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RESEARCH ARTICLE

DESIGNER CROP-BASED FOODS AND THEIR POTENTIAL HUMAN HEALTH SYNERGIES: AN OVERVIEW

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ABSTRACT

During the past decade the knowledge of dietary influence on health and wellbeing has amply been increased and often related to some food components. To ameliorate specific nutritional disorders, designer foods have been ad vented way back in 1980.Designer foods are the processed or fortified foods with potential health promoting food ingredients, which are normal foods consumed daily. The designer food approach is one of the best and low-cost strategies to reduce micronutrient deficiencies among people, because it can deliver recommended allowances of nutrients regularly. These foods are developed by the process of fortification or bio-fortification. The demand, regulatory status and the potential health benefits in alleviating life style and chronic disorders with designercrop-based foods are reviewed in this communication. In developed and developing countries, the designer foods played a major role in improving the diet and eliminating life style and chronic disorders and nutrient deficiencies among people. Designer oils fortified with omega 3-n long chain PUFA are produced by bio-technological methods like transgenic plants have health value. Designer rape seed oil and sunflower oil can alleviate lipid profiles in hyper tension and obesity patients. Designer vegetables like broccoli sprouts and cereals like fermented rice with monascus have reported to have antioxidant and immune- modulator activity in diabetes and hyper cholesterol patients. Cereals like rice, maize, wheat etc are fortified with beta carotene (Golden rice), iron, zinc, lysine and tryptophan as fortified foods are developed and available now in the market. Polyphenol fortified rich foods like tea are proved to have potential health benefits. As of now, designer foods are completely safe but fortification or bio-fortification should be done rationally at less than one third of the total recommended daily allowances of nutrients and they should be strictly regulated with stringent quality control measures to ensure safety and acceptance before releasing into the market. Ultimate success of designer foods depends on creating adequate awareness among people about their health benefits through national and international programs as well.

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INTRODUCTION

Designer foods also termed as functional foods or fortified foods or genetically modified foods are synonymously used to denote foods that are, designed to have health benefits other than its nutritional value. The term "designer food" was coined in Japan in 1980 for referring to processed foods containing nutrients having some health befits in addition to its own nutritional value (Arai, 1996). Health Canada (1998) defines designer food as "a functional food containing bioactive compounds, similar in appearance of its conventional foods that is consumed as part of a usual diet and is having some physiological benefits and reduce the risk of chronic diseases". The institute of medicine and nutrition board (IOM/NAS, 1994) defined designer food as "any food or food ingredient that may provide a health benefits beyond the traditional nutrients it contains". During the past decade the knowledge of dietary influence on health and wellbeing has tremendously increased and often related to some specific food components. Based on the present knowledge, we are now in a better position to design new and healthier foods reducing the risk of several chronic or infectious diseases. Designer foods included a variety of foods and food components believed to improve health and wellbeing, reduce the risk of specific diseases or minimise the effects of other health concerns (IFIC, 2011:

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FAO, 2004). Designer foods are developed by fortification or nutrification of conventional foods. Genetically modified foods containing higher than normal amounts of health promoting nutrients and fermented foods with live cultures of microorganisms (probiotics) are also considered as functional foods. Infant foods may be considered as first designer foods as they contain specific nutrients for the development of brain and immune system in children. The use of probiotics and nucleotides to enhance immune response in sportspersons are important examples of designer foods (Rama Prasad *et al*, 2015). Folk medicines used in various countries like China, Japan and India has the tradition of using fermented foods for health benefits, which include red wine, yoghurt, tempeh, red yeast rice etc. (Rajasekaran and Kalaivani, 2013).

Demand for designer foods

Currently the demand for designer foods or functional foods are focused in developed countries of the world and especially in high income groups in the developing countries ,because they are considered as expensive. Research is being been carried out to make it affordable especially for the poor. There is growing research on application of biotechnology in the development of designer foods for improved health effects of the staple foods in the developed countries including high iron and vitamin A fortified rice, improved oil and protein content in legumes and soybean and orange fleshed sweet potatoes (Niba, 2003). Some developing countries like India and China have been considering designer foods as part of their plan to alleviate malnutrition especially in children. In China, about 3000 varieties of designer foods are available and widely accepted among consumers. In Austria, there are about 470 fortified products are available commercially.

In China the centre for Public Nutrition and Development has proposed that essential commodities /consumables such as salt, flour, edible oils baby foods, soybean etc. should be fortified to solve malnutrition problem in poverty-stricken regions. In India, food companies have introduced specific products with vitamin–A at affordable prices (Japan development institute, 2006) .In developing countries, because of prevalence of poverty, high rates of malnutrition and escalating rates of diet related diseases, designer food market provide an opportunity to improve public health and also can generate employment and income to the people in supply chain (Manjula and Suneetha, 2011). Designer food approach is one of the best and major strategies to reduce micronutrient deficiency in developing countries, which can be done systematically to reach entire population. Best example for commonly used designer food is iodized salt, which is widely used by the population and had eliminated iodine deficiency and its related disorders.

The success of the drive for universal iodization of salt shows that the diets of children, women and families world-wide can be changed in small but very beneficial ways in just a few years as a result of concerted global, national and local action (UNICEF, 2005). The success of iodine fortification of salt leads to supply of other nutrients through designer food approach such as vitamin D and calcium fortified milk for bone health, folic acid fortified cereals, sterols fortified yoghurt, margarine, chocolate, cheese and juice in the management of cholesterol, iron fortified milk, salt and condiments for management of Anaemia, in many parts of the world including China, Japan and India Earlier experience in designer foods indicate that fortification of food is completely safe but it should be done rationally i.e. it is usually less than one third of the total recommended daily allowances (RDA). It should be strictly regulated with stringent quality control measures to ensure that there is no excessive intake of specific nutrients.

Global market

According to the global market surveys the demand for designer foods is very large and growing at rapid pace. The global market estimates has been upto73 billion pounds and at annual growth rates of 8-16% (Manjula and Suneetha, 2011). Since the late 1990s, global designer food sector has experienced phenomenal growth (50-60% in value sales over a five year period) and is expected to continue at a slightly slower pace over the next few years (Data monitor, 2005). The indicated growth rates are significantly higher compared with the 2% annual growth rates for the food sector as a whole (Menrad, 2003). Benkouider, (2005), concluded that growth forecast for main emerging markets as group (Hungary, Poland, Russia, Mexico, Brazil, China and South Korea) are similar to the global market. Dairy products represent the highest value sales (39-56%), followed by functional confectionaries, soft drinks, bakery and cereal foods (Benkouider, 2004). India ranks among the top ten nations in buying designer foods, with its strong tradition of healthy eating habits (Watson, 2006). India's nutrition industry is generating 6.8 billion US dollars in annual revenue and that value is expected to be nearly doubled in the next five years (Ismail, 2006). As per Japan development institute (2006) estimates the functional food industry in India is strong and growing with the aim of becoming a major force in the international health food market. The government of India is working hard and fast at shoring up its intellectual property rights law and food legislation (Ismail, 2006). There exists unanimity among the major companies and also research organizations are also behind this idea (Shrimpton, 2004).

Potential health benefits of designer foods

Potential health benefits of allied designer or functional foods are summarised here under.

Role of designer foods in alleviating life-style disorders

Life style disorders are non-communicable and are associated with the way people live and behave. As per world health organization (WHO) fact sheets, life style disorders like cardiovascular diseases, diabetes, obesity, cancer, osteoporosis, respiratory diseases and gastrointestinal disorders accounts for 59 per cent of the 56.5 million deaths annually and 45.9 per cent of the global burden of diseases (WHO, 1998). Several food components are emerging as factors capable of modifying growth, development and disease resistance. The modern fast food culture, stressful living and sedentary lifestyle have elevated the demand for designer foods. Obesity is the major public health concern affecting all people and main contributor for global ill-health (WHO, 1998).

Functional foods for obesity should be able to control energy intake or energy dissipated as heat. So functional foods for obesity control should also include foods that affect the glucose-insulin homeostasis and ameliorates the risk of collateral illness such as diabetes or cardiovascular diseases (Palou, 2007).Cardiovascular diseases accounted for 20 per cent of all worldwide deaths annually. Consuming a diet rich in natural antioxidants like Vitamin-E and C, Polyphenols, Carotenoids mainly Lycopene and beta carotene, which are of special interest in preventing or treating cardio vascular diseases (Kaliora *et al.*, 2006). Possible ingredients for the development of designer foods that could contribute to optimal immune response include anti-oxidant vitamins, trace elements (Zn, Cu, Mn), n-3 and n-6PUFAs, L-arginine, nucleotides, Probiotics, Prebiotics and Synbiotics. Probiotics (*Lacto bacilli*) and Prebiotics (Inulin and its hydro lysate oligo-fructose are recent concepts and in the future will be used to support the development of designer foods targeted towards the gut infections.

Approaches to designing functional foods

Health benefits are associated with different nutrients present in the diet. Such knowledge can be used to design functional foods to achieve health benefits using different technical approaches, and they include the following:

Product formulation

It consists of incorporation of functional ingredients into designer foods, like nutrification or fortification or reformulation to increase levels of some ingredients such as bran or fibre and adding newer novel ingredients like probiotics, phyto chemicals etc. andalso to reduce the level of harmful components like oils,

Novel processing

Novel processing techniques like extrusion cooking, fermentation by heat or addition of some enzymes or by any processing techniques to improve nutrient availability in the foods can be used with benefits.

Modification of raw materials

More recently, the advent of genetic engineering approaches has led to the development of wide range of genetically modified (GM) foods and crops with enhanced functional components like altering fatty acid profiles, iso-flavine contents etc.

Bio-fortification

There is extensive research on application of biotechnology in the development of designer foods for improved health effects of the staple foods in the developed countries including high iron and vitamin A fortified rice, improved oil and protein content in legumes and soybean and orange fleshed sweet potatoes (Niba, 2003). Designer foods are also developed from transgenic plants and animals.

Safety and global regulatory status

Since the functional ingredients are added to designer foods, it should be approved for its use in foods either by a food additive petition or by obtaining generally recognized as safe (GRAS).However, functional ingredients are biologically active and may therefore produce a wide range of outcomes in the body at various intake levels. To predict the consequences of exposure at the various dose levels, understanding the mechanisms of pharmacological activity as well as toxicological potential of ingredient to be included is important. In order to determine the safe levels of inclusion of functional foods in designer foods, scientific knowledge is essential. Many countries have most stringent regulations for designer foods manufactured and imported into their country for its sale, like Food and Drug Administration (USFDA) in the USA (Anon, 2010), Health Canada for Canada (Health Canada1998), European Food Safety Authority for European Union (EFSA, 2002), The State Food and Drug Administration for China (SFDA), Food Safety and Standards Authority of India (FSSAI) and Ministry of Food Processing Industry (MOFPI) (FSSAI, 2006) for India and Ministry of Health, Labour and Welfare for Japan (MHLW). Only Japan is having specific regulatory approval process for designer foods.

In USA, designer foods or functional foods are gaining greater importance, due to their role in disease prevention and health promotion. USFDAs Dietary Supplement Health and Education Act of 1994 (DSHEA) regulates only the dietary supplement or dietary ingredient but not designer food, but health claims may be made for foods and dietary supplements in accordance with the 1990 Nutrition Labelling and Education Act (NLEA) and the 1994 DSHEA, an amendment to the Food, Drug and Cosmetic Act, Department of Health and Human Services and the Department of Agriculture and from the National Academy of Sciences or any of its subdivision s (USFDA). According to NLEA, health claim represents the relationship between a nutrient and a disease or medical condition that is related to the diet. The European regulatory has the Food Safety Act 1990 (FSA), subsequent primary and secondary legislation and codes of practice ensure that food placed on the market is safe and that any information provided about the product is not misleading. European regulatory includes food for specific health benefit rather than to enhance physiological function, may include infant formula, processed baby foods (weaning foods), low-calorie foods for weight reduction, high-calorie foods for weight gain, ergogenic foods for athletes, and foods for special medical purposes like the treatment of diabetes or hypertension.

In India normal foods, nutraceuticals, or designer foods are not categorized separately (FSSAI, 2006). More over India has Food Safety and Standards Act, 2006: Food Safety and Standards Rules, 2011, Food Safety and Standards Regulations, 2011 and the Food Safety and Standards Authority of India (FSSAI), established under the Food Safety and Standards Act, 2006 as a statutory body for laying down science based standards for articles of food and regulating manufacturing, processing, distribution, sale and import of food so as to ensure safe and wholesome food for human consumption.

Crop-based designer foods

Designer cereal grains

Al-Hooti *et al.* (2002) prepared wheat germ-enriched bread using wheat flour containing, 20 % raw wheat germ, 0.5 % sodium stearoyl-2-lactylate, 30 ppm potassium bromate and 50 ppm ascorbic acid. US had implemented mandate of folic acid fortification of grains (Johnston and Tamura, 2004). Over dose of folate supplementation in adolescence may lead to motivational and spatial memory deficits (Johnston and Tamura, 2004; Sittig *et al.*, 2011). Chilean Ministry of Health recommended the fortification of wheat flour with folic acid at a concentration of 2.2 mg of folic acid/kg for women of child bearing age in order to reduce the risk of neural tube defects in newborns (Hertrampf *et al.*, 2003). Owing to their high nutritional value, several value added oat based designer foods like breads, biscuits, cookies, museli, granola bars, oat flour, oat bread porridge, oat meal, oat based breakfast cereals flakes and infant foods are available which have cholesterol lowering and anti-cancerous effect (Prasad Rasane *et al*., 2013).

Folic acid fortification of grains is recommended in Iran (Abdollahi *et al*. 2008). Vitamin deficiency related diseases are common in the countries where rice is the staple food. Golden rice to combat vitamin deficiency was developed by fortifying rice with vitamins (Potrykus, 2003). Apart from biotechnological approach there are maize and wheat with higher levels of iron, zinc, β—carotene, lysine and tryptophan are available due to natural variation in its germplasm (Hoisington, 2002). In the year 1992 International Rice Research Institute, Manila, Philippines, had initiated a project to improve the iron and zinc content of rice, which was followed by many other researchers and developed lines of rice with increased iron, zinc and β—carotene content. Rice lines with improved iron contents were developed (Sautter *et al.*, 2006). The bio fortification with nutrients was extended to wheat, maize, cassava, sweet potatoes and beans. Maize with improved amino acid balance was developed and grown in several African countries (Khush, 2002; Friedrich, 1999).

Monascus fermented rice

Monascus fermented rice products are produced by fermenting rice with fungi *Monascus* sp, which leads to fortification of rice with active constituents such as monacolins and γ - amino butyric acid (GABA). Tseng *et al*. (2012) reported in vitro antioxidant and immune modulatory activity in RAW 264.7 cells. In India various studies also proved its health benefits for human with regard to diabetes, cholesterol, cancer, and alcohol induced liver disease and inflammation (Kalaivani *et al.*, 2010). It is also proved to have potential for promoting bone formation and immunomodulation. Development of Monascus fermented rice using Indian variety and its anti-diabetic (Rajasekaran and Kalaivani, 2009) and anti-cholesterol (Rajasekaran and Kalaivani, 2011) activity in animal models has been reported. The benefits of the Monascus fermented rice may be due to the presence of monacolins.

Phytosterols enriched designer foods

Phytosterols are isoprene compounds present in different food products, among which the most important are beta-sitosterol, campesterol and stigmasterol. Plant sources of phytosterols are oil seeds, nuts, plant oils, grains, and pulses. It has been reported that there has been reduction in total cholesterol and LDL cholesterol level on regular consumption of 2–3 g phytosterols fortified foods per day (Lugasi, 2009), which in turn reduces the risk of cardiovascular diseases. Polagruto *et al*. (2006) and Escurriol *et al*. (2009) also reported the reduction in total chloesterol and LDL—cholesterol on consumption of food products fortified with phytosterols. Intake of phytosterols enriched designer oil (0.45 g/day (as free sterol) (Seki *et al.*, 2003) significantly reduced total cholesterol, very low density lipoprotein (VLDL) cholesterol and remnant-like lipoprotein (RLP) cholesterol compared with the control vegetable oil, which is helpful in reducing the risk of coronary heart disease (CHD) in the population. Clifton *et al.* (2004) reported that phytosterol ester-enriched milk and yoghurt significantly reduced LDL and total cholesterol.

Plasma sitosterol was increased by 17%–23 % and campesterol by 48%–52 % with phytosterol-enriched milk and bread. Phytosterols, fat-soluble fractions of plants are consumed at levels of 200–400 mg/day in Western diets. Phytosterol chemically resembles cholesterol, inhibits the absorption of cholesterol. Addition of phytosterol in diet is effective in reducing the risk of CHD (Jones *et al.*, 1997). Phytosterol ester-enriched margarine (Mussner *et al.,* 2002) also significantly reduces total cholesterol, LDL—cholesterol, HDL—cholesterol, apolipoprotein B and LDL/HDL cholesterol ratio compared with the control margarine (Cerrato, 1999).

Designer vegetable and fruit products

Recently a functional food biscuit with potential health benefits was developed by incorporating fruit and vegetable dried residue flour (FVRF) at 20-35%, which has acceptable limits of international regulations and have consumer acceptance, (Marium *et al.*, 2015). Broccoli is a highly valued vegetable due to its chemopreventive property. Latté *et al.* (2011) reported that the benefit from consumption of broccoli in modest quantities and in processed form outweighs potential risks. Sulforaphane is a chemopreventive isothiocyanate (ITC) derived from glucoraphanin (GRP) hydrolysis by myrosinase, a thioglucoside present in broccoli. Due to lack of myrosinase in commercially available glucoraphanin supplement bioavailability of sulforaphane is not achieved. Cramer *et al*, (2011) showed that combining broccoli sprouts with the glucoraphanin powder synergistically enhanced the early bioavailability of sulforaphane, proved that regular intake of designer broccoli sprouts enriched with glucoraphanin powder reduces the risk of cancer compared the GRP powder or sprouts alone. Designer broccoli fortified with Se is effective in cancer prevention, due to its high glucosinolate (GSL) content and Se accumulation, which can be developed by fertilizing broccoli with Se (Hsu *et al.*, 2011). Abdulah *et al*. (2009) achieved Se enrichment by using a sodium selenite solution, which showed potential anticancer properties in human prostate cancer cell lines, as compared with those of a control broccoli sprout extract, (Sleator, 2010). Designer vegetables like beta carotene enriched tomatoes and orange fleshed sweet potatoes were developed using biotechnological approaches.

Designer oils with omega 3 fatty acid

Omega 3 fatty acids are unsaturated fatty acids found in green leafy vegetables, vegetable oils, nuts and fish and fish oil. The most common omega-3 fatty acids found in the diet include long-chain PUFA, EPA and DHA. Dietary consumption of omega 3 fatty acids reduces the incidence of cardiovascular disease (CVD), osteoarthritis (Roush *et al*., 2010), and rheumatoid arthritis (Kjeldsen-Kragh *et al*., 1992). Designer diet based approach will be effective for increasing omega-3 fatty acid content in oils (Penny *et al*., 2002). Riediger *et al.* (2008) studied the impact of the source of n-3 fatty acid on cardiovascular benefits using C57BL/6 mice. From the study they suggested that the health benefits may be achieved by lowering dietary omega-6: omega-3 fatty acid even in a high fat diet medium. Riediger *et al.* (2009) studied cardiovascular and metabolic benefits of 'designer oils' containing a lower ratio of omega-6: omega-3 fatty acids. Three groups of C57BL/6 mice were fed for 6 weeks with an atherogenic diet supplemented with either a fish oil- or flaxseed oil-based 'designer oil' with an approximate omega-6: omega-3 fatty acid ratio of 2:1 or with a safflower oil-based formulation with omega-6: omega-3 fatty acids ratio of 25:1. From the observation of food intake, body weight, and blood lipid levels it was concluded that lowering dietary ratio of omega-6: omega-3 fatty acids may significantly reduce cardiovascular and metabolic risks in mice.

Napier and Graham, (2010) have reported the promising approach of transgenic metabolic engineering in developing transgenic plant producing designer oil enriched with omega-3 long chain PUFA equivalent to the level found in marine organisms. Recently, Xu *et al.* (2011) concluded from their experiments that designer oil based approach for rapeseed oil enriched with micronutrients such as polyphenols, tocopherols and phytosterols may be effective in the prevention of atherogenesis Phenol enrichment of olive oils (Suárez *et al*., 2010) and palmitic acid-fortified vegetable oil produced synergistic effects on calcium absorption and it is beneficial for baby foods including infant formula, with regard to increasing absorption of calcium by higher soluble calcium in the small intestinal content (Lee *et al*., 2008). Eshigina *et al.* (2007) investigated the influence of dietary therapy containing sunflower oil with phospholipids (PL) on the lipid profile of plasma and composition of fatty acids of red blood cells in patients with hypertension and obesity and observed the reduction in serum total cholesterol, low density lipoprotein (LDL), apo-lipoprotein A 1, apo-B and fibrinogen.

Role in cancer prevention

The "designer foods" approach is one of the best approaches, by which the constituents having anti-cancer potential can be fortified into the regular diet (Pariza, 1992). It has been proved in various studies that the designer food approach is the best way for the prevention of cancer. Dietary administration of bovine milk lactoferrin and black tea polyphenols combination significantly reduced the tumour incidence, development of hamster buccal pouch carcinomas, carcinogen-metabolizing enzymes and cellular redox status (Chandra Mohan *et al*., 2005, 2006). Polyphenolic compounds such as anthocyanins and flavonoids in red grape wine were proved to have inhibitory effect on breast cancer cells. A study by Hakimuddin *et al.* (2004) also supported that red wine polyphenolic fractions have anticancer property against breast cancer cell lines (MCF-7) and they also reported relatively low cytotoxicity towards normal human mammary epithelial cells (HMEC) and a non-tumorigenic MCF-10A cells, which are contrast to the authentic flavonoids such as *quercetin*, *naringenin* and *catechin* which inhibited the growth of HMEC much more than that of MCF-7 cancer cells. Hakimuddin *et al.* (2006) reported the effect of red grape wine polyphenol in gene expression and biochemical pathways. The polyphenols induced calcium release by disrupting mitochondrial function through membrane damage, which results in selective cytotoxicity toward MCF-7 cells. Apart from its anticancer activity, the polyphenolic fractions showed discrete antioxidant action on cancer cell lines (Damianaki *et al.,* 2000). The above studies suggested that consumption of wine or other polyphenol-rich foods and beverages, could have a beneficial anti proliferative effect on breast cancer cell growth.

Tea (*Camelia Synensis*) is consumed as beverage in many countries across the world, including India. Studies have showed beneficiary effect of tea in reducing the risk of a variety of illnesses such as cancer and coronary heart diseases. Tea plant, is cultivated globally and contains polyphenols as one of the active constituent. Both black tea and green tea have been proved to have potential in preventing lung, stomach, oesophagus, duodenum, pancreas, liver, breast, colon (Weisburger *et al.,* 1998) and skin cancers and also have preventive effect on atherosclerosis and coronary heart disease, high blood cholesterol concentrations and high blood pressure. The health benefits of polyphenols from tea can be extended by combining them with other foods in the form of designer food (Mukhtar and Ahmad, 2000). Among flavonoids, flavone, flavonol, flavanone and isoflavone classes possess antiproliferative effects on various cancer cell lines LLC-PK1 (renal tubular cell line), MCF-7 (human breast cancer cell line), Caco-2 (human colon cancer cell lines) and HT-29 (resembling colonic crypt cells) (Kuntz *et al.*, 1999).

Micro and micro nutrients enriched designer foods

More than half of the world population are affected by one or more micro and macro nutrient deficiencies and one third of the world population suffer from anaemia and zinc deficiency..In Austria, in a survey showed that about 470 fortified products are available commercially (Wagner *et al* 2005). The most frequently used nutrients for fortification were vitamin C (73 %), vitamin B6 (43 %), and niacin (37 %) and among mineral and trace elements calcium (23 %) was the most added. Among people who are buying fortified foods the contribution of vitamins and minerals increased up to 74 and 19 %, respectively and no risk due to overdose was found. To address micronutrient deficiency in European population, micronutrients are added safely to foods at levels recommended by European Commission Recommended Daily Intake (EC RDA): the micronutrients includes vitamin B12, vitamin C, vitamin E, riboflavin, pantothenic acid, niacin, thiamine, vitamin B6, vitamin D, folic acid, biotin, copper, iodine, selenium, iron, zinc, calcium, phosphorus and magnesium (Flynn *et al*., 2003). Dietary micronutrient deficiencies lead to diseases such as iodine deficiency disorders, iron-deficiency anaemia, and vitamin A deficiency, and other serious public health problems in the developing world. Fortification of salt with iodine, iron, and vitamin A is an easier approach and is followed in most of the developing countries including India (Raileanu and Diosady, 2006).

Cereal-based infant foods, fortified with micronutrients are recommended for reducing multiple micronutrient deficiencies in infants (Gibson *et al.*, 2011). Home fortification of foods with multiple micronutrient powders is an effective intervention to reduce anaemia and iron deficiency in children of 6 to 23 months age (De-Regil *et al.*, 2011). Micronutrient deficiency in pregnant women leads to low birth weight, lower cognition and reproductive performance and anaemia. Deficiencies of micronutrients (zinc, iron, folic acid and iodine) is highly prevalent in pregnant women in South Asia, India and other developing countries (Seshadri, 2001; Pathak *et al.*, 2004; Haider and Bhutta, 2006), which may be due to poor dietary intake of food and low frequency of consumption of foods rich in micronutrients. UNICEF/United Nations University/World Health Organization jointly proposed a formulation for a multiple micronutrient supplement for pregnant women. Use of multivitamin supplementation among pregnant women is effective in improving anaemia status (Sunawang *et al*, 2009). Multiple micronutrient supplements increases haemoglobin and improves micronutrient status in pregnant women better than iron supplements alone or iron with folic acid (Allen and Peerson, 2009). Micronutrient fortified flour reduced both iron and zinc deficiency postpartum among breast-feeding women (Stuetz *et al.*, 2011)

Biotechnologyrole in designer food

Biotechnology had created a platform for genetic manipulation in farming and the use of plants as ‘pharma’ factories to manufacture therapeutics (Chang, 2001). Transgenic technology can improve functional properties of dairy milk by altering major component of milk in high producing dairy cows (Karatzas, 2003). In a study by Brophy *et al.* (2003), casein concentration in the milk was enhanced by introducing additional copies of the genes encoding bovine beta- and kappa-casein (CSN2 and CSN3, respectively) into female bovine fibroblasts. In another study by Hyvönen *et al.* (2006) human lactoferrin content was increased in cow’s milk. Altering the milk composition paved a path for designer milk (Sabikhi, 2007). To address vitamin A deficiency, an important nutritional problem in India, advances in biotechnology had developed genetically modified mustard (*Brassica juncea*) to express high levels of β—carotene, the precursor of vitamin A (Chow *et al.*, 2010).

Bio fortification

Bio-fortification of staple crops using modern bio-technological methods can potentially help in alleviating malnutrition in developing countries, because it can offer long-term sustainable, food based solution for world population (Raj Kishore Gupta *et al.*, 2015: Cak mak *et al.*, 2010). Global population is growing at the rate of 1.4 % per year, i.e. 8 billion by 2030, to meet the nutritional needs of fast growing population, there is a need for 50 % more food grains with higher and more stable yields (Khush, 2002 and Yan and Kerr, 2002). Macronutrient and micronutrient deficiencies are prevalent in most of the developing countries and there is a decline in natural resources such as arable land and water. To meet these challenges biotechnology is a valuable tool to improve nutritional value in plants and crops (Yan and Kerr, 2002). Plant biotechnology has made important contributions in developing designer grains enriched with vitamins, amino acids and micronutrients.

The use of conventional breeding techniques and biotechnology to improve the quality of staple crops are the new strategies to address nutrient deficiencies in developing countries, which is referred to as “bio fortification”. Potential of bio fortification is proved in improving iron, zinc, and vitamin A status in low-income populations (Hotz and McClafferty, 2007). Biofortification is the cost effective way as it does not require a change in dietary habits. In the year 1992 International Rice Research Institute, Manila, Philippines, had initiated a project to improve the iron and zinc content of rice, which was followed by many other researchers and developed lines of rice with increased iron, zinc and β—carotene content. Rice lines with improved iron contents were developed (Sautter *et al.,* 2006). The bio fortification with nutrients was extended to wheat, maize, cassava, sweet potatoes and beans. Maize with improved amino acid balance was developed and grown in several African countries (Khush, 2002; Friedrich 1999). The rapidity of research in food biotechnology, regulatory issues, legislation and intellectual property rights will enhance the discovery and innovations, but public education on awareness about genetically modified (GM) and produced products should be continually enhanced for its acceptance among the people (Chang, 2001).

Conclusion

Designer food approach is advantageous as it does not require change in dietary habit of the population and it can meet the recommended amount of nutrients regularly and can be easily merged with existing system of food production and distribution. In developed countries designer foods played a major role in improving the diet and eliminating nutritional deficiencies. Elimination of vitamin A deficiency leading to night blindness was achieved through vitamin A fortified margarine in Denmark, and vitamins A and D fortified milk eliminated vitamin D deficiency and rickets in Europe and North America. In the developing countries, food fortification has gained importance since 1990s. Fortification of wheat flour with iron, vitamin A, folic acid and other B vitamins in Asian countries such as India, Indonesia and the Philippines was successful in eliminating these micronutrient deficiencies, whereas in Thailand and Japan, foods such as noodles and fish were fortified with micronutrients. In India malnutrition is widesread. National family Health Survey-3 (NFHS 2007) in India showed children up to the age of five are underweight due to malnutrition, The success of iodine fortification of salt leads to supply of other nutrients through designer food approach such as vitamin D and calcium fortified milk for bone health, folic acid fortified cereals, sterols fortified yogurt, margarine, chocolate, cheese and juice in the management of cholesterol, iron fortified milk, salt and condiments for management of anaemia. Food is considered as medicine in Indian system of medicine. Regularly used foods in India such as tea, green tea, oil, sugar, dhal, etc. can be positively explored for designer food approach in improving health of the society. Earlier experience in designer foods indicate that fortification of food is completely safe but fortification should be done rationally i.e. it is usually at less than one third of the total recommended daily allowances (RDA). It should be strictly regulated with stringent quality control measures to ensure that there is no excessive intake of specific nutrient. The ultimate and extensive use of designer foods among people will depend on the proper development and proper regulation in the market by the regulatory authorities of the country besides creating consumer awareness among people about their health benefits through nationwide programs.

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