorbic acid supplementation (800 mg/day) partially replenishes ascorbic acid levels in patients with type 2 diabetes but endothelial dysfunction or insulin resistance is not affected at all [17].

Bunyapraphatsara et al. [45] observed a combined effect of Aloe vera juice with Lipoic acid reported advantageous in the treatment of diabetes [45]. Aloe vera juice showed significant reduction in fasting blood glucose level and triglycerides within two weeks and four weeks respectively. Aloe vera, however, did not show any effect on level of cholesterol, but was found to be effective in the treatment of diabetes [45].

Acacia is non-starch polysaccharides which is not digested in the intestine, but generate short chain fatty acids in large bowel that produce extensive biological effects. Philips et al. [46] conducted study over the extract of Acacia Arabica and confirmed the anti-diabetic effect of acacia resulted by increasing the insulin release. Hou et al. [47] demonstrated significant hypoglycemic effects of Acacia Arabica powder in healthy rabbits, whereas no significant decrease in blood sugar was observed in the alloxan-induced diabetic rabbits was observed. Wadood et al. [48] concluded that Acacia arabica initiates the release of insulin from pancreatic beta cells of normal rabbits. Antidiabetic activity of glycyrhiza in non-insulin dependent diabetic model was observed by Takii [49].

High intake of isoflavone (20–100 mg/day) is helpful in lowering of rate of mortality in diabetes of type 2, osteoporosis, cardiac disease and certain cancers [50]. Docosahexaenoic acid is vital for neuro-visual development which helps in modulating insulin resistance and nurture the advocacy for essential fatty acids in pregnancy in women with gestational diabetes mellitus [51].

Omega-3 fatty acids helps in reducing blood glucose tolerance in patients predisposed to diabetes. Insulin is needed to synthesize long chain n-3 fatty acids; thus heart may be victim to their depletion in case of diabetes. Hence it is concluded that ethyl esters of n-3 fatty acids may be advantageous in diabetic patients [52]. Lipoic acid is a well-known antioxidant, and in Germany being used to cure diabetic neuropathy. Lipoic acid; as a long-term dietary supplement is aimed at the prophylactic protection of diabetics from complications [53]. α-Lipoic acid enhances insulin sensitivity by approximately 18–20% in patients suffering from type 2 diabetes [54]. Clinical trial studies on α-lipoic acid reported advantageous in the treatment of diabetic neuropathy [55].

Dietary fibers obtained from psyllium have been used to reduce weight and lipid levels in hyperlipidemia as dietary supplement [56]. Intake of Chromium supplements may be helpful to
enhance sensitivity to insulin and boost glucose tolerance in type II diabetic patient [48]. Magnesium-rich diet intake may reduce risk of diabetes by improving in insulin sensitivity [57]. Diabetes management is supported by one of the nutraceuticals Biotin which increase insulin production and stimulates liver glucokinase activity, thus improves the uptake of glucose in muscle cells [58-60]. Pharmacological effect of epinephrine can be inhibited by Azadirachta Indica which results in enhanced utilization of peripheral glucose [61,62] and reduce hypoglycaemic activity without change in the serum cortisol level [63,64].

Kernels of Eugenia jambolana (Syzygium cumini) are useful in diabetes management; their aqueous/alcoholic extract shows hypoglycemic effect [65]. Green Tulsi (Ocimum sanctum) leaves extract also reduces blood sugar significantly by cortisol inhibiting potency as proved in both normal and alloxan induced diabetic rats [66,67].

3.3 In Parkinson's Disease

Latif et al concluded that diet enriched with vitamin E may decreases the chances of Parkinson's disease [68] while Brower V reported that creatine is helpful in management of Parkinson's disease by decreasing the clinical symptoms [69].

Antioxidant vitamin supplements such as tocopherol, ascorbic acid and beta-carotene are the abundantly occurring nutraceuticals. As per various earlier literature vitamin E supplements are becoming popular in treatment of Parkinson's disease, whereas epidemiological studies reported that vitamins C and E rich diets are associated with decreased risk of Parkinson's disease [70-71].

3.4 In Alzheimer's Disease

Literatures have been reported that fulvic acid, an active principle of Shilajit is highly effective against brain disorders exclusively and in combination with vitamin B complex. [72] Patients suffering from Alzheimer's disease treated with donepezil and vitamin E found effective although future study was suggested to check and compare additive as well as individual effect [73]. Wettstein et al. [74] reported that mild to moderate Alzheimer's dementia could be treated with metrifonate, donepezil, rivastigmine which are second-generation cholinesterase inhibitors. Hager et al. [75] found stable cognitive function especially in those patients who were administered with 600 mg Alpha-lipoic acid along with acetyl-cholinesterase inhibitors, in comparison to those patients who only received therapy of standard acetyl-cholinesterase inhibitors since last 337 days. Huperzine-alpha is a plant alkaloid derived from club moss plant (Huperziaserrata), which is a member of the Lycopodium species. Huperzine-alpha is in phase III clinical trial in the USA and is available as a dietary supplement [76]. The meta-analysis of Huperzine A reported here highlights that this treatment has certain
significant improvement for patients with Alzheimer’s disease and Vascular Dementia, and longer durations may result in better efficacy for patients with Alzheimer’s disease [77].

Literature survey supports that Lipoic acid also helps to improves potential of mitochondrial membrane, memory loss due to ageing and brain ailments as well as in patient suffering from Parkinson’s and Alzheimer’s disease [78].

Table 3. Detailed review on various nutraceuticals

| Types of Nutraceuticals | Sources | Active Constituents | Applications |
|-------------------------|---------|---------------------|--------------|
| **Dietary fibre**       | Whole grain foods (wheat and corn bran, nuts) | Insoluble fibre | Reduce chances of colon or breast cancer (anticancer) [94,95], maintain health of digestive tract [96] |
|                         | Oats, barley | Beta-Glucan | Reduce risk of cardiovascular disease, lower down Low Density Lipids and total cholesterol [97,98] |
|                         | Beans e.g. Legumes, oats, barley and some fibrous fruits | Soluble fibre | Anticancer (Colon Cancer), Digestive [99,100] |
| **Fatty acids**         | Salmon and other fish oils | Long chain omega-3 Fatty Acids-DHA/EPA | Reduce risk of CVD, Improve mental, visual functions[101-103] |
|                         | Cheese, meat products | Conjugated Linoleic Acid | Improving body composition, Decreases chances of certain cancers [104-106] |
|                         | Fruits | Anthocyanidins | Antioxidant; reduce risk of cancer [87-109] |
|                         | Green Tea | Catechins | Antitumor [110] |
| **Phenolics**           | Citrus | Flavonoids | Antioxidative activity, Prevention of coronary heart disease, hepatoprotective, Effective in inflammation and cancer [111] |
|                         | Cocoa, Chocolate, Cranberries & cranberry | Tannins | Anti-microbial, Reduce risk of cardiovascular disease [112] |
|                         | Corn, soy, wheat, wood oils | Plant Sterols, Stanol ester | Lower blood cholesterol levels by inhibiting cholesterol absorption [113] |
|                         | Tomatoes | Lycopene | Antioxidant, protect against prostate cancer [114] |
| **Carotenoids**         | Corn, various fruits, egg yolk, spinach | Lutin | Antioxidant, Muscle regeneration, anti cancer activity, protect eyes against age related muscular degenerations, cataract [115,116] |
|                         | Carrots, various fruits (Guava, papaya, Water melon etc) and vegetables (tomatoes etc) | Beta carotene | Antioxidant, protection of cornea against UV light. |
|                         | Soya beans | Saponins | Effective against colon cancer, reduces cholesterol level [117] |
| **Probiotics/Prebiotics** | Curd | Lactobacillus | Antibacterial, acute diarrhea [118] |
|                         | Whole grains, onions, | Fructo-- | Improve GI health, restore gut flora |
### Types of Nutraceuticals

| Sources | Active Constituents | Applications |
|---------|---------------------|--------------|
| combination of Pro & Prebiotics | oligosaccharides | [119] |
| Grains | Tocotrienols and tocopherols | The growth of diverse tumors cell lines was suppressed via initiation of apoptosis and concomitant arrest of cells in the G1 phase of the cell cycle [120] |
| Cereal grain, dairy & egg products and plants oil | Phytosterols | Exhibitantioxidant, anti-inflammatory, anti-neoplastic, anti-pyretic & immune-modulating activity, decrease cholesterol [121-123] |
| Various plants, whole grain | Phenolic constituents | Antioxidants, Anti-hyperglycemic, and anti hypertensive [124] |
| Grapes, berries, cocoa, green tea, acacia spp. | Catechin & gallic acids | Antioxidants, Antiradical property, cyto-protective. [125,126] |
| Soybeans | Isoflavonoids | Treating cancers & attenuates bone loss [127,128] |

### 3.5 In Erectile Dysfunction

L-arginine in combination with pycnogenol, a product obtained from the pine bark (*Pinuspinaster*), is found safe and effective in mild to moderate erectile dysfunction in Japanese patients [79]. When Patients suffering from moderate to severe ED and dyslipidemia were kept on Niacin rich diet, significant improvement was observed in patients [80].

*Kaempferia Parviflora Wall* Ex. Baker (KP), which is a Thai plant with name, Kra-Chai-Dum and rhizomes of which are used as a traditional medicine to alleviate male impotency, improve male libido, as energizer, control blood pressure and also reduce stomachache. Study reveals that KP is a potential nutraceutical compound effective in male erectile dysfunction caused due to ageing [81].

### 3.6 Osteoarthritis

Chondroitin sulfate and Glucosamine both are commonly used to alleviate/reduce the symptoms of osteoarthritis. Chondroitin sulfate and Glucosamine both act as nutraceuticals and possible mechanism of their anti-inflammatory activity may be due to synthesis of NO and PGE2 [82]. Capsaicin reduces pain and stiffness and increases joint functioning by acting as agonist for transient receptor potential vanilloid 1 (pain receptor) [82]. Boswelliaserrata relieved joint pain, reduced joint swelling, and stiffness by inhibiting TNF-α-induced MMP-3 expression and protected against IL-1β-induced chondrocyte death [83-85]. Capsaicin reduces pain and stiffness to increased joint function by agonising transient receptor potential vanilloid 1 (pain receptor) while prolonged exposure of capsaicin leads to desensitization of this pain pathway [86-87].

Cat’s claw reduces osteoarthritis associated pain by inhibiting lipo-polysaccharide induced PGE2 production and activation of TNF-α. Avocado/soybean unsaponifiables reduced pain in osteoarthritis patients and reduces NSAID consumption by suppressing TNF-α, IL-1β, COX-2, and iNOS in LPS-activated chondrocytes [88,89]. Collagen hydrolysates alleviate osteoarthritis related pain by stimulating regeneration of type II collagen and by increasing biosynthesis of proteoglycans [90].

### 3.7 Nutraceuticals Tailoring Genes-Nutrigenomics

Nutrigenomics is an emerging field to know interactions between food and genes, due to manipulated diet [91]. Nutrigenomics is the study of the use of functional genomic tools to probe a biological system followed by a nutritional stimulus to understand how nutritional molecules may affect metabolic pathways and homeostatic control [92]. Study of effect of nutrigenomics also becomes necessary to find out the effect of foods on factors that may interact with particular genes.
to increase risk of diseases like diabetes mellitus, obesity, cardiovascular diseases etc. [93]. Hence it is a vast field that describes the impact of food on genes of human being and requires that a lot of studies be done.

4. CONCLUSION

In the present scenario nutraceuticals have become more popular in modern society and became important due to increasing applications of Nutraceuticals which serves as a part of growing pharmaceutical industry. Modern society now is being aware of the food products that are beneficial to them in the aspects of health and nutrition owing to very few or no side effects. Nutraceuticals thus appear to be the way forward to prevent, control and possibly cure chronic diseases in the most natural, safe and easily affordable manner.

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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