Published Online on 22 December 2016

Proc Indian Natn Sci Acad **82** No. 5 December 2016 pp. 1565-1577

DOI: 10.16943/ptinsa/2016/48888

Review Article

Traditional Foods, Functional Foods and Nutraceuticals

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(Received on 28 June 2016; Accepted on 03 August 2016)

Food is essential not only for body functions but also to improve health and well-being. In this context, the terms that are usually discussed and debated are 'traditional foods', 'functional foods' and 'nutraceuticals'. This article attempts to define, differentiate and discuss the current knowledge and regulatory aspects related to these foods. While 'traditional foods' are best described as the foods that people have eaten for ages, the understanding that both processed and unprocessed foods that we eat deliver a large number of physiologically active small molecules that exert both beneficial and deleterious effects has led to the emergence of the concept of 'functional foods'. The distinct set of food-derived chemicals popularly referred to as 'nutraceuticals' are responsible for functional attributes of foods. Nutraceuticals exert a wide range of effects on human physiology such as on gastro-intestinal health, antioxidant defences, metabolic homeostasis, signalling processes, detoxification mechanisms, and other vital cellular processes. This article also attempts to provide insights into some of the latest research findings on some of these foods and nutraceuticals from the traditional Indian food system. Owing to their importance and commercial implications, many countries have placed regulatory control to govern them. In Indian context, the Food Safety and Standards Authority of India (FSSAI) brought out draft regulations on nutraceuticals, functional foods and on labelling and advertising guidelines. Adequate scientific evidence and rational use should be the basis for choice of nutraceuticals and their use for promoting and improving public health.

Keywords: Traditional Foods; Functional Foods; Nutraceuticals

Introduction

"Let food be thy medicine…" these famous words of Hippocrates are a dictum today. Food scientists, manufacturers and most importantly consumers now realize that many health benefits of the foods are not only for specific body functions but also to improve health and well-being in general. There has been an escalated research effort into understanding the health benefits of foods in the past few decades (El Sohaimy, 2012). This is driven by increased awareness of the relationship between diet and optimal health as well as motivation to take control of health among consumers. These beliefs are well founded since scientific research increasingly shows that foods, their ingredients can confer many overall, often unrecognised health benefits. In this context, the terms that are usually discussed and debated are 'traditional foods', 'functional foods' and 'nutraceuticals'. They are often used interchangeably as many people have the notion that anything that is traditional is definitely nutritious and confers varied health benefits. This article attempts to examine these terms, define and differentiate between them while providing brief insights into some of the latest research findings, unexplored areas and regulatory framework around them in the Indian context.

Defining Traditional Foods

Traditional foods include a gamut of food preparations or raw food commodities, whose use is deep rooted

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in traditional practices. Traditional foods are best described as foods that people have eaten for ages. These foods have become part of traditions and cultures. Traditional foods are generally perceived as foods with beneficial properties due to genuineness, local production, propagation and minimal or no industrial processing. According to FAO (2008), traditional food products represent an expression of culture and lifestyle resulting from the local climatic, agricultural and economic conditions that determine production and processing practices. As a consequence, the traditional nature of a product is based on collective heritage and is linked to a specific territory although it is transmitted by migration of individuals or populations. The European Food Information Resource Network project defines traditional foods as those with specific features that distinguish them clearly from other similar products of the same category in terms of use of traditional raw materials/primary products/traditional composition/ traditional production and/or processing methods.

Traditional Foods of India

Indian traditional foods can be broadly classified into preparations made from cereals, pulses, fruits, vegetables, dairy and meat; and their products. Traditional Indian foods have been greatly influenced by culture, geographic patterns and seasonal variations and exhibit large diversity (Achaya, 1994). Realization of functional properties of Indian traditional food eventually lead to development of one of the world's oldest medicinal system, the Ayurveda (Sarkar *et al*., 2015).

Cereals and Millets

Cereals and millets serve as the most important source of macro-nutrients. The two important cereals that are widely consumed in India are rice and wheat, although others like *jowar* (sorghum), *bajra* (pearl millet) and *ragi* (finger millets) and other minor millets are used as staples or substitutes in many regions. They are traditionally used for making varieties of food preparations that are consumed during all meals of the day. However, the varieties of rice or wheat and the way they are processed for consumption have changed over the years. For instance, polished rice is the most predominantly sold form in both urban and rural settings. Interestingly, rice used to be polished only at 2.5% level in the 1960s, while presently the polish is around 10% for commercial purposes. Similarly, wheat is industrially processed to make flour of two types i.e., whole wheat flour (*Atta*) and refined wheat flour (*Maida*).

Pulses and Legumes

Pulses and legumes have been an integral part of the traditional Indian food system. They serve as sources of protein besides energy and micronutrients (vitamins and minerals). Pulses and legumes are used to prepare a large number of stews, and recipes that are consumed as side dishes along with large variety of Indian breads (unleavened) flat such as rotis and chapathis, rice preparations, and breakfast items such as *idli*, *dosa, apam* etc. Many pulses and legumes such as black gram, green gram, green peas and *rajmah* (Kidney bean), soy beans find important place in Indian food system alongside Bengal gram and red gram.

Dairy Products/Milk and Milk Products

The products exclusively derived from cow or buffalo milk are important traditional foods in India. Milk is an important source of nutrition for infants and children and is equally ubiquitously consumed by adults. It is used as such and as an ingredient in a variety of beverages such as tea/coffee, *kheers* (sweet porridge), and many regional sweet preparations like *rosogolla, sandesh* and *pedha*. *Dahi* (Indian yoghurt) is a popular fermented product prepared from milk using lactic acid bacteria. The bacterial activity results in low pH which causes milk proteins to curdle, giving characteristic texture to *dahi*. It is used in a variety of culinary preparations, and also as a complement to plain rice. *Dahi* is rich in B complex vitamins, folic acid, and riboflavin and confers a wide range of health benefits due to the presence of probiotic bacteria (Sarkar *et al*., 2015). Other dairy products used in the Indian traditional food system are butter, *ghee* (clarified butter) and *paneer* (Indian cottage cheese). There is, however, a sea of change in the way milk and milk products are processed today compared to the earlier times. Milk, as it was understood earlier, was only whole milk (fresh) that came from the udders of the milch cattle. All the nutritional qualities or functional attributes of the milk were of that kind of milk, which was always locally sourced and fresh without any processing. Today, homogenized and

pasteurized standard milk is available, in which fat percentage is adjusted to meet the regulatory requirements (FSSAI, 2011). Similarly, *ghee* available in the markets today is made from the cream of fresh milk and not from the cream from curds or boiled milk as in the traditional way.

Fruits

These are rich sources of flavonoids, minerals, vitamins, carotenoids, electrolytes and other bioactive compounds that have impact on human health. While many fruits such as apple, pineapple, papaya, bael (*Aegle marmelos*), citrus fruits, guava etc form part of traditional Indian food, the most commonly consumed fruits are mango and banana. They have always had a special place in Indian culture and tradition and have always been treated as an integral part of the traditional diets.

Spices

One of the major factors that set the Indian food apart from the rest of the world is the use of spices and their blends, which enhance the aroma of food. The spice tampering given in searing hot oil gives Indian stews their characteristic flavour and aroma. Spices are used in a large number of ways to prepare stews and curries, and to marinate various food preparations. Spices commonly used in India are turmeric, black pepper, garlic, fenugreek seeds, ginger, cumin seeds, coriander seeds, cardamom, and nutmeg. They bring to food a large number of bio-actives that render foods functional. Several such bio-actives have been listed separately under the *Nutraceuticals* section of this article.

Functional Foods

Today there is growing recognition that food plays more roles than just being a source of macro- and micronutrients. It is also a source of large number of physiologically active small molecules that provide health benefits. This has led to the emergence of the concept of Functional Foods. The Functional Food Centre (FFC, USA) defines functional food as "natural or processed foods that contain known or unknown biologically-active compounds; these foods, in defined, effective, and non-toxic amounts, provide a clinically proven and documented health benefit for the prevention, management, or treatment of chronic disease". This definition is unique because it acknowledges the bioactive compound and draws attention to the fact that bioactive compounds must be taken in non-toxic amounts because they have upper limits beyond which they are likely to become dangerous (Martirosyan and Singh, 2015).

Probiotics and Prebiotics

Beneficial effects of interaction between the host and the 'healthy bacteria' in the intestinal milieu have been unequivocally established. The so called 'healthy bacteria' have been classified as probiotics and are defined as live microbial food ingredients that are beneficial to health. Once consumed, the microbial load of the food interacts with the intestinal components of the host to elicit a wide variety of beneficial biological effects (Roberfroid, 2000). Probiotics were mostly consumed as a part of fermented food products such as yoghurt and curds. But the weight of evidence in favour of probiotics has inspired food industries to develop food products fortified with probiotics. One example of such improvisation is ice-creams containing probiotics, which is claimed to be a commercially viable carrier of probiotics (Cruz *et al*., 2009). Other food products such as biscuits containing probiotics, and soy- and juice-based products are being developed and/or evaluated for health-effects (Rampelli *et al*., 2013, Nagpal *et al*., 2012). The importance of probiotics has also been recognized by the medical/ pharmaceutical industry and several strains of *lactobacilli* and *bifidobacteria* are currently available for treating gastrointestinal infections (Salminen *et al*., 2005). Many strains of probiotics including *L. acidophilus LA-1, L. paracasei, B. lactis Bb-12, and L. Casei Shirota,* are currently available across many platforms for commercial utility (Nagpal *et al*., 2012).

Prebiotics are specialised plant fibre that nourish and promote the growth of good bacteria which are already in the bowel. Detailed discussion of probiotics and prebiotics is covered in the chapter on Diet and gut microbiota in human health.

Some Examples of Commonly Consumed Functional Foods

Garlic

Garlic is a common food with many functional

attributes. Garlic is used as spice, herb and a vegetable whose biological properties are attributable to low molecular weight sulphur-compounds. Active principles of garlic are demonstrated to confer a wide array of therapeutic effects including anti-microbial, anti-cancer, anti-diabetic, anti-inflammatory, and anti-oxidant activities as well as ability to improve cardiovascular health (Rivlin, 2006; Milner, 2010; Bayan *et al*., 2014).

Ginger

The root of *Zingiber officinale* is used as a spice in large variety of vegetable and meat preparations. Ginger is used for therapeutic purposes in many countries in Asia, Europe and Middle East and there is supportive evidence that suggests that ginger may exert beneficial effects against nauseating discomforts, platelet aggregation & cardiovascular diseases, dyslipidemia, inflammation, oxidative stress and hypertension (Singletary, 2010). In addition, reports indicate that ginger possesses anti-mutagenic and anti-microbial properties (Nirmala *et al*., 2007; Panpatil *et al*., 2013).

Fenugreek

Both the leaves and seeds of fenugreek plant are used in traditional Indian food system. Fenugreek seed, which is used as a spice in culinary practices, is known to exert a large spectrum of therapeutic effects such as gastro-protectant, hepato-protectant, and anti-diabetic effects in addition to exhibiting antioxidant activity and hypocholesterolemic activity (Srinivasan, 2006; Meghwal and Goswami, 2012). The anti-diabetic effects of fenugreek are attributable to components such as 4-hydroxyleucine (potentiator of insulin secretion), disogenin (α-amylase and α-glucosidase inhibitor), and the fibre fraction comprising galactomannan (Smith 2003, Ghosh *et al*., 2014; Fuller and Stephens, 2015). Most encouraging aspect of utility of fenugreek seeds as an anti-diabetic agent is its established efficacy in clinical studies (Sharma *et al*., 1990; Sharma and Raghuram, 1990; Raghuram *et al*., 1994).

Turmeric

Turmeric has been effectively used as a general tonic or stimulant, food preservative, cosmetic agent, carminative, diuretic, blood purifier, anti-phlegm, and as well as remedy for cough, cold, sinusitis, pain, and intestinal and liver disorders in India, China and Middle Eastern countries over centuries (Krishnaswamy, 2009). The active ingredient (nurtraceutical) in turmeric is curcumin. Health attributes of curcumin are discussed under the section on nutraceuticals.

Tomato

Tomato, although termed as a fruit, is considered and used as a vegetable. It is a principle ingredient in a wide variety of products. The importance of the tomato as a vegetable is exemplified by the fact that it is fourth most heavily consumed vegetable in the world. It delivers a healthy dose of carotenoids such as lycopene and pro-vitamin A (β carotene) and vitamins C and E (Canene-Adams *et al*., 2005). Most of the functional effects of tomatoes are attributable to its carotenoids content. A case controlled study by Gann *et al*., (1999) suggested that consumption of tomato products and other lycopene containing foods might reduce the occurrence or progression of prostate cancer. High levels of lycopene has also been linked to reduced risk of cardiovascular diseases (Canene-Adams *et al*., 2005). Experimental studies indicate that tomatoes or its constituents may exert neuroprotective, antioxidant and anti-diabetic effects (Ali and Agha, 2009; di Matteo *et al*., 2009; Gokul and Muralidhara, 2014; Hsiao *et al*. 2004; Lavelli *et al*., 1999; Owoeye and Onwuka, 2015).

Cinnamon

Cinnamon, a colloquially used term for the inner bark of trees *Cinnamomum zeylanicum and Cinnamon cassia*, is a spice used world over. Scientific evidence suggests that cinnamon is useful in control of glycaemia and hypertension. In addition cinnamon is reported to exert antioxidant, anti-microbial, anti-inflammatory, neuroprotective and hepato protective effects. Cinnamtannin B1 is believed to be a major molecule responsible for anti-diabetic effect of cinnamon (Ranasinghe and Galappaththy, 2016).

Other Functional Components of Food

Recently, there has been increased focus on consumption of whole grains or products made from whole grains. A significant determinant of health-effects of whole grains is their non-digestible carbohydrate component. The non-digestible

carbohydrates of food act as dietary fibres and are mainly composed of non-starch polysaccharides such as arabinoxylans, cellulose, and other components such as resistant starch, resistant dextrins, lignin, chitins, pectins, beta-glucans, and oligosaccharides. Among these, beta-glucan and resistant starch are perhaps the most important functional components due to the fact that they are present in commonly consumed cereals and their ability to modulate glycaemic index of food.

Beta-glucans

Beta-glucans, particularly (1→3, 1→4)-β-d-glucan, are soluble dietary components predominantly found in oats and barley, and to some extent in rye and wheat. They are linear homo polysaccharides of consecutively linked (1-4)-b-D-glucosyl residues separated by single (1-3)-linkages. They exhibit functional properties of viscous and gel forming food hydrocolloids. Beta-glucans are associated with physiological benefits such as reducing serum cholesterol and regulating blood glucose levels (Brennan and Cleary, 2005; Lazaridou and Biliaderis, 2007). In view of their effects on glycaemic regulation, beta-glucans are being explored for their potential use in reducing glycaemic index of food. A decrease in glycaemic response to carbohydrate consumption has been reported in type 2 diabetics as a result of beta-glucan ingestion (Tappy *et al*., 1996).

Resistant Starch

Resistant starch (RS) refers to the fraction of dietary starch which is not hydrolyzed to d-glucose in the intestine within 120 mins after consumption. RS is a linear molecule of a-1, 4-D-glucan, essentially derived from the retrograded amylose fraction, and has a relatively low molecular weight. Compact molecular structure that hinders interaction between starch and hydrolytic enzymes and gelatinization brought about by cooking in excess of water could be the major reasons for lack of effects of hydrolytic enzymes on RS. RS exhibits properties such as swelling capacity, viscosity, gel formation and water-binding capacity. RS is useful in prevention of colonic cancer, glycaemic regulation, regulation of lipid homeostasis, prevention of fat accumulation, absorption of minerals and as a prebiotic (Fuentes-Zaragoza *et al*., 2010). Major food categories and their functional components are provided in Table 1.

Examples of Nutraceuticals

Nutraceuticals can simply be described as natural phytochemicals that render foods functional. Functional properties of food are attributable to their active principals that interact with a host of targets of human body at physiological, cellular and sub-cellular level to elicit effects that are associated with preventive or therapeutic outcomes.

Omega-3 Fatty Acids

Both omega-6 and omega-3 fatty acids are essential fatty acids, implying their obligatory need for dietary consumption. This is due to the fact that mammals are not endowed with synthetic machinery to introduce double bonds at positions 6 and 3, relative to the –CH3 end. Consequently, their synthesis is almost

Table 1: Major Food categories and their functional components

S.No.	Category	Functional Components
1	Cereals	Minerals, vitamin E and γ-oryzanol (rice bran), insoluble fibre (wheat bran), beta-glucan (oats)
2	Legumes and pulses	Isoflavones and dietary fibre
3	Oil	Omega-3 fatty acids (flax seed oil), γ-oryzanol (rice bran oil), oleuropein (olive oil)
4	Fruits and vegetables	Dietary fibre, carotenoids (carrot), dithiolthiones (cruciferous vegetables), beta-carotene and lutein (green leafy vegetables), lycopene (tomato), resveratrol (grapes), sulphur compounds (alliums), wide range of polyphenols
5	Fishes	Omega-3 fatty acids (Tuna, salmon, mackerel)
6	Dairy products	Probiotics
7	Spices and herbs	Curcuminoids (turmeric), piperine (pepper), Eugenol (clove, bail and cinnamon), gingerol and shogol (ginger), disogenin, 4-hydroxyisoleucine and galactomannan (fenugreek), flavonoids and diallyl sulphate, alliin, ajoene, and allicin (garlic), cinnamtanninB1 (cinnamon).

exclusively dependent on dietary sources of linoleic acid (LA, 18:2n-6) and a-linolenic acid (ALA, 18:3n-3), which serve as precursors of long chain omega-6 and omega-3 fatty acids respectively. Their metabolism involves a series of desaturation and elongation steps, leading to formation of typical omega fatty acids. Arachidonic acid (20:4n-6) is the major omega-6 fatty acid, while eicosapentaenoic (EPA, 20:5n-3) and docosahexaenoic acids (DHA, 22:6n-3) are the major omega-3 fatty acids. The best sources of these nutraceuticals are the vegetable oils, fish and algae. Scientific literature clearly suggests that human evolution paralleled consumption of diets with omega-6/omega-3 fatty acids ratio of approximately 1:1 (Simopoulos, 2002). The modern Western diets, which enjoy worldwide presence now, are relatively deficient in omega-3 fatty acids and consequently suffer from very high omega-6/omega-3 fatty acids ratio of 15:1 to 16:1. Indian diets are very high in omega-6 compared to omega-3 fatty acids since most commonly used oils in India are very low in omega-3 fatty acids. Diets with high omega-6/omega-3 fatty acid ratio are known to cause various types of disorders.

Omega 3 Fatty Acids and Neuro-health

Owing to their high levels in brain, it can be argued that omega fatty acids have profound impact on brain functioning. DHA, the principal omega 3 of the brain, accumulates in brain during perinatal cortical expansion and maturation. Although there is a lack of specific studies exploring the role of DHA deficiency in human brain function, it is now becoming clear that omega3 deficiency may also be associated with impairments in neuro-anatomy, neuro-cognition as well as Attention deficit hyperactivity disorder in humans (McNamara and Carlson, 2008). Several reports show that DHA levels are reduced in brains of human subjects with Alzheimer's disease (Corrigan *et al.*, 1998; Skinner *et al.*, 1989; Söderberg *et al.*, 1991). High omega-3 consumption has been suggested to decrease the risk of cognitive decline and dementia in middle and old aged men (Kalmijn *et al.*, 2004; van Gelder *et al.*, 2007). Decrease in DHA in serum phosphatidylcholine has been suggested as risk factor for dementia associated with AD (Kyle *et al.*, 1999). Dietary intake of n-3 fatty acids and weekly consumption of fish has been shown to reduce the risk of incident Alzheimer disease in human subjects (Morris *et al.*, 2003). Similarly, EPA and ethyl-EPA have been found to be associated with improvements in Huntington's disease patients (Vaddadi *et al.*, 2002; Puri *et al.*, 2002, 2008).

Omega-3 Fatty Acids and Cardiovascular Functions

There is sufficient evidence that omega-3 fatty can protect against cardiovascular disease and their consumption is beneficial after myocardial infarction. Ability to lower triglycerides and blood pressure are hallmark effects of omega-3 responsible for their cardio-protective activity. In addition, anti-arrythmatic, anti-thrombotic, anti-atherosclerotic and anti-inflammatory activities are key mediators of cardiovascular effects of omega-3 fatty acids (Din *et al.*, 2004; Mozaffarian and Wu, 2011).

Curcumin

Curcumin, a non-flavanoid polyphenol, is the active ingredient of turmeric (*Curcuma longa* Linn). Turmeric has been effectively used as herbal remedy for many conditions in India, China and Middle Eastern countries over centuries. Curcumin is referred to as the '*holy grail'* of natural molecules as there is no other molecule known to exert such a wide array of health effects. Curcumin exhibits anti-cancer, anti-oxidant, anti-diabetic, and anti-inflammatory activities and neuro-protective properties. Curcumin has been demonstrated to improve cardiovascular, reproductive and gastrointestinal health (Aggarwal and Harikumar, 2009; Noorafshan and Ashkani-Esfahani, 2013). Curcumin has been reported to delay the onset and progression of cataract in experimental studies (Suryanarayana *et al.*, 2003; 2005). The biological effects of curcumin and their underlying mechanisms have been exhaustively reviewed by Krishnaswamy (2009). One of the hallmark biological effects of curcumin is its anti-inflammatory attributes. The anti-inflammatory activity of curcumin is attributable to its ability to down regulate lysosomal enzymes and PMNL aggregation, suppression of superoxide generation, suppression of inflammatory mediators such as eicosanoids, TNF-alpha, INF-gamma, IL1, MCP1 and suppression of NFkB pathway. With regard to cardio protective effects, suppression of serum cholesterol and triglycerides, increase in HDL-C and Apoprotein A1, inhibition of platelet aggregation, suppression of cycloxegenaseII and thromboxane A2

along with prevention of LDL oxidation appear to be the chief mechanisms (Krishnaswamy, 2009).

Poor bioavailability of ingested curcumin is a major impediment for full exploitation of therapeutic effects of curcumin. Animal studies show that 85% of curcumin is excreted in faeces with little or no urinary recovery. Interestingly, rate of curcumin metabolism is faster in man as compared to rats (Krishnaswamy, 2009). Many derivatives and formulations are being developed to improve the bioavailability of curcumin (Anand *et al*., 2007; Maiti *et al*., 2007; Shaikh *et al*., 2009; Sharma *et al*., 2005; Shoba *et al*., 1998; Yu and Huang, 2012). Use of piperine, a p-glycoprotein inhibitor (Bharadwaj *et al*., 2002), has been a popular practice that has led to dramatic improvement in oral availability of curcumin (Shoba *et al*., 1998).

Resveratrol

Resveratrol is a stilbenoid type of plant polyphenol produced in response to injuries. It is found in a variety of berries, particularly in the skin and seed of grapes. Red wine is a rich source of Resveratrol (Frémont, 2000). Resveratrol is noted for its multiple biological effects. In addition, it has been reported to be an oestrogen receptor agonist (Gehm *et al*., 1997). Antioxidant potential is an important attribute of resveratrol and determinant of biological activity. Antioxidant potential of resveratrol has been demonstrated using chemical *in vitro* models (Soares *et al*., 2003) and biological models (Kasdallah-Grissa *et al*., 2007; Kode *et al*., 2008; Lu *et al*., 2008; Sharma and Gupta, 2002; Sinha *et al*., 2002; Ungvari *et al*., 2009). There is evidence that the antioxidant activity of resveratrol may be mediated by activation of nrf2 pathway (Kode *et al*., 2008; Rubiolo *et al*., 2008). Resveratrol has been demonstrated to protect LDL from oxidative damage (Brito *et al*., 2002), a property which plays an important role in cardiovascular health. One of the most recognized biological effects of resveratrol is its ability to exhibit anti-cancer effects that interfere with important stages of carcinogenesis; namely, tumour initiation, promotion and progression. There is extensive data from pre-clinical studies and clinical studies that resveratrol may offer protection against different forms of cancer (Athar *et al*., 2007). In addition, there is sufficient evidence for cardio-protective (Agarwal *et al*., 2013; Bradamante *et al*., 2004; Gurusamy *et al*., 2010; Petrovski *et al*., 2011) and neuro-protective effects (Fukui *et al*., 2010; Jin *et al*., 2008; Lofrumento *et al*., 2014; Lu *et al*., 2008; Quincozes-Santos and Gottfried, 2011; Sakata *et al*., 2010; Virgili and Contestabile, 2000; Wang *et al*., 2004; Wu *et al*., 2011) of resveratrol in addition to its protective effect against insulin resistance and diabetes (Bagul *et al*., 2012; Bhatt *et al*., 2012; Pereira *et al*., 2015; Szkudelski and Szkudelska, 2011).

Quercetin

Quercetin (3,4,5,7-tetrahydroxyflavonol) is a naturally occurring polyphenol belonging to the class of flavonoids. It is usually found conjugated to sugars in various types of dietary sources such onions, apples, black and green tea, beans, grapes, berries, vegetables and fruits. Intake of quercetin is suggested to be associated with benefits against a wide range of human chronic diseases. Anti-oxidant and anti-inflammatory attributes are major determinants of the biological effects of quercetin. There is sufficient evidence that suggests that quercetin affords protection against certain types of cancer, inflammatory conditions, cardiovascular diseases, diabetes, and aging as well as aiding in bone formation (Boots *et al*., 2008; Coates *et al*., 2010).

Piperine

Piperine is an alkaloid found in black pepper and is responsible for the characteristic pungency of black pepper. Piperine is known for its anti-oxidant, anti-mutagenic, anti-cancer and anti-depressant effects (Srinivasan, 2007). Piperine is best known for enhancing bioavailability of drugs and nutraceuticals. Co-Q10, â carotene, curcumin, antibiotics are some examples of substances whose bioavailability is enhanced by piperine. This is explained on the basis of inhibitory potential of piperine against detoxification enzymes and inhibition of intestinal p-glycoproteins responsible for efflux of drugs (Patil *et al*., 2011).

Eugenol

Eugenol (1-allyl-4-hydroxy-3-methoxybenzene) is phenolic compound found in *Eugenia caryophyllata*, *Ocimmum gratissimum* and several other medicinal plants. It is known for exhibiting anti-mutagenic, anti-cancer, anti-fungal, anti-viral, anti-bacterial, anti-parasitic, anti-inflammatory (Charan Raja, 2015) and

anti-diabetic effects (Srinivasan *et al*., 2014).

Based on the evidence available from clinical and experimental studies, it is clear that food-derived nutraceuticals exert beneficial effects. These interactions maintain homeostatic conditions and offer protection against diseases and disorders by inducing an array of biological effects. Anti-oxidant potential, anti-inflammatory effects, anti-microbial outcomes, modulation of signalling pathways, and up-regulation of detoxification mechanisms are chief mediators of biological effects of nutraceuticals. A summary of biological effects of nutraceuticals is given in Table 2.

Regulations Concerning Functional Food

Legislations on Functional Foods

Japan was one of the few countries to realize the need for creating legislative regulations for functional foods very early. Functional food, in 1991, was given a formal legislative food category called *Foods for Specified Health Uses* (FOSHU). Effectiveness in clinical studies, safety in clinical and non-clinical studies, and determination of active/effective components are strict requirements as per law for food to be called Functional. In order to obtain a FOSHU designation, an application containing scientific evidence supporting the proposed medical or nutritional link, the suggested dose of the functional food, safety of the food, and descriptions of the food's physical/chemical qualities, experimental methods, and composition must be filed by the manufacturer. The process of taking approval typically requires a year and is subject to review by the Ministry of Health and Welfare (MHW) and local authorities. The completed FOSHU label contains: "the approved health claim; recommended daily intake of the food; nutrition information; guidance on healthy eating; a warning against excessive intake, if necessary; any other special precautions relating to intake, preparation or storage; and other information (Martirosyan and Singh, 2015).

Although Europe lacks a specific law for functional food, it categorizes food into conventional foods, modified foods, foods for special dietary use and medical foods. Owing to increase in interest in functional foods and their health claims, the European Union set up a European Commission Concerted Action on Functional Food Science in Europe (FUFOSE). This commission aims to develop and establish a science-based approach to the evidence needed to support the development of food products that can have a beneficial effect on an identified physiological function in the body, that can improve an individual's state of health and well-being and/or reduce the risk of disease. It supports the development of two types of health claims relevant to functional foods, which must always be valid in the context of the whole diet and must relate to the amounts of foods normally consumed.

Table 2: Summary of mechanisms and biological effects of important nutraceuticals

S.No.	Nutraceutical	Mechansims/Biological Effects
1	Omeg3 fatty acids	Anti-inflammatory action, activation of PPARα and PPARγ, interaction with G-Protein coupled receptors, and influence on membrane phospholipid content and fluidity. Neuroprotection, improvements in cardiovascular health, improvement of insulin sensitivity
2	Curcumin	Activation of AMP-activated protein kinase, inhibition of protein-tyrosine phosphatase 1B, activation of nrf2 pathway, anti-cancer, anti-oxidant, anti-diabetic, and anti-inflammatory activities and neuro-protective properties
3	Resveratrol	Activation of AMP-activated protein kinase, prevention of LDL oxidation, Anti-oxidant activity, anti-cancer attributes, cardio-protective effects, and anti-diabetic effects
4	Quercetin	Free radical scavenger, nrf2 activation, Anti-oxidant, topoisomerase inhibition, anti-cancer, cardio-protectant, anti-inflammatory and antidiabetic effects, modulation of drug metabolizing enzymes. Known to promote bone health.
5	Eugenol	Anti-mutagenic, anti-cancer, anti-fungal, anti-viral, anti-bacterial, anti-parasitic, anti-inflammatory, and anti-diabetic effects
6	Piperine	Anti-oxidant, anti-mutagenic, anti-cancer and anti-depressant effects. Best known for enhancing bio-availability of drugs and nutraceuticals via inhibiting p-glycoprotein mediated efflux.

1. TYPE A: "Enhanced function" claims that refer to specific physiological, psychological functions and biological activities beyond their established role in growth, development and other normal functions of the body.

2. TYPE B "Reduction of disease-risk" claims that relate to the consumption of a food or food component that might help reduce the risk of a specific disease or condition because of specific nutrients or non-nutrients contained within it (Diplock *et al*., 1999).

The United States does not have a formal definition for functional foods. However, the Food and Drug Administration (FDA) recently released guidelines for assessing health claims, entitled the "evidence-based review system for the scientific evaluation of health claims" with aim of systematically reviewing the health claims of foods (Martirosyan and Singh, 2015). Australia regulates products mainly as therapeutic or non-therapeutic. Therapeutic products are regulated at a national level under the coverage of the Australian Therapeutic Goods Administration (TGA) (Australian Government Department of Health and Ageing 2007c). Non-therapeutic products are handled at the local territorial or state levels. Most often, standards developed by the Food Standards Australia New Zealand (FSANZ) (Food Standards Australia New Zealand 2008b) are followed for regulatory aspects (Smith and Charter, 2011).

In India, the Food Safety & Standards Act, 2006, under Chapter IV, Article 22 deals with nutraceuticals, functional foods, dietary supplements and their regulation alongside products like novel foods, genetically modified foods, irradiated foods, organic foods, and foods for special dietary uses, and health supplements. In addition, Articles 23 and 24 address the packaging and labelling of food and restriction of advertisement for these foods (Keservani, 2014). As per this Act, foods for special dietary uses, functional food, or nutraceuticals or dietary supplements are

- The foods that are specially processed or formulated in order to satisfy particular dietary requirements that exist because of a particular physiological or physical condition
- Foods processed as such wherein the composition of the foodstuffs significantly differs from the ordinary food of comparable nature
- Such ordinary foods with one or more of the ingredients like plants or botanicals in the form of powder, concentrates, or extracts in water, ethyl alcohol, single or in combinations, minerals, vitamins, or proteins [amounts not exceeding recommended daily allowance (RDA)] or enzymes
- Dietary substance used by human beings to supplement the diet by increasing the total dietary intake.

It also says that a product that is labelled as 'food for special dietary uses' 'functional food' or 'nutraceuticals dietary supplements' can also be those which are not represented for use as conventional food and are formulated for oral administration in the form of powders, granules, tablets, capsules, liquids, jelly and other dosage forms but not parenterals. In fact, FSSAI has brought out new draft regulations on nutraceuticals, functional foods and supplements etc (*FSSAI Notification*, 2015). These regulations, which will be in place soon, attempt not only to define and differentiate these foods but also provide the labelling and advertising guidelines. Another salient feature of this regulation is that it recognizes specialty foods containing ingredients based on traditional health systems of India such as Ayurveda, Unani and Siddha.

Conclusion

In today's changing food scenario, the terms traditional foods, functional foods and nutraceuticals are often used interchangeably. There is a lot of scope for miscommunication if the subtle differences that underlie in these foods are not understood. In the context of many dietary supplements flooding the markets, it is often so common to confuse them and/or use synonymously with nutraceuticals/functional foods. It is not necessary that all traditional foods are functional foods. But it can be said that the common denominator for dietary supplements, nutraceuticals and functional foods is that they all are products designed to supplement the human diet by increasing the intake of bioactive agents that are thought to enhance health and well being. However, each term describes a different product category. Adequate scientific evidence and rational use of available scientific knowledge should form the basis for their choice, use and promotion for public health.

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