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A systematic review on functional foods-the food of 21st century

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Abstract
The present study the present study aims to investigate all about functional foods, genesis, definitions and meanings, health implications, therapeutic benefits, and food products developed from functional foods. Functional foods can be considered to be those whole, fortified, enriched or enhanced foods that provide health benefits beyond the provision of essential nutrients (e.g., vitamins and minerals), when they are consumed at efficacious levels as part of a varied diet on a regular basis. Linking the consumption of functional foods or food ingredients with health claims should be based on sound scientific evidence, with the “gold standard” being replicated, randomized, placebo-controlled, intervention trials in human subjects. However, not all foods on the market today that are claimed to be functional foods are supported by enough solid data to merit such claims. This review categorizes a variety of functional foods according to the type of evidence supporting their functionality, the strength of that evidence and the recommended intakes. Functional foods represent one of the most intensively investigated and widely promoted areas in the food and nutrition sciences today. However, it must be emphasized that these foods and ingredients are not magic bullets or panaceas for poor health habits. Diet is only one aspect of a comprehensive approach to good health.

Keywords: Functional food, benefits, definitions, health claims, therapeutic use, food products

Introduction
In the 21st century the new lifestyle adopted by people has changed their basic food leading to consumption of more processed foods which leads to a number of lifestyle disorders and onset of metabolic diseases due to improper nutrition. In recent years, a new diet and health paradigm is evolving which places more emphasis on positive aspects of diet focusing more emphasis and demand for foods with additional health enhancing properties. In developing country like India with the increasing urbanization, technological, industrial and economic advances, the demand for functional foods are also increasing rapidly.

In 1980, Japan’s Ministry of Health and Welfare initiated a regulatory system, Foods for Specified Health Use (FOSHU) for development and commercialization of the concept of functional foods that could legitimately be labelled and categorised as possessing specific health promoting or disease preventing properties. FOSHU defined Functional foods as “Any food or food ingredient designed to have physiological benefits and reduces the risk of chronic disease beyond basic nutritional functions, may be similar in appearance to conventional food and consumed as a part of a regular diet with additional function along with the maintenance of health”. Functional food are potentially rich in functional ingredients that includes carotenoids, dietary fiber, fatty acids, flavonoids, isothiocyanates, phenolic acids, plant sterols, polyols, prebiotics and probiotics, phytoestrogens, soy protein, vitamins and minerals. The Department of Health and Human Services, stated several potential health benefits of functional foods namely the ability to lower the incidence of cancer, cardiovascular diseases, reducing tumor incidence, lowering blood pressure, diminish the incidence of coronary and cardiovascular heart diseases, rate of fat absorption, delaying gastric emptying, supplying gastrointestinal bulk, irritable bowel syndrome, prevent obesity, diabetes, avoid colon cancer, and increase survival in breast cancer (Gupta *et al.*, 2012) [18].

In 2010, USDA reported that Functional foods includes cereals like sorghum, oats, little millet, buckwheat, Proso millet and pulses like chick pea and lentils that are rich in functional ingredients like phytonutrients especially flavonoids and total phenolic content etc. along with dietary fibre, antioxidants and trace elements which play a potential role in treatment of degenerative diseases and metabolic disorder by improving cholesterol-metabolism, preventing the oxidative damage of body tissues and DNA as well as regulation of blood sugar.

In 2018, ICRISAT under the UN sustainable development goal initiated the promotion of production and consumption of Neglected and Underutilized Species (NUS) as Future Smart Food (FSF), since they are environment friendly, nutrition dense and locally available. Sorghum and millets like pearl millet, finger millet, foxtail millet and pulses like chick pea, green gram, lentils, roots & tubers especially sweet potato are few FSFs which are rich in phytonutrients particularly phenolic compounds like phenolic acids, flavonoids, phytosterols and policosanols and antioxidant capacity along with dietary fibre and trace elements, that contribute to achieve the universal goal of 'Zero Hunger'. In 2014, the National food security mission cell has emphasized and highlighted the cultivation and consumption of underutilized cereals like sorghum, millet and pulses to improve the food availability and food security of the population and also to bridge the gap of protein energy malnutrition among the vulnerable group. Since 2013, WHO emphasis use of lesser known and underutilized cereals like sorghum for development of nutrient dense composite flour mix for fortified food products as it is superior to wheat and rice due to their higher levels of macro and micronutrients. Sorghum being the fifth most important cereal crop grown in the world and is considered to be nutritionally superior and one of the non-glutinous, non-acid forming food which is soothing and easily digestible (WHO, 1995) [62].

Therefore the present study aims to investigate all about functional foods, genesis, definitions and meanings, health implications, therapeutic benefits, and food products developed from functional foods.

Methodology

A systematic review of literature was performed as previously reported, to identify published studies, which investigated all about functional foods, genesis of functional foods, definitions and meanings, health implications, therapeutic benefits, food products developed from functional foods and association between them. A computerised search of the online databases was carried out using the terms 'functional foods', 'health implications of functional food' 'products developed from functional foods' and 'therapeutic benefits and advantages of functional foods'. The specific objectives of this systematic review are to collect relevant information on the role of functional foods and develop an analytical summary of current evidence of intervention impact and draft recommendations.

Results

Genesis of functional foods

In 1980, Japan's Ministry of Health and Welfare initiated a regulatory system, Foods for Specified Health Use (FOSHU) for development and commercialization of the concept of functional foods that could legitimately be labelled and categorised as possessing specific health promoting or disease preventing properties. FOSHU defined Functional foods as "any food or food ingredient designed to have physiological benefits and reduces the risk of chronic disease beyond basic nutritional functions, may be similar in appearance to conventional food and consumed as a part of a regular diet with additional function along with the maintenance of health". The term functional food was originally coined in 1989 by Dr. Stephen L. De Felice, founder and chairman of the Foundation on Innovation Medicine (FIM), Crawford, New Jersey. According to him "any food or part of food that provides medical or health benefits, including the prevention and treatment of disease and range from isolated nutrients, dietary supplements and specific diets to genetically engineered designer foods and herbal products". Consumer interest in relationship between diet and health has increased demand for information on functional foods (Alzamora, 2005) [66]. Cereal bran was probably the first functional food introduced in 1984 claiming chemo preventive benefits of dietary fibre against colon cancer (Dosset *et al.* 2011) [67].

In 2015, Martirosyan stated that functional food science originated from the collaboration of sciences and the public need. It is the melding on food science, nutrition, and medicine as it produces sustenance that crosses between food and pharmaceuticals. Specifically, researchers study food components and their beneficial health effects. They measure changes in health and homeostatic behavior through the use of biomarkers or "indicators" in the body. From this research, functional food scientists determine the health effects and proper/safe dosages of functional foods.

Functional foods are broad term coined to describe substances which are derived from the food sources that provide extra health benefits. They donot fall into the legal category of food and drug and often inhibit a grey area between the two. Functional foods consist of both traditional and non-traditional foods. Traditional foods are simply whole foods with new information about their potential health quality. There has been no change to the actual foods, other than the way the consumer perceives them. Many of the cereals and legumes, vegetable and root tubers, fish, dairy and meat products contain several natural components that delivers benefit beyond the basic nutrition. Non-traditional functional foods resulted from agriculture breeding or added nutrients or ingredients. Agricultural scientist are able to boost the nutritional content of certain crop through the same breeding techniques that are used to bring out other beneficial traits in plants and animals for e.g. Beta carotene enriched rice to vitamin enriched broccoli and soyabeans. Food formulated with nutrients or other ingredients include products such as orange juice fortified with calcium, cereals with added vitamins and flour with added folic acid. Health claims on functional foods serve to alert consumers to a food's health potential by stating that certain food or food substances, as part of overall healthy diet, may reduce the risk of certain diseases (Lockwood, 2018) [32].

Definition of functional foods

Institute of Food Technologists (IFT) in 2000 defines "functional foods" as: "substances that provide essential nutrients often beyond quantities necessary for normal maintenance, growth, and development, and/or other biologically active components that impart health benefits or desirable physiological effects.

In 2005, Alzamora defined functional foods affect beneficially one or more target functions in the body, beyond adequate nutritional effects, to either improve stage of health and well being or reduce the risk of diseases.

The International Life Sciences Institute in 2009 defines functional foods as "foods that, by virtue of the presence of physiologically-active components, provide a health benefit beyond basic nutrition".

In 2012 at the Functional food centre 10th International Conference in Santa Barbara, proposed definition for "functional food as natural or processed foods that contains known or unknown biologically-active compounds; which in defined amounts provide a clinically proven and documented health benefit for the prevention, management, or treatment of chronic disease.

Functional foods and its health implications

In addition, whole grains contain unique phytochemicals that complement those in fruits and vegetables when consumed together (Liu *et al.* 2007) [31]. Polyphenols are the biggest group of phytochemicals that have been found in plant based foods and have been linked to several health benefits. Therefore, dietary polyphenols have received tremendous attention among nutritionists, food scientists, and consumers due to their roles in human health (Tsao, 2010) [58]. It has been reported that soluble-and insoluble – bound phenolic extracts of several varieties of sorghum and millet and whole grains are rich sources of phenolic compounds and show antioxidant, metal chelating, and reducing power. However, the potential of whole grains as natural sources of antioxidants depend on the variety used.

Functional foods are the source of absolutely necessary nutrients providing more than the quantities required for maintenance, growth, and development. The term is specially retained for food or food components that carry the evidence to provide advantageous factors for health beyond basic nutrition. The functional foods contain biologically active ingredients associated with physiological health benefits for preventing and managing chronic diseases, such as type 2 diabetes mellitus (T2DM) and hypercholesterolemia. A regular consumption of functional foods may be associated with enhanced anti-oxidant, anti-inflammatory, insulin sensitivity, and anti-cholesterol functions, which are considered integral to prevent and manage T2DM along with other non-communicable diseases (Spano, 2010) [53].

A wide range of research studies have demonstrated thatfunctional foods prevents or delays high risk individuals through regular intake of functional foods and has high impact in glycemic control, blood pressure regulation, hypocholesteromic effect, activation of antioxidant enzymes, gut microbiota, and suppress over production of pro-inflammatory cytokines during diabetes. Additionally, the use of functional foods as a complement therapy for prevention and management of diseases has steadily increased over the past few decades as a means of promoting health and emotional well-being, and has been increasingly applied in cases where individuals seek relief of symptoms associated with chronic illness and other NCD's (Preuss 2009) [46].

In 2013 WHO/FAO stated that "Food security and right to food" can be achieved by utilization of underutilized cereals and legumes as they contain high quality protein, dietary fibre and other micronutrients and have been explored to have profound antioxidant and protective effect against cardiovascular diseases and diabetes and along with other numerous health benefits.

In recent decades, consumption of tuber crops has gained lot of interest and attracted huge attention since many epidemiological and biochemical studies have consistently demonstrated a clear and significant positive alliance between regular intakes of these natural food products and reduce rates of heart diseases, common cancers, ageing and other degenerative diseases. Similarly legumes also possesses similar functional qualities in human health when consumed regularly rather having high storage capacity than fruits and vegetables. Utilization of food grains depends on their physical and physicochemical characteristics. Millets are a group of highly variable small seeded grasses, widely grown around the world as cereal crops or grains for fodder and human food. Millets have substantive potential in broadening the genetic diversity in the food basket and ensuring improved food and nutrition security (Mal *et al.* 2010) [34] as they are nutritionally comparable or superior to major cereals and respect to protein, energy, carbohydrate, dietary fibre, phytochemicals and trace elements (Sehgal and Kwatra, 2003) [49]. Millets are important crops in the semi-arid tropics of Asia and Africa especially in India and Nigeria, with 97% of millet production in developing countries. Among all the eight millet species sorghum pearl millet finger millet, foxtail millet, kodo millet, proso millet, barnyard millet and little millet. Sorghum has been important staples in the semi-arid tropics of Asia and Africa for centuries because of the principal sources of energy, protein, vitamins and minerals for millions of the poorest people in these regions (Muriu *et al*,, 2002) [40]

In 2000, Carson stated that sorghum contain a protein namely prolamin (Kaffirin) which has a unique feature of lowering protein digestibility upon cooking whereas, the millets have a better amino acid profile. It has been reported that sorghum proteins upon cooking are significantly less digestible than other cereal proteins, which might be a health benefit for certain dietary groups. On the other hand, millets contain fewer cross-linked prolamins, which may be an additional factor contributing to higher digestibility of the millet proteins.

National Institute of Nutrition (ICMR) in 2010 [21] assessed Glycemic Index (GI) of sorghum based foods in collaboration with the Indian Institute of Millets Research, Hyderabad under National Agricultural Innovation Project (NAIP). The results revealed that sorghum based foods have low GI and reduces the postprandial blood glucose level, glycosylated hemoglobin. Another study also points to the fact that blood glucose level of nonobese patients with non-insulin-dependent diabetes mellitus (NIDDM), who consumed sorghum bran Papadi, showed considerable reduction in blood glucose levels.

Several studies King *et al.* 2000 [27]; Awika 2004 [6]; Carr in 2006 [68] have reported that sorghum is a good source of potassium, magnesium, iron, zinc, copper and is practically devoid of sodium. The percentage of available magnesium and iron content is higher in sorghum than any other cereals. Hence magnesium plays a central role in just about every bodily process, from the synthesis of DNA to the metabolism of insulin leading to decrease prevalence of NCD's like Alzheimer's, diabetes and heart disease. A study conducted by Bhaskarachary (2013) [9] on 160 boys and 160 girls aged between 9 to 12 y to receive 60% sorghum diet and 40% rice diet. Hemoglobin, serum ferritin, albumin, retinol binding protein and iron levels were improved in both genders, with an increase in serum folic acid and calcium levels in boys when the meal was replaced with 60% sorghum.

Legumes are known as a cheap source of protein and energy for rural populations in India. It has been reported that 23% to 70% of the population in some states of India suffers from protein energy malnutrition (PEM) and 17%to 54% from chronic energy deficiency (CED). Legumes seeds are the most important source of nutrients and can also serve as high quality dietary protein sources to meet human nutritional requirements. Legume seeds have an average of twice as much protein as cereals and the nutritive value of the proteins are usually high Legumes are normally consumed after processing, which not only improves palatability of goods but also increases the bioavailability of nutrients by inactivating trypsin, growth inhibitors and haemagglutinins (Tharanathan and Mahadevamma). Locally available legumes which are a good source of proteins but underutilized are *Lathyrus sativus* (Grass pea), *Vigna unguiculata* (Cowpea), *Cicer arietinum* (Chick pea), *Vigna radiate* (Moong bean), and *Cajanus cajan* (Pigeon pea). (Kalidass and Mohan 2012) [25].

Legumes provide a range of essential nutrients including protein, low glycemic index carbohydrates, dietary fibre, minerals and vitamins. Legumes are uniquely rich in both protein and dietary fibre. Legumes are particularly rich in low glycaemic index carbohydrates, resistant starch (RS), oligosaccharides (OS, mainly raffinose) and fibre (Munro, 2007) [39]. The RS, OS and fibre pass undigested through the stomach and small intestine until they reach the colon, where they act as “prebiotics” or “food” for the “probiotic” or beneficial bacteria residing there. Their bacterial fermentation leads to the formation of short-chain fatty acids, such as butyrate, which may improve colon health by promoting a healthier gut microbiome reducing the risk of colon cancer (Holland *et al*. 2010) [20]. They are also satiating which may help reduce food intake thus playing a potential role in weight management. Additionally, they can help moderate blood sugar levels after meals and improve insulin sensitivity. Legumes are significant sources of resistant starch, which are fermented by colonic bacteria to short chain fatty acids. These fatty acids act locally within the gut improving colonic health and reducing the risk of bowel cancer. They are also absorbed into the portal circulation where they favorably affect glucose and lipid metabolism in the liver (Li *et al*. 2014) [30].

Joshi *et al*. in 2006 [24] focused on the importance of Khesari dal (*Lathyrus sativus* L) as it is known to be highly nutritious and are good sources of carbohydrates, proteins, minerals and vitamins and are of immense economic significance, especially in developing nations including India, Bangladesh, Pakistan, Nepal, and Ethiopia. Protein in khesari dal is rich in limiting amino acids methionine and tryptophan. The seeds are also rich in other amino acids including valine, tyrosine and lysine (Khadka and Acharya, 2009) [26]. The seeds contain vitamins such as thiamine, riboflavin, niacin and ascorbic acid.

Xu Y *et al*. in 2014 [65] stated that the nutritional quality of legumes may be affected by anti-nutritional factors like trypsin, growth inhibitors and haemagglutinins content. These factors reduces the digestion and absorption of nutrients or interfere with the action of absorption of nutrients. Traditional food preparation techniques such as soaking, boiling, sprouting and fermenting not only improve flavour and palatability of legumes but also increase the bioavailability of nutrients, by deactivating anti-nutritional factors. Legumes contain several phenolic compounds (in addition to glutathione and tocopherols) which protects against some cancers.

In 2012, Bansal [7] *et al*. stated that legumes are nutrient dense with low energy density. Legumes are a good source of B vitamins, iron, zinc, calcium, magnesium, selenium, phosphorus, copper and potassium, but are a poor source of fat soluble vitamins and vitamin C. They are generally low in fat and have no cholesterol (being an animal sterol). Soybeans and broad beans are the exception, with significant levels of mostly mono- and polyunsaturated fatty acids, including alpha-linolenic acid. 2012). They are a good source of linoleic (21%-53%) and alpha-linolenic acid (4%-22%) (Reddy *et al*. 2012) [69] Chickpeas have the highest monounsaturated fatty acid content (34 g/100 g), butter beans have the highest saturated fat content (28.7 g/100 g) and kidney beans the highest polyunsaturated fat content (71.1 g/100 g).

Veny (2011) [59] revealed that the crude fibre content of raw Khesari dhal were higher than other underutilized legume dhals. It is often broadcast-seeded into standing rice crops one or two weeks before the rice harvest. This allows grass pea to effectively exploit the residual moisture left after the rice harvest. Grass pea holds tremendous potential as a functional food to improve health conditions associated with cardiovascular disease, hypoxia, and hypertension (Rao *et al*. 2011) [48]. Importantly, patents have been granted based on ODAP (as a hemostatic agent) in the USA and China, and an increasing number of therapeutic applications derived from Lathyrus may be developed in coming years. Further, as highlighted by Singh and Rao in 2010 [72], ODAP is increasingly being used for therapeutic purposes owing to its role in the stabilization of hypoxia inducible factor-1 (HIF-1). In short, the evolving view of grass pea as a functional food is likely to cause a dramatic shift in the ways pulses and lathyrism are perceived.

The sale and storage of Khesari dal has been banned due to higher presence of harmful chemical called ODAP (Beta-N-oxalyl-a, Beta-diaminopropionic acid), which causes an irreversible motor neuro disorder called neurolathyrism. However, the food safety regulator FSSAI has sought Health Ministry approval to hold public consultation on approval of three new khesari dal varieties -- Ratan, Prateek and Mahateara -- having low ODAP. These three varieties have been released for general cultivation in traditional Khesari growing areas of the country. ICAR is trying to replace the traditional high ODAP containing varieties of Khesari with its improved varieties (Rao *et al*. 2011) [48].

According to Lima *et al*. 2017 the legume diet reduces cardiovascular risk considerably more than the whole wheat diet, owing mainly to a decrease in blood pressure: Compared to no blood pressure change on the whole wheat diet, on the legume diet, systolic pressure dropped from an average of 122 to 118 points and diastolic pressure dropped from an average of 72 to 69, corresponding to a roughly 1% decrease in the 10-year risk of heart attack or stroke. Furthermore, the legume diet significantly lowered average total cholesterol and triglyceride levels.

According to National Health and Medical Research Council, Australian Dietary Guidelines. 2013. “Legumes are the star performers for blood glucose control” As a high fibre, low glycemic index (GI) source of protein, legumes make an excellent choice to include for the dietary management of blood glucose control. Legumes have been shown to improve short-term blood glucose control, and as part of a low GI diet are linked to long-term improvements in HbA1c and reduced risk of type 2 diabetes. The main mechanism by which legumes moderate the glycemic response is due to the nature of the starch in legumes which is encapsulated and is higher in amylose than grains. This means it is less likely to be fully gelatinised during cooking which reduces the rate of starch digestion and therefore the glycemic response. It has also been proposed the protein in legumes stimulates insulin secretion, facilitating a more rapid extraction of glucose from the bloodstream into cells compared to other carbohydrate foods. Legumes particularly chickpea, grass pea, beans and peas also reduces the risk of diabetes through the second-meal effect. The second meal effect is the ability of legumes to lower both postprandial glycemia after the meal at which they are consumed and also at a subsequent meal later in the day or even on the following day.

A study published in the "American Journal of Clinical Nutrition (2003)" concluded that a high-protein diet from legumes helped lower blood glucose levels and exerts hypolipidemic effects after eating and improved overall blood glucose control in people with Type 2 diabetes. Test individuals on the high-protein diet had a ratio of protein to carbohydrates to fat of 30:40:30, compared to 15:55:30 for the control group. Both groups consumed the diet for five weeks.

Sweet potato features among the top seven staples in the world, following wheat, rice, maize, potato, barley and cassava. Sweet potato is a major source of carbohydrate for millions of people, especially in developing countries. It is grown for its edible tuberous roots which contain about 27 per cent carbohydrate and high concentrations of vitamin A and C, calcium and iron. Sweet potato (*Ipomoea batatas* L.) is one of the most important root crops globally. It is considered an important, versatile and underutilised food security crop (Le Bot, 2009) [28]. Sweet potatoes have been ranked number one in nutrition out of all tuber crops by the Centre for Science in the Public Interest, USA because they are a rich source of dietary fibre, natural sugar, complex carbohydrates, protein, carotenoids, vitamin C, iron and calcium. It represents the second most important set of food crops in developing countries (Le Bot, 2009) [28]. It is highly nutritive, and it outranks most carbohydrate foods in terms of vitamin, mineral, dietary fibre and protein content (Mukhopadhyay *et al.* 2011) [38]. It is one of the crops that can be used to combat malnutrition in developing countries.

A wide range of research studies have reported about the medicinal properties of sweet potato polyphenol-rich extracts reported to play a role in reducing prostate cancer (Neupane *et al*., 2011) [43]. In 2000, Graham reported that flavonoid compounds of tuber crops are considered as therapeutic agents since they have beneficial health effects such as their supposed protection against certain cancers, cardiovascular diseases and aging. This suggests that sweet potato may possibly have some nutraceutical benefits which are still an aspect that need further investigation in South Africa. It would also need to be investigated if and how drought alters these properties since phenols and flavonoids are reported to increase in response to stress. Orange-fleshed sweet potato has been reported by several authors to contain high amounts of vitamin A and is currently being promoted by the Food and Agriculture Organization (FAO) and other in-country programs as a supplementary food to combat vitamin deficiencies in children of developing countries. (Amagloh *et al*. 2011) [73].

Research done by many studies indicates that Sweet potato is popular for its low fat diets and is recommended as a low glycemic index (GI) food, which release glucose very slowly into the bloodstream. Other research shows that sweet potatoes can help regulate blood sugar because of their ability to raise blood levels of adiponectin, a protein hormone created by fat cells, to help regulate how body metabolizes insulin. Several studies have reported that (Miyazaki *et al*. 2005) [36] the phytochemical isothiocyanates present in sweet potato inhibits the breakdown of glucose molecules and hence the level of blood glucose in the blood gets reduced. Also, the oral anti-diabetic activity of this extract was comparatively higher than that of Diabenese - a drug of choice to treat diabetes. People with diabetes tend to have lower levels of adiponectin and sweet potato extracts have been shown to significantly increase adiponectin levels in persons with Type II diabetes. In a study involving rats to determine sweet potato's effects on several markers of diabetes, sweet potato showed significant abilities to decrease some of the more harmful markers. The Experimental animals showed impressive improvement in pancreatic cell function, lipid levels, and glucose management. They also showed decreased insulin resistance in just eight weeks. Improved insulin sensitivity was also observed in a human study when sweet potatoes were added to the diet.

A recent report by the FAO (2010) [15] indicated that 24.8% of the population in Sub-Saharan Africa remained undernourished and agricultural projects (crops) that can deliver quick results were needed to meet the millennium goal number 1 (MGD1) targeted for 2015. Sweet potato can be used as a quick turnover crop due to its wide ecological adaptation, drought tolerance and a short maturity period of three to five months. It can also be harvested sequentially thus ensuring continuous food availability and access, an important dimension of food security. They also stated that good health is considered as an outcome indicator for food utilization in food security measurement, and the high nutritional status of sweet potato qualifies the crop as a food security alternative. Improved early maturing cultivars are often ready for harvest in 3 – 5 months and can be harvested as needed over several months. The benefit of harvesting early and consuming over several months implies that there is a quick turn-over and lasting source of food, therefore improved food access, availability and stability. The food security benefits of sweet potato mentioned above can also lead to the crop being removed from the 'underutilized' category since it would have caught the eye of the consumers and will be utilized accordingly (Asis, 2004) [4].

Flax (*Linum usitatissimum*) is an annual plant of the Linaceae family and is emerging as one of the key sources of phytochemicals in the functional food arena. In addition to being one of the richest sources of a-linolenic acid oil and lignin, flaxseed is an essential source of high-quality protein and soluble fibre and has considerable potential as a source of phenolic compounds. Specifically flaxseed contains good amount of a-Linolenic Acid (ALA), omega-3 fatty acid, protein and dietary fibre and lignin, specifically Secoisolariciresinol di glucoside (SDG) which is a lignin derivative antioxidant. Several studies reveal that these components work well for nutritional benefit in Human being. ALA is beneficial for infant brain development, reducing blood lipids and cardiovascular diseases (Prasad 2002) [45].

Flaxseed is a rich source of dietary fiber (accounting 28%), both soluble as well as insoluble fibers (Morris, 2007) [37]. Soluble fiber and other components of flaxseed fraction could potentially affect insulin secretion and its mechanism of action in maintaining plasma glucose homeostasis. Lignans have antioxidant activity and thus may contribute to the anticancer activity of flaxseed. Flaxseed dietary fibre exhibits positive effect to reduce constipation, to keep better bowel movement and as hypocholestermic agent. SDG have antioxidant activity and free oxygen radical scavenging activity (Ganorkar and Jain, 2013) [16]. Dietary fibres have been used extensively both as pharmacological supplements, food ingredients, in processed food to aid weight reduction, for glucose control in diabetic patients and to reduce lipid levels in hyperlipidemia. Flaxseed flour is high in omega-3 fatty acids, which have been shown to reduce hypertension, cholesterol and triglyceride level (Butt *et al*. 2008) [12].

The flaxseed protein was also found to be effective in lowering plasma cholesterol and triacylglycerides (Bhathena *et al*. 2003) [10]. Flax contains polysaccharides (other than starch) which, due to their anti hypercholesterolemic, anti-carcinogenic and glucose metabolism controlling effects, may prevent or reduce the risk of various important diseases, such as diabetes, lupus nephritis, arteriosclerosis and hormone dependent types of cancer (Williams *et al*. 2007) [63]. Lucas *et al.* (2002) [33] found a reduction of cholesterol in the plasma and arterosclerotic lesions after the incorporation of flax mucilage and ã-linolenic acid into diet.

According to Cintra *et al.* (2006) [14], the studies on lipid profile of male Wister rats fed on high fat diets like flaxseed and trout (sources of polyunsaturated fatty acids), peanut (source of monounsaturated fatty acids) and chicken skin (source of saturated fatty acids) indicated that total cholesterol levels in rats fed on flaxseed diet were lower than in rats fed on the other fats. Alpha Linolenic acid (ALA) from flaxseed exerts positive effects on blood lipids. The flaxseed protein was also found to be effective in lowering plasma cholesterol and triacylglycerides (Bhathena *et al*. 2003) [10].

In 2000, Payne discussed the dietary intake of flax seeds in bakery products, as a source of phytoestrogenic lignans. Aspects considered included concentration of lignans in flax seed flour and milled flax seed, health benefits of lignans in postmenopausal women, anticancer activity of lignans, mineral and vitamin composition of flax seed; appearance and flavor of flax seeds; use of whole and milled flax seeds in bakery products. Sturgeon *et al*. (2007) [55] studied the effects of flaxseed on serum sex hormones implicated in the development of breast cancer. Flaxseed is a rich source of dietary lignans. Experimental studies suggested that lignans may exert breast cancer preventive effects through hormonal mechanisms. Results suggested that dietary flaxseed may modestly lower serum levels of sex steroid hormones, especially in overweight/obese women.

Rabetafika *et al.* (2011) [47] reviewed food uses and health benefits of flaxseed proteins. Flaxseed proteins are potent multi-functional ingredients for food formulation owing to their techno functionalities, food preservation capacity, and health benefits. A possible synergistic effect with mucilage on their functionalities could be valuable even though this co-product in flaxseed may limit the protein yield during their production processes. Their techno functional properties could also be considered in mixture with other flax bioactive components such as lignans and fiber to enhance the value of the flaxseed meal. New perspectives according to consumers demand for products with health promoting bioactive components were also suggested.

Therapeutic benefits of functional foods

The alarmingly rapid increase in the incidence of NCD's raises concerns together with metabolic syndrome among different population. Diet together with physical exercise plays a major role in preventing the onset of chronic conditions such as metabolic syndrome. The food industry has already reacted to this challenge and a number of products have been either reformulated or re-positioned to meet the current need for healthier foods. Thus a functional food with health promoting or disease preventing property beyond the basic function of supplying nutrient is the current need (Nehir, 2002) [42].

There are obstacles in developing functional foods is that many consumers are suspicious of eating highly processed foods with a long list of ingredients and additives. Thus functional foods need to be healthy, tasty, convenient and natural (Hardy, 2009) [19].

In Asian countries, many types of foods have been traditionally been associated with specific health benefits. Folk medicine, East and West depend on functional foods. During the first 50 year of the 20th Century scientific focus was on the identification of vitamins and their role in the prevention of various dietary deficiency diseases (Sethi 2008) [50]. Scientist suggested consuming a diet that is low in saturated fat, high in vegetables, fruits, whole grains and legumes to reduce the risk of chronic diseases such as heart disease, cancer, osteoporosis, diabetes and stroke at the same time scientists also began to identify physiologically active components present in food from plants and animals known as phytochemical that potentially could reduce risk for variety of chronic diseases. Experts from different countries realized that besides being able to lower the cost of healthcare, functional food might also give a commercial potential for the food industry. There is widespread recognition that diet plays an important role in the incidence of many diseases. Functional foods can help to prevent chronic disease or optimize health, therefore reducing health care costs and improving the quality of life. Functional food products cover a wide variety of food components. Now, extensive research is currently directed toward increasing our understanding of functional foods and development of therapeutic products (Goncalves, 2012). Shading and Jaganatam in 2014 developed millet based biscuits rich in calcium, dietary fibre, polyphenols and protein. Millet based biscuits are gluten-free, and are an excellent source for people suffering from celiac diseases and also rich in phytochemical which helps to lower cholesterol level and reduced cancer risk and potentially lowers blood glucose level.

Patil *et al.* in 2014 developed biscuits using composite flour of sago, peanut, banana, potato, foxtail millet, barnyard millet in different proportion. These biscuits showed a potent blood glucose lowering effect and thereby beneficial for diabetic population.

Shiny and Shelia in 2012 also developed sorghum based high fibre roti. It contains a very good amount of fibre (13.21 g/100 g). The high soluble dietary fibre content has been found to reduce gastric emptying and absorption of glucose after a meal, resulting in improved glucose tolerance. The soluble dietary fibre component has been reported to decrease the activity of digestive enzymes, thus resulting in incomplete hydrolysis of carbohydrates, protein and fats and delaying absorption and potentially lowering blood glucose level.

Thathola *et al*. 2003 [57] developed foxtail millet (*Setaria italica*) for diabetics and conducted case control clinical trial on 30 type 2 diabetic patients and concluded that foxtail millet as a low G1 food product leads to modest improvement in long-term glycemic and lipidemic control in Type II diabetics. Sorghum plays a potential role in treatment of diabetes by improving cholesterol-metabolism. They recorded significant reduction in serum cholesterol (6%), serum low density lipoprotein (LDL) cholesterol (20%) and a slight decrease in serum triglyceride and very low density lipoprotein (VLDL) cholesterol after supplementation of low glycemic index (GI) sorghum flour based biscuits. Serum high density lipoprotein (HDL) cholesterol increased significantly by (23%). Therefore, sorghum is suitable in diabetic diet to improve metabolic control of body functions.

Anju and Sarita in 2010 developed low glycemic index biscuits from sorghum and barnyard. The sorghum flour biscuits had higher content of crude fibre, total ash and total dietary fibre and low glycemic index and thereby helpful for diabetic population to maintain a healthy blood glucose level.

In 2010 Lee *et al*. investigated the impact of flour of Proso millet, foxtail millet and sorghum on lipid profiles of hyperlipidemic rats compared to those resulting from a white rice diet. Study revealed that the concentrations of serum triglycerides were significantly lower in the sorghum and Proso millet compared to those of foxtail millet and white rice.

Food product development

Food is the basic necessity of life. Worldwide consumers are becoming more interested in the relation between food and health. The growing awareness of the consumer combined with scientific possibilities, gives the functional food industry the opportunity to develop a wide variety of new functional food concepts. At this moment, the functional foods on the market can be divided into three main categories (Verduijn, 2004) [60]. The first category consists of functional foods of which the producers claim that the consumption of these foods have a positive effect on human health and reduces the risk of certain diseases. Diseases for which functional foods are developed include cardiovascular diseases, cancer, obesities and diabetes. There are various ways of producing novel food products providing health benefits: by fortifying existing products with additional nutrients, by adding nutrients or enriching and by replacing some potentially harmful or undesirable constituents by more beneficial components or with enhanced content of certain compounds with health benefitting properties, so called as altering (Spence, 2006) [54].

The second category of functional foods claims that the consumption of these foods has a positive effect on the physical and mental wellbeing. It is reported that food with high concentrations of carbohydrates enhances sleep and have calm down effect. Sucrose could diminish stress feelings of children and specific food ingredients are such as choline, caffeine and specific amino acids enhances the cognitive performance (Ashwell, 2002) [3].

The third category consists of sport functional foods which improve physical performance and recovery. They also often use energy drinks, developed from malted cereals and legumes e.g. AA Energy Drink, Extran energy (Ashwell, 2002) [3].

Functional foods are also designed to reduce health related problems like high cholesterol, high blood pressure, high blood sugar etc. The most important and popular functional food products are traditional homemade foods like Indian bread, bakery food items like cookies and bread and confectionary items like ladoo which are designed to cater the needs of the different segment of the population for promoting better health (Wolfart *et al*. 2008) [64].

In 2011, Arora *et al*. prepared products like laddu and chakki from yellow sorghum as a base and they incorporated legumes and fenugreek seeds. These food products prepared from mix showed hypoglycemic effect in human volunteers. The data revealed that proximate composition of yellow sorghum based food products revealed that of all the food products, laddu contained the highest amount of protein. A non-significant difference was observed in total crude fibre content of the products prepared from Unmalted and malted sorghum.

Another study conducted by Asma *et al*. in 2006 [5] studied development of Paratha from sorghum flour supplemented with legumes and oil seeds. Results showed that, legumes and oil seeds can be effectively used in sorghum based traditional food items as an acceptable protein and mineral supplement. The process parameter and formulations developed in this study showed that the paratha was high in protein and energy with acceptable functional and sensory characteristics, as well as excellent nutritional quality.

Murugkar *et al*. 2015 [41] have prepared a nutrient dense Ladoo with flours from corn, whole wheat, malted finger millet sprouted whole green gram, soy protein isolates, unsalted roasted peanuts, dairy whitener and dried papaya in different proportions to develop a multi-nutrient food. The developed Ladoo was compared with traditional Bengal gram flour Ladoo as control, in terms of nutritional, particle size and rheological properties. The developed Ladoo was superior to the control porridge in all aspects.

Bhaskar *et al*. 2001 [8] conducted a study on biological evaluation for protein quality of Indian bread based on germinated cereals and legumes suitable for feeding rural mothers and children in India. Eight different formulations of Indian bread based on germinated cereals (Wheat, ragi, bajra and sorghum) and legumes (soy and Bengal gram) were prepared. When these blends were evaluated for Crude protein and Net protein utilization (NPU), it was found that incorporation of legume soy plays a significant role as a supplementary protein in diets of cereal predominance to meet consumer expectations.

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