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SIGNIFICANT ROLE OF NUTRACEUTICALS AND FUNCTIONAL FOODS IN THE MANAGEMENT OF METABOLIC SYNDROME

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ABSTRACT: Metabolic syndrome is the most widely and prevailing health concern globally. It is a cluster of biochemical and physiological abnormalities that involve obesity, insulin resistance, dyslipidemia, and hypertension. Several studies have reported that the prevalence of the overall metabolic syndrome rate in adults is about 25% (approx. 31% in women and 18.5% in men) in India. Whereas the global prevalence is about 20-25% in 2020. The direct relationship between diet and health leads to various scientific studies to find the significant relation and their specific beneficial functions. Certain foods are thought to have physiological effects in the management of metabolic syndrome by assisting the body's hemostasis mechanism. The present paper reviews different features of nutraceuticals and functional foods and their influence on the management of metabolic syndrome. Also, it overviews numerous functional ingredients in different food sources and their possible health benefits.

INTRODUCTION: The first ever full-fledged scientific term "metabolic syndrome" was introduced by the famous diabetologist, Gerald Reaven. In 1988, Reaven hypothesized that in many chronic diseases, the central element in the pathogenesis especially in ischemic heart diseases and Diabetes Mellitus, is the emergence of insulin resistance. Insulin resistance is a compensatory response characterized by elevated insulin levels in the bloodstream. The factors associated with insulin resistance encompass hyperinsulinemia, impaired glucose tolerance, high blood pressure, and dyslipidemia (increased triglycerides, decreased HDL). For the first time, Reaven introduced the word "X syndrome" (X denotes some unknown entity). Then, after almost a decade the word "X syndrome" was renamed as metabolic syndrome and was internationally accepted [1].

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The term metabolic syndrome (MetS) can be defined as a complex interrelated cluster of diseases. It is a condition of at least three risk factors associated with the development of cardiovascular risk factors. These factors include central obesity, diabetes mellitus, hypertension, and dyslipidemia. It represents the state of the body marked by insulin resistance, oxidative stress, and chronic inflammation [2]. It can also be represented by a cluster of events associated with the alteration of carbohydrates, fats, macrovascular and microvascular metabolism. The factors associated with the advance of MetS are unhealthy food

habits, higher intake of sugars, sedentary lifestyle, processed food with high content of saturated fatty acids and sodium, high energy-dense foods, alcohol and tobacco, inherent genetic/ progenetic factors, advancing age, *etc* [1, 3]. There is growing evidence that the prevalence of MetS is higher in urban areas as compared to rural areas. Globally, it affects nearly one-fourth of the total adult population. The majority of MetS elements are interrelated and interconnected. For example: insulin resistance is associated with various risk factors such as obesity, DM, and hyperlipidemia, which in turn causes an increase in cholesterol (high LDL, low HDL), and high triglycerides. Furthermore, it results in the development of atherogenic cardiovascular events [3]. These patients are at higher risk of developing hypertension due to excessive sodium and water retention in renal. It also causes endothelial dysfunction as a result of the secretion of cytokines. Furthermore, increases the expression of endothelial transcription factors and impairs the synthesis of nitric oxide [4].

Generally, patients with metabolic syndrome require multiple pharmacotherapies. Due to the adverse effects of synthetic drugs extra precautions are needed. Thereby limiting the use of synthetic drugs and introducing nutraceuticals and functional foods for the management of MetS. Currently, numerous studies are showing the beneficial effects of nutraceuticals, their long-term safety and efficacy, and their optimal dose. Functional foods and Nutraceuticals play a major role in combating and mitigating lifestyle disorders. These foods contain dietary ingredients that help in maintaining a healthy lifestyle [5]. The term nutraceutical was coined in 1988 by the US Foundation of Innovation in Medicine. It is the combination of two words i.e., nutrients and pharmaceuticals. According to FSSAI, a nutraceutical is a food or the component of food possessing a substance that has medical health benefits and helps to prevent and treat many diseases. Also, it is observed that nowadays there is a rising demand for nutraceuticals. The annual growth of nutraceuticals in India is about 25% which is similar to Japan. In India, the nutraceutical market is divided into two parts functional foods and beverages and dietary supplements. Nutraceuticals occupy around 64% market with vitamins and minerals supplements [6, 7].

FIG. 1: CONCEPT OF NUTRACEUTICALS [5, 8–12]

The term nutraceutical is derived from food containing essential components like functional foods, that have therapeutic properties. These include bioactive components, isolated plant-based components, minerals, vitamins, amino acids, and fatty acids, animal-based, and marine-based. Food is categorized as nutraceutical when it plays a role in preventing diseases and also serves as a form of medication for conditions beyond deficiencies like anemia. Hence, functional food has the potential to serve as a nutraceutical to different consumers. It contains non-toxic food components that can prevent or cure unhealthy conditions [5].

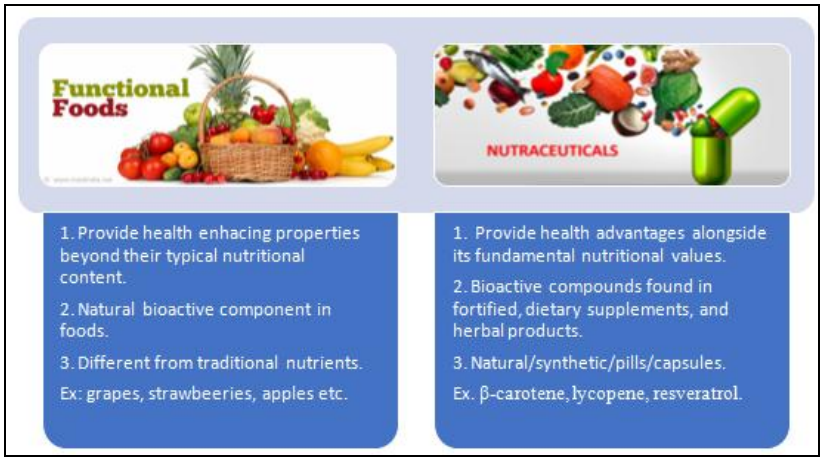

FIG. 2: DIFFERENCE BETWEEN FUNCTIONAL FOODS AND NUTRACEUTICALS [5]

Some categories of nutraceuticals by the following criteria: food-based nutraceuticals (fruits, vegetables, egg, fish, and dairy), nutrients as nutraceuticals (minerals, fatty acids, amino acids, and vitamins), herbal extracts or concentrates of botanical products (tannins, flavonoids, terpenoids like peppermint and methanol, carotenoids, curcumin, and ginger), probiotic microorganisms, nutraceutical enzymes, non-traditional nutraceuticals (orange juice fortified with calcium, cereals fortified with vitamins and minerals), fortified nutraceuticals (minerals in cereals, calcium, folic acids and iron in flour, fortified milk with cholecalciferol) and recombinant nutraceuticals (nutraceuticals obtained by the application of biotechnology in food product like extraction of nutrients from dairy products like cheese, and bread) [13].

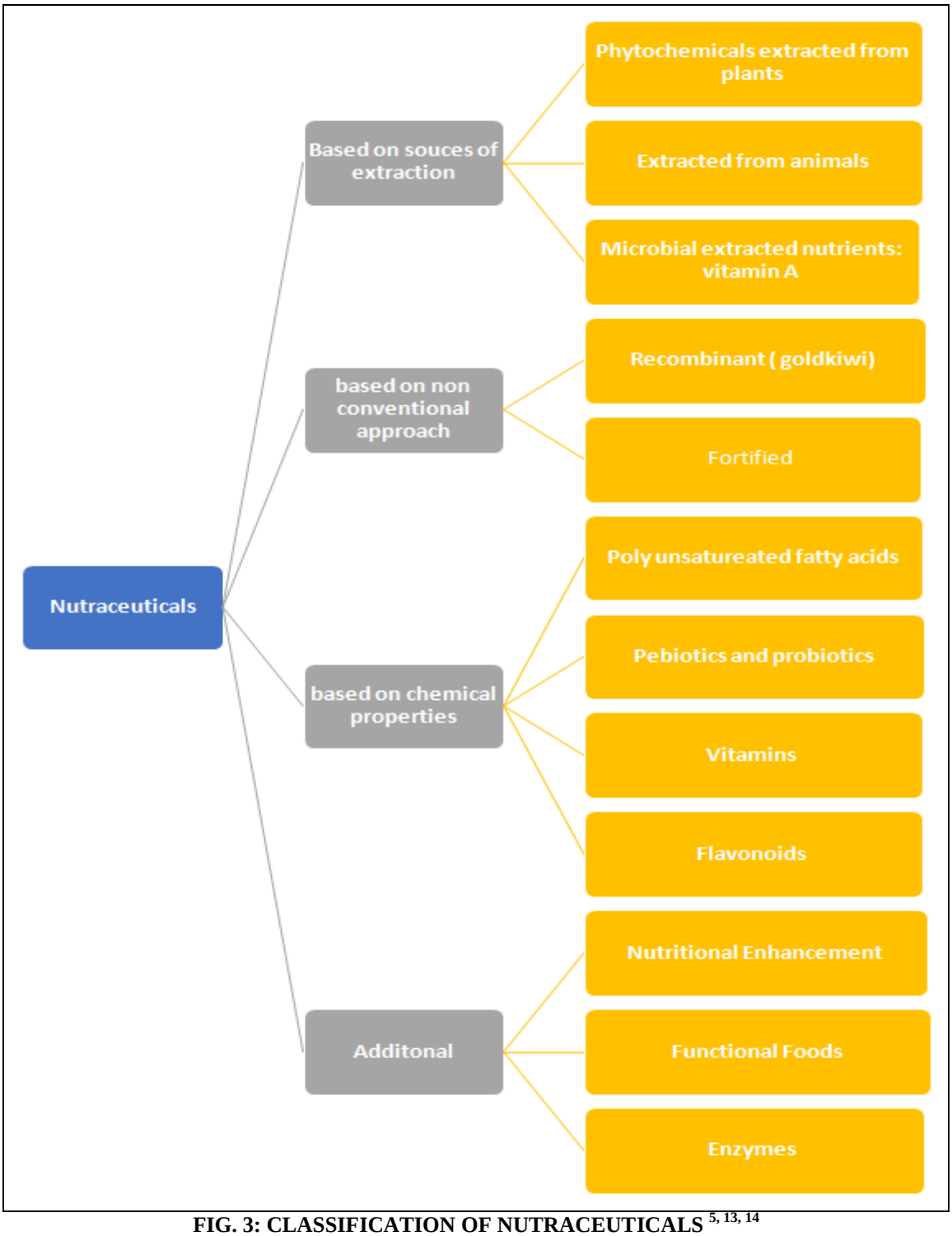

FIG. 3: CLASSIFICATION OF NUTRACEUTICALS [5, 13, 14]

The term functional food was first derived in Japan. In Japan, these foods carry specific labels for specific health uses (FOSHU). These foods are made in many ways. The other terms used as functional foods are "pharma foods", "Medi foods", vita foods", medical foods". The functional component can be added, removed, or modified during processing via genetic changes resulting in the development of new products in the market. The regular consumption of functional foods helps prevent diseases like CVDS, tumors, hypertension, diabetes, *etc* [13, 15–17].

However, there is no universal definition of functional food accepted by the FDA [18]. Yet, foods are functional at some physiological level but the American Diabetic Association defines functional foods as those that include wholesome, fortified, modified, enriched, or enhanced and show health benefits on regular consumption in the diet. In 1944, the US Institute of Medicine's Food and Nutrition Board introduced the concept of "Functional food" as any food or food component that provides health benefits beyond its conventional nutrient content [19, 20]. The Food and Nutrition Board of the National Academy of Sciences defines functional food as "any food or food ingredient modified that may provide health benefits beyond the conventional nutrient it contains" [21]. According to the International Food Information Council (IFIC), functional foods are described as the dietary components that may provide health benefits beyond providing basic nutrition [22].

In Japan, the first functional food was a dietary fiber drink named "Fiber-Mini" which was commercially launched in 1988. The product was promoted for gut regulation and to everyone's surprise, quickly gained significant popularity in the market [22]. There are various types of functional foods and it is necessary to be aware of the functional foods. They are not medication products. Some of the functional food examples are anti-oxidants, prebiotics, probiotics, salt-reduced foods, sugar-reduced foods, anthocyanins, phytosterols, isoflavones, and symbiotic foods [23].

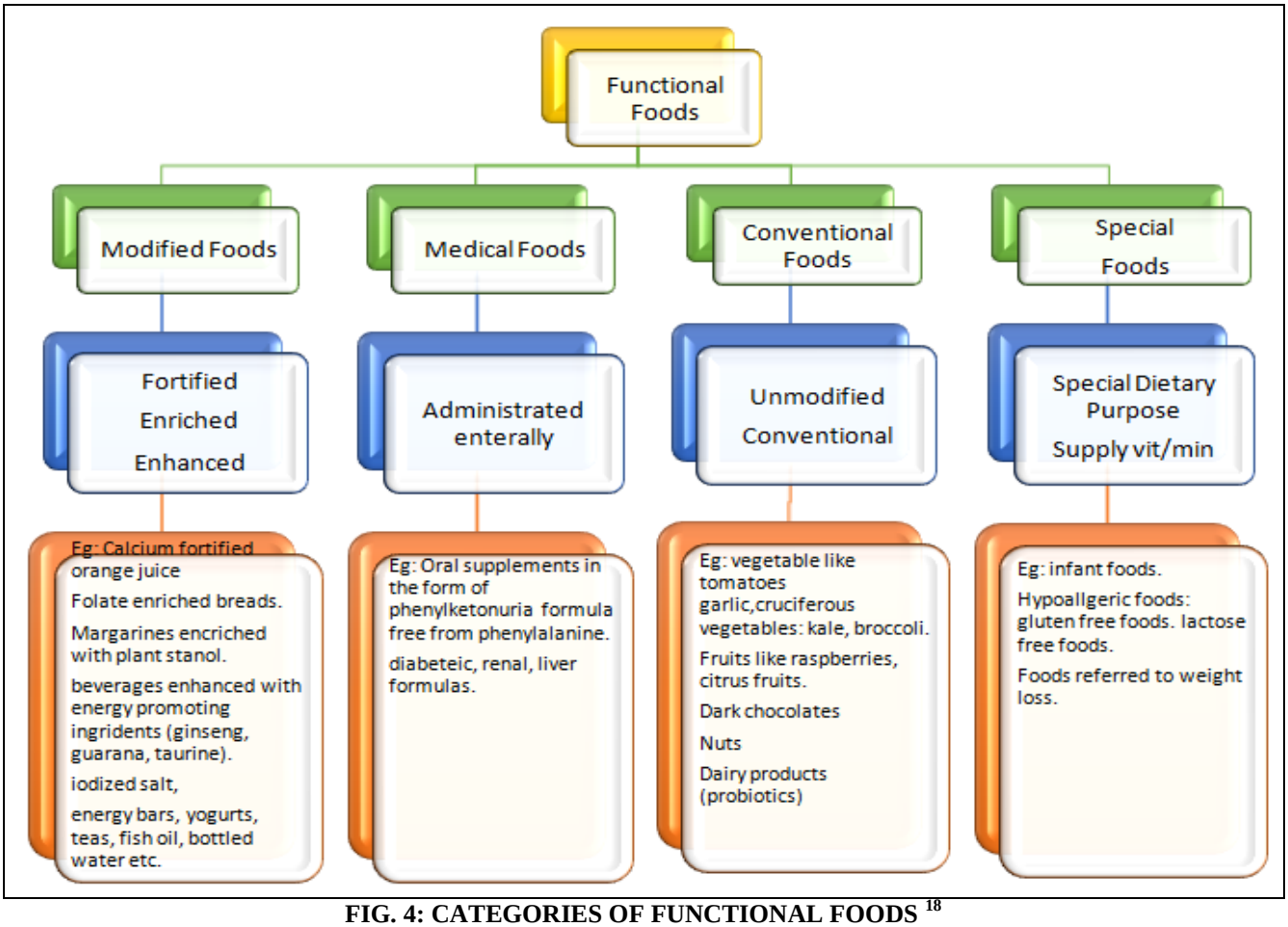

FIG. 4: CATEGORIES OF FUNCTIONAL FOODS [18]

TABLE 1: DIETARY SOURCES AND THEIR FUNCTIONAL USES [2, 18, 24–36]

Dietary sources/components	Health claim
raw, cooked, canned, dry tomatoes (LYCOPENE)	Prostate, ovarian, gastric, and pancreatic cancers, CVDS, muscular degeneration, obesity, liver cholesterolemia, hypercholesterolemia, and leukemia.
calcium supplements	Colorectal cancers and polyps, intestinal irritation, Essential and gestational hypertension, preeclampsia
green tea and its supplements	Breast and prostate cancers, oral health, fibrosis, hypertension, obesity, insulin resistance, neural degeneration, oxidation, hyperlipidemia, hepatotoxicity.
β- carotene (carrots, orange, tangerines, corn, avocado, numerous fruits and vegetables)	Oxidation
selenium supplements	Certain cancers, oxidation
phosphatidylserine supplements	Mental impairment and dysfunction (dementia)
chromium picolinate supplements	Insulin resistance
prebiotics and probiotics (dairy products like yogurt) (lactobacilli, bifidobacteria)	Immune and gastrointestinal dysfunction.
folic acid supplements (Vitamin B)	Neural tubes defects
Tocotrienols (VITAMIN E)	Hepatic cancers, diabetes, pancreatic cancers, CVDs, Alzheimer's, Parkinson's, dementia, lung cancers, dermatitis, obesity, muscular dystrophy, gastric cancers, colorectal cancers, nephropathy, chronic kidney diseases, rheumatoid arthritis, cervical and ovarian cancers, breast cancers, oral cancers, oxidation, inflammation.
retinol (Vitamin A)	Oxidation, skin disorders, eye infections.
whole oats	Heart diseases (CVDS), Obesity, and Insulin resistance.
psyllium seed husk soluble fiber	Heart diseases (CVDS), Obesity, Insulin resistance, hyperlipidemia, hypercholesterolemia.
peptides/ hydrolysates (buckwheat, casein, and whey protein)	Hypercholesterolemia, hypertension, constipation, diabetes.
barley soluble fiber	Heart diseases (CVDS), Obesity, and Insulin resistance.
black gram (*Vigna mungo*)	Renal dysfunction, obesity, diabetes, hypercholesterolemia.
amla (*Embica officinais*)	Hepatotoxicity, inflammation, digestive disorders, hypercholesterolemia, oxidative stress.
plant sterol and stanolsESTERS(NUTS, seeds, legumes, seeds, fat spreads)	Heart disease (CVDS), hyperlipidemia.
omega 3 and 6 fats (fish, krill, egg, squid, algae, edible seeds, walnuts)	Heart disease (CVDS), Obesity,Insulin resistance, Parkinson's, psychosis. Hyperlipidemia, hepatoprotective, fatty acid oxidation, inflammatory disease, mood swings, gastrointestinal disorders.
black tea	Inhibit pancreatic lipase.
cocoa powder	Obesity, Insulin resistance, Fatty liver, Cancers.
apple	Oxidative stress, Dyslipidemia, gastrointestinal discomfort.
acai berry, blueberries, cranberries, bilberries, maqui berries, mulberries, strawberries, raspberries, wild Alaskan berries, rose hip, chokeberries (resveratrol, quercetin, catechin, epicatechin)	Insulin resistance (improves b-cell function), Dyslipidemia, Obesity (reduces waist circumference, visceral fat mass, increases intracellular lipolysis), hypertension, cancer, neurodegeneration, oxidative stress, inflammation, visual problems (increase rhodopsin regeneration), plasma atherogenesis, liver injury, muscular triglyceride accumulation, skeletal muscle fatty acid oxidation, and protein kinase adenosine-monophosphate inhibition.
citrus polyphenols (red oranges, grapefruit)	Overweight, dyslipidemia.
cabbage, cauliflower, broccoli, brussels sprouts, Chinese cabbage, watermelon	Dyslipidemia, LDL cholesterol, atherogenic diet-induced tissue lipid elevation, cardiac and hepatic peroxidation/ injuries, lipid peroxidation, postprandial Diabetes, dyslipidemia, thyroid dysfunction, oxidation.
plums	Diabetes, adiposity.
pomegranate extract	Diabetes, dyslipidemia, high LDL cholesterol, inflammation.
mango peel extract (procatechuic acid, mangiferin, β- catotene)	Adipogenesis, microbial infections, diabetes, inflammation, cancers.
vitisin (resveratrol tetramer)	Adipocyte differentiation, fat accumulation.
Hibiscus sabdariffa	Hypertension, diabetes, liver disorders.
potato	Human autoimmune rheumatoid arthritis, LDL cholesterol, anti-type II collagen antibody.

eggplant	CVDS, myocardial infarction, diabetes, hypertension.
beetroot	Oxidation, inflammation, obesity, dyslipidemia.
bittermelon	Hypothyroidism, diabetes, adiposity.
Garcinia cambogia	Fat accumulation
Korean fermented red pepper paste	Obesity, adiposity, dyslipidemia, tumour necrosis.
mushroom	Diabetes, obesity, atherosclerosis, hypertension, metabolic diseases,tumors, oxidative stress, hypercholesterolemia, mutagens, virus, thrombosis, dyslipidemia, inflammation, immune inactivity.
Piper sarmentosum	Visceral fat adiposity, metabolic disorders.
plantainstem juice	Obesity, kidney stones, diabetes, metabolic disorders.
seaweeds (Gelidium elegans)	Indigestion, gastric empty time (delayed), oxidative stress, lipide oxidation, obesity (↑BMR), diabetes, virus, inflammation, tumour, renalpathy, uropathy, coagulation, allergy, hepatopathy.
Nigella sativa seeds	Obesity
lemon balm (*Melissa officinalis*)	Visceral adiposity
soybeansand soy protein (Genistein, daidzein), fermented soybean, soy trypsin/ chymotrypsin	Diabetes, hypertension, inflammation, tumour necrosis, hepatotoxicity, hyperlipidemia, CVDs, infertility, hypothyroidism, and obesity.
whole grains	Obesity (↑BMR), stroke, oxidative stress, constipation, hypercholesterolemia, hypertension, dyslipidemia, and hepatic injury.
nuts (tress nuts and peanuts)	Underweight, CVDS, gallstone, diabetes, oxidative stress, cancers, inflammation.
sesame seeds	Oxidative stress, inflammation, CVDS, diabetes, hepatic steatosis.
chia seeds	Obesity, oxidative stress, metabolic syndrome.
black cumin	Obesity, hypercholesterolemia.
cinnamon water extract	Protein aggregation (reduce tissue changes), oxidative stress, glycation, lipid peroxidation, obesity, dyslipidemia, diabetes, inflammation,
clove	Diabetes, oxidative stress.
fenugreek seeds alcoholic extract	Obesity, diabetes, cataracts, Hypercholesterolemia, liver dysfunction
garlic (allicin) and onion	Hypercholesterolemia, hypertension, platelet aggregation (decrease), fungal and bacterial infections, thrombosis, inflammation, and parasitic infections.
ginger	Hypercholesterolemia, liver dysfunction, oxidative stress, inflammation, diabetes
bitter guard (*Momordica charantia*)	Obesity
chameleon plant (*Houttuynia cordata*)	Obesity, liver and plasma adiposity, oxidative stress in the heart and liver, diabetes, tumour necrosis.
licorice oil	Obesity, fatty acid oxidation (increases).
Irurmomordica charantia, Morinda citriffolia, Centella asiatica	Obesity
processed aelovera gel	Diabetes (insulin resistance), reduces liver and plasma triglycerides, and adipogenesis.
Korean Ginseng	Angiogenesis, obesity.
oregano	Oxidative stress
RosemaryExtract	Liver injury, inflammation, obesity.
saffron	Inflammation, obesity, oxidative stress, CVDS, diabetes.
curcumin (turmeric)	Lipid peroxidation, diabetes, galactose induce oxidative stress, cell apoptosis, and gene expression dysfunction, Inflammation, oxidative stress, angiogenesis, respiratory, hepatic, pancreatic, and degenerative diseases, blood clotting, Parkinson's, HIV.
vitex negundo	Diabetes, oxidative stress.
dendrobium moniliforme	diabetes, hypercholesterolemia, renal dysfunction, and oxidative stress.
spirulina	Hyperlipidemia, inflammation, oxidation, atherosclerosis, diabetes,
red yeast rice extract	Hyperlipidemia, hypercholesterolemia, atherosclerosis, renal tumors.
bergamot (citrus fruit)	Hyperlipidemia, diabetes, tumors
artichoke leaf extract	Hyperlipidemia, hepatotoxicity, hypertension, diabetes, gastrointestinal problems.
berberine (coptis, hydrastis, berberis roots, stems, rhizomes, fruit, bark)	Hepatotoxicity, hyperlipidemia, constipation, diarrhea, abdominal distension, diabetes, hypertension.

TABLE 2: FOOD SOURCES AND ITS BIOACTIVE COMPONENTS [2]

Food Categories	Sources and Examples	Bioactive compounds
Fats and oils	Fish oil, olive oil, flax seeds oil (omega 3 and omega 6 fatty acids)	Dodecohexaenoic acid and Oleic acid

Drinks	Black, and green tea, coffee, herbal tea	Caffeine, Epigallocatechin-3- gallate
Fruits	Berries, apples, citrus fruits, pomegranates, plums, watermelons, mangoes, rosehips	Resveratrol, anthocyanin
Vegetables	Onion, garlic, cabbage family, tomato, potato, seaweeds, mushrooms, bitter melon.	Alliin, all-Cin, glucosinolates
Grains and legumes	Nuts, sesame seeds, whole grain cereals, soya	Beta-glucan, isoflavones
Flavorsand spices	Turmeric, cinnamon, cumin, clove, chillis, fenugreek seeds, pepper, ginger	Curcumin, eugenol
Herbs and aromatic plants	Oregano, thyme, rosemary, vitex negundo, mint	Thymol, rosmarinic acid
Digestive enzyme inhibitors	Berries, green and black tea	Tannins, Epigallocatechin-3- gallate

Protective Role of Ffunctional Foods and Nutraceuticals in the Management of Metabolic Syndrome: Functional foods help regulate the intestine's health, including controlling the intestinal transit time, bowel habits, mucosal motility, and modulation of epithelial cell proliferation. Furthermore, it regulates gastrointestinal function by balancing the colonic microflora, controlling nutrient bioavailability, and modifying GI immune activity, and endocrine activity. Also, it maintains lipid homeostasis, which is directly influenced by nutrient intake and fermentation. Moreover, it helps in memory-related diseases like Parkinson's and Alzheimer's. functional foods are proven to be beneficial for fetal health, CVDS, cancers, weight reduction, mental health disorders, osteoporosis, *etc* [37].

On the other hand, the consumption of nutraceuticals like nuts, cod liver capsules, folic acids, lutein, omega-3 fatty acids, omega-3- 3 eggs, omega-3 enriched yogurt, calcium-enriched orange juice, green tea, *etc*., helps to prevent diseases and promote health. Nutraceuticals have many health benefits like CVDS, diabetes, cancers, obesity, chronic inflammatory diseases, Parkinson's disease, and Alzheimer's disease [38]. Dyslipidemia is the primary cause of many metabolic diseases. The serum lipid profile includes four components, total triglycerides, total cholesterol, LDL, and HDL. It is been observed that the intake of soy protein, fruits, vegetables, especially citrus fruits, seaweeds, and whole grains helps in eliminating dyslipidemia along with depression. Furthermore, prebiotics help to increase colonic fermentation and hypocholesterolemia effects [22]. Diabetes is a significant health concern known to trigger both macrovascular and microvascular disorders. Patients require ongoing self-care and therapeutic concern to mitigate the serious consequences of life-threatening conditions. Several functional foods are known to show hypoglycemic effects like garlic oil, diallyl trisulfide, and S-allyl cysteine sulfoxide (product from garlic) are effective in lowering blood glucose and possess anti-cancerous activity. Garlic has shown effectiveness in promoting the release of insulin from the pancreas and feeling-bound insulin. Moreover, onion (*Allium cepa* L.), allyl propyl disulfide, and S-methyl cysteine, also possessa hypoglycemic effect and can be used as anherbal treatment to cure diabetes. Additionally, fenugreek (*Trigonella foenumgraecum* L.) contains steroid saponin, decreasing insulin uptake from the intestine. *Mangifera indica* tree leaves, cloves, and bitter guard (*Momordica charantia* L.) are widely used as a traditional medicine to cure the situation.

Moreover, Oats and barley are recognized as beneficial functional foods, because of the presence of beta-glucan, which helps to reduce cholesterol and glycemic levels [39]. Nuts like almonds, Brazil nuts, hazelnuts, pine nuts, cashew, walnuts, pecans, *etc*., are also considered beneficial source of antioxidants, vitamins, minerals, unsaturated fatty acids, and other bioactive components that helps to decrease the incidence of diabetes and CVDs, reduce inflammation, reduce blood pressure, increase endothelial function, decrease platelet aggregation, decrease the risk of neurogenerative disorders, decrease the incidence of cancers, hypertension, decrease LDL cholesterol and triglycerides. In addition to this, unprocessed whole grains, vegetables and fruits, beans, seeds, species, and, herbs are potent sources of antioxidants, minerals, and vitamins and are considered superior sources to control diabetes as compared to supplements [22, 41]. Further, extracted β- glucan has been extensively integrated into a diverse range of innovative food items such as breads, nutrition bars, chews, breakfast cereals, beverages, yogurt, ice cream, pasta, and dietary supplements. Some

Canadian companies like Nutraceutical Inc., Ceapro Inc., and Parrheim Inc. provide concentrates and food products enriched with these ingredients. One dietary approach to reduce the occurrence of hypertension involves the use of functional food in one's diet. Bioactive peptides, typically consisting of 2-50 amino acids, hold the potential to enhance human well-being by lowering blood pressure through their anti-hypertensive properties.

Pomegranate juice, beetroot juice, sesame, non-roasted green coffee, peas, soybean, garlic, and wheat plant protein also contain potent inhibitors of high blood pressure, thus helping in managing hypertension. Moreover, dairy products like sour milk contain lactotripeptides isoleucine-proline-proline and valine-proline-proline, which are recognized as potent hypertensive agents. Additionally, cheese, whey, and casein of yogurt can used to curtail many symptoms. Besides, the oral consumption of β-casein bioactive compounds was also found to be beneficial in reducing the rate of hypertension. The product named "BIOZATE" and "BIOPURE-GMP" with whey protein isolates has β-lactoglobulin fragments and glycomacropeptides that are beneficial in lowering blood pressure as well as bacterial and virus infections [22, 39, 40].

Moreover, some of the nutraceuticals popularly known nutraceuticals known for the treatment of CVD s are flavonoid plant pigments, flavanols from chocolate polyphenols such as resveratrol extracted from red grapes, omega-3, catechins from tea, and quercetin. It is found that the juice of nitrate-rich beetroot is beneficial for pulmonary atrial hypertension. Also, the supplements of vitamins A and C are found to help improve the life expectancy of patients with pulmonary atrial hypertension. Some of the other nutraceuticals that help to treat pulmonary atrial hypertension are "genistein" extracted from soybean, chickpea, sunflower seeds, cauliflower, broccoli, soy milk, alfa-alfa, sunflower seeds, and clover seeds, " L-arginine" extracted from soya, peanut, walnut, and fishes, "berberine", extracted from medicinal herbs such as cortex phellodendri and Rhizome coptidis, "Naringenin" extracted from oranges, tomatoes, and grapefruits, "Ellagic acid" obtained from strawberry, raspberry, blackberry, green tea, and pomegranate, "L-citrulline" obtained from watermelon, "Capsaicin" obtained from chili pepper, "Xanthohumol" obtained from hops flowers, "Chrysin" obtained from passion fruit, honey, and propolis, " blueberry extract", "Quercetin" obtained from apple, cranberries, grapes, onion, pepper, and asparagus, "beet juice", "chlorogenic acid" obtained from coffee and tea, "fatty acids" obtained from fish oil, plant oils, flaxseeds, "sulforaphane" obtained from broccoli, and "allicin" obtained from garlic etc [41].

Likewise, dietary fiber is included in the food product as a functional additive to offer various health advantages. These include cellulose, maltodextrin, polydextrin, and insulin isolated from different foods and known for their positive effect on health by promoting laxation, stool softening, healing constipation, reducing blood cholesterol, regulating blood glucose, etc. Besides, probiotics are gaining prominence attention as a crucial dietary component as it promotes nutrient absorption, and digestion while preserving the equilibrium of helpful gut microorganisms. The World Health Organization and Food and Agriculture Organization of the United Nations defined prebiotics as "live microorganismswhen administrated in adequate amounts confer health benefits".

As the definition states, it is helpful in averting and curing disorders such as lactose intolerance, hepatic encephalopathy, gastroenteritis, diarrhea, and inflammatory gastrointestinal diseases, etc. on the other hand, prebiotics can be defined as the substrate that is selectively utilized by the host microorganism to confer health benefits". As the definition states, it helps avert and cure hyperglycemia and irritable bowel syndrome. Plant foods such as nuts, cereals, and vegetable oils containing stanols and sterols tend to reduce cholesterol absorption from the intestines and possess anti-atherogenic, anti-inflammatory anti-obesity and anti-oxidative effects. Additionally, turmeric, ginger, and saffronare more commonly utilized as a spice than a medicinal remedy, despite their anti-inflammatory, anti-depressant properties. Some of the dietary sources of prebiotics are asparagus, wheat bran, barley, garlic, leek, onion, banana, artichoke, chicory, etc. Moreover, some examples of prebiotics that act as functional foods

are fructans, galacto-oilgosaccharides, poly-dextrose, and Xylo oligosaccharides, cyclodextrins, lactulose, Triphala, *etc* [22, 42–44]. In addition to probiotics and prebiotics, para probiotics also help in the management of intestinal lumen health. Paraprobiotics can be defined as inactivated microbial cells (cells as a whole) that confer many health benefits to humans. They work by interacting with the cells in the small intestine through cell wall component interaction. It can regulate the immune system, act as an anti-inflammatory, antiproliferative, antioxidant, and exert antagonist against pathogens, protect against dermatitis, respiratory diseases, viral infections and allergies, and liver and intestinal disorders. Some of the examples of paraprobiotics are *Bifidobacterium* sp., *Enterococcus* sp., lactobacillus sp., *etc* [45].

A thermogenic compound called capsaicin present in the red chilies has the potential to decrease body fat. Also, it enhances diet-induced thermogenesis in the body stimulates fat oxidation, and reduces the appetite. Moreover, green tea extract also shows a positive impact on body fat reduction and cholesterol levels in the body. Moreover, stilbenes including polyphenols (resveratrol and pterostilbene), present in grapes and blueberries show anti-inflammatory and antioxidant - properties, which are also able to regulate the thermogenic capacity of adipose tissues and help in weight reduction. In addition to that flavonoids present in fruits, wines, vegetables, and tea help protect against obesity, CVDs, and type 2 diabetes mellitus. Green tea compounds such as catechin and caffein are functional foods that curtail the white fat mass and act as ant obesogenic [22, 46].

Furthermore, some of the nutraceuticals that reduce the incidence of obesity are *Gelidium elegans* (seaweed), ginger, *angelica sinensis, nigella sativa*, Bidens Pilosa flower, *Theobroma cacao, Coptis chinensis, isodon adenantha, zizipus jujube*, bitter guard, lemon balm, *coptidis rhizome*, mulberry, turmeric, mangosteen, lotus, chicory, *cordyceps militaris* (fungus), sorghum bicolor, *angelica keiskei, isodon eriocalyx, ginkgo bilboba, Hieracium sp., morus nigra*, dwarf apricot, *rhus verniciflua, Panax ginseng, guarana etc* [32]. Some of the nutraceuticals that help in the management of heart failure prevention are multivitamins including Mg, Zn, Cu, and Se, drink powders including spirulina, citrulline, taurine, glycine, soy is flavones, cocoa flavanol, EPA/DHA caps, melatonin caps, glutathione booster caps [47].

CONCLUSION: In this paper, we have tried to increase the knowledge of the readers about the therapeutic knowledge about properties of nutraceuticals and functional foods. Functional food contains physiological active components that help to promote a healthy life. It focuses on prevention rather than treatment. Regular intake of these functional foods and lifestyle modifications helps to reduce various metabolic syndromes such as oxidative stress, cardiovascular diseases, neurogenerative diseases, diabetes, obesity, cancers, immune disorders, *etc*. Nutraceuticals can be defined as substances that provide physiological benefits beyond their basic nutritional functions. Generally, they are derived from purified forms of vegetables and fruits, colostrum supplements, and dairy products. They are marketed in the form of medicines. The increasing trend of urbanization and evolving lifestyle has led to higher sustainability to various health risks like heart stroke, diabetes, hypercholesterolemia, hypertension, *etc.* although many of these conditions can be managed by lifestyle modifications and diet intervention. Thus, nutraceuticals, functional foods, and dairy foods should be incorporated into one's diet.

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