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RESEARCH ARTICLE

DESIGNER LIVESTOCK- BASED FOODS AND THEIR POTENTIAL HUMAN HEALTH BENEFITS: AN OVERVIEW

*,[1]Rama Prasad, J., [2]Suhas Souri, J., [3]Ashish Kumar Sharma, [1]Cherukuri, V. R., [1]Lemma Fita and [1]Chala Merera Erge

[1]College of Agriculture and Veterinary Sciences, Ambo University, Ambo, Ethiopia
[2]Suresh Gnan Vihar University, Jaipur, Rajasthan, India
[3]Principal, Arya College of Pharmacy, Jaipur, Rajasthan, India

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ABSTRACT

During the past decade the knowledge of dietary influence on health and wellbeing has 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 nutrification or bio-fortification. The demand, regulatory status and the potential health benefits in alleviating life style and chronic disorders with designer livestock - based foods like milk, meat and eggs are reviewed. 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. Several designer milk and milk products were developed by fortifying with macro and micronutrients with health benefits. The conjugated linoleic acid (CLA), omega 3-n fatty acids, vitamin A and D, calcium and probiotic enriched milk and yoghurt have specific health benefits. Designer eggs enriched with CLA and omega3-n fatty acids and antioxidants are not only improve health but also reduce the risk of cardio vascular diseases. Selenium, vitamin A and beta carotene enriched eggs, chicken and beef can bring dramatic changes in health of humans. As of now, designer foods are completely safe but nutrification or 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 consumer acceptance before releasing into the market. Ultimate success of designer foods depends on creating adequate awareness among people of their health benefits through national and international programs as well.

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INTRODUCTION

During the past decade the knowledge of dietary influence on health and wellbeing has highly 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 or 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 foods as "any food or food ingredient that may provide health benefits beyond the traditional nutrients it contains".

Designer foods include, a variety of foods and food components believed to improve health and wellbeing, reduce

Corresponding author: Rama Prasad, J.
College of Agriculture and Veterinary Sciences, Ambo University, Ambo, Ethiopia.

the risk of specific diseases or minimise the effects of other health concerns (IFIC,2011; 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. 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 is concentrated in developed countries of the world and especially in high income groups in the developing countries, because they are considered as expensive. Research has 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. (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, about 470 fortified products are available commercially.. 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 provides an opportunity to improve public health and also can generate employment and income to the people in supply chains (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 and 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 needs to 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 an annual growth rate 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 nearly double 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

The potential health benefits of designer or functional foods are summarised here under in Table 1.

Role 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 account 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 life style have elevated the demand for designer foods. Obesity is the major public health problem 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 per year.

Table 1. Summary of designer foods and their health benefits

S.No	Micro/Macro nutrient	Designer foods	Health benefits
1	Omega 3 fatty acid	Omega 3 fatty acid enriched egg, oil and milk	Management of Cardiovascular Diseases hypertension, autoimmune, allergic, neurological disorders, maternal health (Hargis and Van Elswyk, 1993), osteoarthritis (Roush *et al*., 2010) and rheumatoid arthritis (Kjeldsen-Kragh *et al*., 1992)
2	Conjugated linoleic acid (CLA)	CLA enriched egg and milk	Anti adipo genic, anti-carcinogenic, anti-atherogenic and anti-inflammatory (Magdalena *et al*., 2008)
3	Selenium (Se)	Se enriched egg and milk	Prevents cardiac muscle degeneration, muscular dystrophy (Beale *et al*., 1990) reduce the risk and prevalence of prostate and colon cancer and antioxidant activity (Navarro-Alarcon and Cabrera-Vique, 2008)
4	Probiotics	Probiotic yoghurt	Produces pro-inflammatory cytokines (Meyer *et al*., 2007), eliminates enterotoxigenic *Bacteroides fragilis*, *H. Pylori,* prevents gastrointestinal (Odamaki *et al.,* 2012) and lower respiratory tract infections (Jayakanthan *et al*., 2011), improves defecation frequency and abdominal pain due to constipation in paediatric patients (Guerra *et al*., 2011), improves antioxidant status in type 2 diabetic patients (Ejtahed *et al*., 2011)
5	Vitamin D and calcium	Vitamin D and calcium fortified milk	Lowers PTH levels, reduce bone turnover, prevents the occurrence of overweight and obesity among postmenopausal women (Bonjour *et al*., 2009; Kruger *et al*., 2010)
6	Micronutrients	Micronutrient fortified milk, salt fortified with iodine, iron and vitamin A	Improves anaemic status and reduces anaemia in children and pregnant women (De-Regil *et al*., 2011; Sunawang *et al*., 2009)
7	Docosahexaenoic acid (DHA)	DHA enriched milk	Reduces the level of blood lipids, improves composition of red blood cell membranes (Atalah *et al*., 2009) and intelligence in infants when consumed by pregnant and lactating mother (Gale *et al*., 2010)

Source: (Rajasekaran and Kalaivani, (2013)

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 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, these include:

Product formulation

It consists of incorporation of functional ingredients into designer foods, like nitrification or fortification or reformulation to increase levels of some ingredients such as bran or fibre and adding newer novel ingredients like probiotics, phytochemicals and also oils to reduce the level of harmful components like oils,

Novel processing

Using 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.

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 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). Designer foods are also developed from transgenic plants and animals.

Safety and global regulatory status of designer foods

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 countries for its sale, like Food and Drug Administration (USFDA) in the USA (Anon, 2010), Health Canada for Canada (Health Canada,1998), 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 subdivisions (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). 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.

Livestock –based designer foods

A brief account of selected livestock based designer foods such as milk, meat and eggs for human health benefits are reviewed here under.

Designer milk

The composition and functional properties of milk are of considerable importance not only to the dairy farmers due to its economic importance, but also to the milk products manufacturers and consumers. Designer milk may have modification in the primary structure of casein, alteration in the lipid profile to include more healthy fatty acids such as conjugated linoleic acid (CLA) and omega-fats, improved amino acid profiles, more protein, less lactose and absence of beta-lacto globulin (beta-LG) and increased protein recovery. Lauric , myristic and palmitic acids of milk fat are known to have hypercholesterolemia effect (Palmquist, 2006). Hence products products with reduced contents of these can be designed for healthy life style.

Designer milk can be developed through dietary manipulation or through transgenic technology. Other milk containing nutraceuticals are the important aspects in designer milk achieved through transgenic technology. Cow milk allergy in children could also be reduced by eliminating the beta-LG gene from bovines (Sabikhi, 2007). The genetic manipulation of dairy cattle is also feasible and has significant impacts on milk quality, attributes of novel dairy products for human health (Karatzas and Turner, 1997).

Cow milk is a complete diet for all human age. Milk fats of cow are typically composed of 50-70% of saturated fatty acids (SFA), 20-40% of monounsaturated fatty acids (MUFA) and 1-5% of polyunsaturated fatty acids (PUFA).Although variation in composition of fatty acid levels is noted in different breeds of animals, mainly influenced by nutrition. In addition, the relative proportion of SFA and MUFA are influenced by stearioacy coA desaturase (SCD), which is the coenzyme responsible for delta9 desaturation of fatty acids in the mammary gland and other tissues. The main biological role of SCD in the mammary gland is to maintain fluidity of milk by converting 18:0 to cis9 18:1, to a lesser extent and other SFA into their respective MUFA. Both 18:0 and 6:0 are solid at body temperature; hence there is physiological need to convert a portion of each to convert to cis 9 18:1 and cis 16:1, so that they remain as liquid. It has been observed that heritability for SDA (0.38) and milk yield (0.38) is similar; desaturase activity could therefore be used in future breeding programmes to improve the fatty acid profiles of milk by increasing MUFA and CLA isomer acid concentrations and decrease SFA concentrations (Bauman and Griinari, 2001).

Effect of nutrition on milk fat

Extensive ruminal biodegradation of unsaturated fatty acids occur in ruminants resulting in production of numerous cis and trans isomers of 18;1 and of conjugated and non- conjugated 18:2fatty acids, and the incorporation of them into ruminant products depends on the composition of the diet (forages : concentrates) and of dietary lipid supplementation, Hernández *et al.* (2007) studied the effect of 11.2 % sunflower seed supplemented diet for cows on the chemical composition of milk and dairy products. The results of the study showed that the contents of CLA and transvaccenic acid (TVA) increased from 0.54 to 1.6 g/100 g total fatty acid, respectively in control products to 2 and 6.4 g/100 g total fatty acid, respectively in diet supplemented group without affecting lactose content in milk, total fat, protein and ash contents in the dairy products, which is approximately 4 fold higher. Moreover, CLA-rich products showed considerably low atherogenicity index and thrombogenicity index i.e. 38.4 and 25 % less than those from control products. The study also demonstrated that fatty acid profiles were unaffected during processing. From these studies it was concluded that designer milk produced by supplementing cow with 11.2 % sunflower seed diet may contribute to the reduction of the risk of CVDs in humans.

Supplementation with cereal grain

Supplementation of low quality roughage diet with cereal grains as a strategy to increase ME intake of lactating cows usually increase the ratio of amino acids and glucose relative to that of acetate to very long chain fatty acid (VLFA) in circulation resulting in increased rates of synthesis of proteins, lactose and to a lesser degree fat in the mammary gland (Sutton, 1989). But high cereal grain intakes increased the production of microbial protein and of propionate relative to acetate in the rumen as reported, while lipo genesis in mammary gland tissue may increase leading to milk fat depression (Palmquist *et al*., 1993) consequently, milk and milk fat concentration may fall.

Supplementation with lipids

Supplementing cows on grazing pastures with both LCFA (0.5Kg/cow/day) and cereal grains can reverse the reduction in milk fat concentration. Lactating cows can be offered 30-40-g supplemented LCFA/Kg DM to increase the cows total ME intake .Sunflower oil is high in linoleic, peanut oil is high in oleic acid and cotton seed contains malvalic acid and sterulic acid which is inhibitor of delta 9 desaturase in mammary gland There are two methods to manipulate milk fat composition one by feeding protected lipid supplements, and the other method is feeding increased amounts of 18c fatty acids in the diet (Bauman and Griinari, 2001).

In the recent past various forms of designer milk and milk products were evaluated by researchers for the health benefits of human, which are summarised in Table 2 below.

Table 2. Designer milk and milk products evaluated recently

S.No	Name of designer food	Reference
1.	Milk based beverage fortified with apple or grape polyphenols	Axten *et al*., 2008
2.	Lutein fortified fermented milk	Granado-Lorencio *et al*., 2010
3.	Milk fortified with phenolic compounds from olive vegetable water and fermented with y-amino butyric acid(GABA)-producing(lactobacillus plantarum C48) and autochthonous human gastro-intestinal (lactobacillus paracasei 15 N) lactic acid bacteria	Servili *et al*., 2011
4	Prebiotic and probiotic fortified milk	Sazawal *et al*., 2010
5	Lactoferrin-enriched fermented milk	Kim *et al*., 2010
6	Folic acid fermented milks	Achon *et al*.,2011
7	Milk fortified with EPA	Martin-Bautista *et al*., 2010
8	Fermented milk fortified with chinshey purple sweet potato(CPSP) and other compounds	Wu *et al*., 2011
9	Calcium and vitamin D fortified milk and cheese	Bonjour *et al*., 2009
10	Designer ice cream fortified with calcium	Van der Hee *et al*., 2009
11	Micronutrients (iron) fortified milk	Sazawal *et al*., 2010
12	Designer milk with fish oil, oleic acid ,minerals and vitamins	Romeo *et al*., 2011
13	EPA and DHA enriched milk	Lopez-Huetras, 2010

Calcium and vitamin A fortified milk and cheese are necessary for bone growth of children and women (Kruger *et al*., 2010). Consumption of vitamin D fortified milk prevents the occurrence of obesity and over weight in women (Angeles-Agdeppa *et al*., 2010). EPA and DHA enriched milk reduces the level of blood lipids, mainly cholesterol, LDL cholesterol and triglycerides (Lopez-Huertas, 2010). Atalah *et al.* (2009) observed improved composition of RBC and human milk by consumption of DHA fortified milk and showed improved intelligence in children (Gale *et al*., 2010).Various studies reported the use of fortified human milk in preterm infants, which produces adequate growth and satisfies the specific nutritional requirements (Zachariassen *et al.,* 2011).

Designer drinking yoghurt

The fermented milk product 'yoghurt' is good example of naturally occurring probiotic, as it contains lactic acid producing bacteria such as *lactobacillus sp,Bifido* bacteria sp and *streptococcus thermophilus* that can prevent many infections like 'travellers' diarrhoea and also provides various health benefits. Daily intake of conventional yoghurt stimulates the production of pro-inflammatory cytokinins in young healthy women (Meyer *et al*., 2007) and anti-inflammatory bowel disease patients (Lorea-Baroja *et al*., 2007). Conventional probiotic l yoghurt eliminates entero toxic *Bacteriodes flagellis*, which can prevent several diseases (Odomarki *et al*., 2012). Jayakanthan *et al.* (2011) reported that designer yoghurt containing *Bifido bacterium LactisBb12 (R)* prevents gastrointestinal and lower respiratory tract infections. Designer yoghurt intake daily improves defecation frequency and abdominal pain due to constipation in children (Guerra *et al*., 2011). Regular consumption of probiotic yoghurt improves fasting blood glucose and anti-oxidant status in type-2 diabetic patients (Ejtahad *et al*., 2011).Vitamin D-calcium fortified yoghurt ameliorates vitamin D status and improves lipid profiles and endothelial biomarkers in type-2 diabetic patients (Nikooyech *et al*., 2011). Curcumin mixed into yoghurt exhibited anti-diabetic activity and improved physiological and biochemical markers of experimental diabetes (Guirres *et al*., 2011) Studies showed that probiotics have immune modulatory effect at the level of gut associated lymphoid tissues (GALT), which is a major site of HIV activity and influences prognosis. Irvine *et al*. (2011) in Mwanza and Tanzania evaluated the ability of probiotic fortified yoghurt in reducing the incidence of infections among people with HIV and concluded that yoghurt supplemented with *L-rhamnosus* ,may alleviate GI symptoms and improves tolerance to antiretroviral treatment among people with HIV.

In conventional yoghurt, bacteria produces water soluble vitamins (B1 and B12) and daily intake of 200 g of conventional yoghurt will be a good source of these vitamins (Fabian *et al.,* 2008). Horie *et al*. (2004), designer drinking yoghurt containing *L,acidophilous* and *Bifido* bacterium sp and fortified with 1% egg yolk. 1gy-urease, consumption of which may lead to suppression of *H.pylori* infections in human. Estrada *et al.* (2011) developed straw berry fortified yoghurt containing micro-encapsulated salmon oil, which helps to improve intake of long chain n-3 fatty acids.

Mc Cowen *et al.* (2010) studied that omega -3 fatty acids fortified yoghurt increases omega -3 fatty acid content of plasma lipids and reduces arachidonic acid concentrations in plasma lipids. Apart from health benefits designer yoghurt are useful in maintaining healthy skin. Antioxidant potential of yoghurt face mask using natural ingredients (F-Yop) improved the moisture, brightness and elasticity of treated skins (Yeom *et al*., 2011).

Designer meat

Meat and meat products are essential components of diet for people in developed countries, the consumption of which increases the economic development of the population. Although these foods are important sources of high quality protein and several micronutrients (vitamin-A, iron, zinc, etc.), there is convincing evidence that relate them to an increased risk of cardio vascular diseases. A growing consumption of meat and meat products is foreseen, despite the recommendations of nutrition experts pointing out that these circumstances may increase the relative contribution of nutrition to the development of chronic diseases. There is increased consumer preference for ready to eat dietary fibre rich meat products, because of health benefits of dietary fibre. For adults, the recommended acceptable intakes of dietary fibre are 28-36 g/ day, 70-80% of which must be insoluble fibre. The dietary fibre rich meat products are considered clinically better than the traditional meat products, since they can bring improvement in gastro intestinal tract health, prevent cancer and effective tool of weight management (Nitin Mehta *et al*., 2013).

Food fortification has been proven to be an effective and low cost way to increase micronutrient availability and can reduce the consequences of micronutrient deficiencies (Sera-Manjem *et al*., 2001; Dary and Mora, 1986). Introducing several components into meat by nutritional interventions or biotechnological methods has been carried out by many researchers. Selenium enriched chicken, pork and beef are produced by feeding organic selenium in the diets of poultry and farm animals (Fisinin *et al*., 2009). Selenium, a micronutrient is essential for preventing cardiac muscle degeneration. Selenium supplementation is used globally for preventing and treating muscular dystrophy and other Se deficiency syndromes (Beale *et al*., 1990). Se deficiency is a global problem; to treat this deficiency regular intake of Se rich foods like meat and eggs is essential .So designer foods containing Se in organic form are more utilized than inorganic form. Several researchers introduced ingredients into meat and reformulated products which can be referred as designer meat (Marriott *et al*., 1988; Kim *et al*., 2000; Tsai *et al.,* 1998; Miles *et al*., 1986) Olmedill-Alonso *et al.* (2006) developed restructured beef streaks with added walnuts, potentially functional ingredient for cardiac infections and concluded that development of meat based functional foods may be the useful approach for specific applications with potential market and can bring health benefits to population study. Olmedilla-Alonso *et al.* (2008) concluded that restructured meat products with walnuts can be considered as functional foods for subjects of high risk of cardio vascular disease, as their regular consumption provokes a reduction in total cholesterol of 4.5% with respect to base line values (mixed diet) and 3% with respect to the restructured meat without walnuts.

Transgenic pigs

Pork contains abundant fat with rich cholesterol content. Several attempts were made through dietary manipulation to reduce fat content and alter fatty acid composition in meat and to produce lean pork. Pork and pork products are low in omega 3-n fatty acids, which are beneficial for human health. Diets with high ratio of n-6/n-3 fatty acids may contribute to the prevalence of diseases like coronary artery disease, cancer, diabetes and arthritis. The high ratios of n-6/n-3 fatty acids in pork are largely due to extensive use of grains rich in n-6 fatty acids. In addition, pigs cannot convert n-6 fatty acids into n-3 fatty acids because they lack n-3 fatty acid desaturases. In recent years the demand for n-3 fatty acids in diets has been increased considerably due to the health beneficial effects. So the only way to enrich n-3 fatty acids has been dietary provision of n-3 fatty acids, thus animal feeds should contain flax seeds or fish or other marine products. Because of decline in availability of marine products, escalating costs and contamination of fish with toxic chemicals, an alternative land based dietary sources of n-3 fatty acids are needed. Development of transgenic pigs which can have more n-3 fatty acids in muscle and fats is the viable strategy. Lai *et al.* (2006) developed cloned pigs that express a humanized *caenorhabditis elegans* gene, fat-I encoding n-3 fatty acid satutase. The fat-I transgenic pigs produce high levels of n-3 fatty acids from n-6 fatty acids analogues and their tissues have significantly reduced ratios n-6/n-3 fatty acids.

With the advent of somatic cell nuclear transfer (SCNT) technology it is possible to produce transgenic pigs with less fat and more muscle. Transgenic pigs with human insulin like growth hormone (factor- I) had, 30% larger loin mass,10% more carcass lean tissue and 20% less total carcass fat in comparison with normal pigs. The latest study (Jessica Marshall, 2006) found that omega 3-n fatty acids made upon an average of 8% of total fat in six transgenic pigs, muscle compared with 1-2% in normal pigs .Development of transgenic pigs which contains n-3 fatty acids in its fat is advantageous, economical and sustainable strategy.

Culturing meat in laboratory

Environmental Science and Technology in 2011, reported that full scale production of cultured meat in the laboratory could be possible, where there is reduction in water, land and energy and also emission of methane and other greenhouse gases is also possible, compared with conventional raising and slaughtering of livestock. Dr Post in USA developed a cultured meat from stem cells ,precursor cells that can turn into others that are specific to muscle, for example techniques used to develop human organs. The test tube burger consists of about 20,000 thin strips of cultured muscle tissue without any fat produced with material including fatal calf serum used as a media to grow the stem cells. At present this cultured meat is very expensive and in future it may become a reality.

Gabor Francis is a researcher at the University of Missouri and founder of Modern meadows, Start-up Company that wants to develop and market cultured meat devoid of fats. Its process does not use stem cells but rather use skin fibroblasts, specialized cells that produce collagen–new quasi animal product into our lives. This processed meat is not natural but create a new uniform safe and ethical meat products with all appeal of latest permutations of creators (Twitter, May 15, 2013).

In Japan, recently imitation crab meat and eel meat were developed, which are different from designer or functional foods but are similar in taste, juiciness and tenderness to that of original crab meat or eel meat. They are not been advised to be given to diabetic persons as they are prepared from carbohydrate rich foods and fish oils (www/nhk world news, sp. June, 2015).

Designer poultry eggs

Egg is a wholesome and unadulterated natural poultry product, containing easily available and balanced essential nutrients to the body and is the best medium for incorporating health components in it. Designer egg approach was started in 1934 by Cruickshank, who reported the modification of fatty acid composition in egg yolk by making feed interventions. Omega-3 fatty acids are proved to be beneficial in various disorders such as cardiovascular disease, hypertension, autoimmune, allergic, and neurological disorders and it is also essential for normal functioning of the human physiology not only in normal adult and also in pregnant and lactating women. After realising the cardio-protective beneficial effects of omega 3-n fatty acids found in eggs, poultry nutritionists have started research to incorporate more of omeg3 n fatty acids in eggs and are successful in developing dietary eggs or functional eggs. The designer eggs rich in omega-3n fatty acids and antioxidants were developed by Sim (1998) and Sim and Sunwoo, (2002) by feeding hens with flax seed and patented as Professor Sim's "designer Egg", in which saturated fatty acid in yolk was replaced with 3-poly unsaturated fatty acid (PUFA) i.e. the yolk triglyceride is replaced by linolenic acid and yolk phospholipids are replaced by longer chain omega-3 fatty acids, such as eicosapentaenoic (EPA), dososapentaenoic and docosahexaenoic (DHA) acids (Jiang *et al*., 1991). They incorporated natural antioxidants like vitamin E, selenium and carotenoid pigments to overcome the instability due to 3-PUFA. Caston and Leeson, (1990) also reported increase in the concentration of omega-3 fatty acid in hen's egg by adding flax seed or fish oil in hens diet.

Bourre and Galea, (2006) produced "designer egg/diet egg" fortified with omega-3 fatty acid by feeding hens with linseed, minerals, vitamins and lutein. The nutritional value of 100 g of these eggs contains 6 times more of the omega-3 fatty acid alpha-linolenic acid (ALA), 3 times more DHA, 3 times more vitamin D, 4 times more folic acid, 6 times more vitamin E, 6 times more lutein and zea xanthine, 2.5 times more iodine and 4 times more selenium. These eggs also contain a little amount of cholesterol and, like standard eggs, are rich in B—complex vitamins and vitamin A, phosphorus and proteins. The consumption of these eggs improved the blood concentration of omega-3 fatty acids, high density lipoprotein (HDL)—cholesterol, low density lipoprotein (LDL)—cholesterol and triglycerides. These omega-3 fatty acids enriched designer eggs showed better stability of PUFA during egg storage and cooking, high availability of such nutrients as vitamin E and carotenoids, which improves antioxidant and omega-3 status of people consuming these eggs (Surai and Sparks, 2001).

Cholesterol content of chicken eggs has received more attention due to increase in cardio vascular diseases in human, mainly atherosclerosis and hyper tension. Egg yolk is considered as one of the rich source of cholesterol in human diet. Cholesterol content of egg (about 200-250 mg) and blood (150 mg) is high and presently research is going on to reduce cholesterol content in eggs either through use of feed additives or through dietary supplementation. Fortification of omega-3 fatty acid not only increases the health benefits of designer egg but also reduces the cholesterol content of the egg by replacing saturated fatty acid in egg yolk. The dietary cholesterol and fatty acids plays an important role in various cardiovascular diseases. The scientific attempt to reduce cholesterol content in diet is the promising approach for the management of cholesterol (Hargis,1988). Designer eggs were also developed by replacing yolk cholesterol with conjugated linoleic acid (CLA). CLA is studied for its various health related properties such as anti-adipo genic, anti-carcinogenic, anti-athero genic and anti-inflammatory (Magdalena *et al*., 2008). Raes *et al.* (2002) produced designer egg enriched with CLA by feeding hens with CLA rich diet and found that adding CLA to layers diets rich in omega-3 fatty acids produces CLA enriched eggs. Cook *et al*. (2000) had patented a method of production of CLA enriched designer eggs by feeding poultry a diet enriched in CLA. Dietary addition of CLA to hens diet decreased lipid content and concentrations of monounsaturated fatty acids in egg yolk, but increased CLA and saturated fatty acids. CLA supplementation of egg also increased yolk moisture content, firmness and impaired the sensory quality of eggs.

Magdalena *et al.* (2008) studied the anti-cholesterol and anti-inflammatory effect of CLA-enriched eggs in animal models and found that CLA-enriched eggs significantly reduced total plasma cholesterol as compared with CLA-supplemented eggs and it also reduces the size of atherosclerotic plaque, number of atherogenic macrophages and increases the area occupied by smooth muscle cells in atherosclerotic. Cholesterol content of the egg yolk can also be reduced by supplementing hen's feed with chromium at 200–800 ppb concentration (13.9 to 33.7 % reduction) (Anderson *et al*., 1989; Lien *et al*., 1996). The pharmacological approach was also studied for reducing cholesterol level in egg by administering egg laying hens with cholesterol lowering drugs. US patent was issued to Meier and Wilson, (1997) for the method of reducing the cholesterol content of egg by supplementing hen with L-dihydroxyphenylalanine (L-DOPA).

Selenium enriched eggs

Selenium (Se) supplementation is used globally for preventing and treating muscular dystrophy and other Se deficiency syndromes (Beale *et al*., 1990). Se deficiency is a global problem, to treat this deficiency regular intake of Se rich food is important. Organic source of Se is better absorbed than inorganic source (Fortier *et al*., 2012). Egg and meat are the good source of Se. Recommended daily requirement of Se is 55 µg for human adults (Bennett and Cheng, 2010). Regular dietary intake at recommended level may reduce the risk and prevalence of prostate and colon cancer and it also proved to have a role in prevention of cardiovascular diseases through antioxidant property (Navarro-Alarcon and Cabrera-Vique, 2008; Bennett and Cheng, 2010). Among the food sources of selenium egg is the most important and it is easy to fortify the egg with increasing amount of Se. Se concentration in egg had increased from 0.044 to 0.243 μg/g for eggs from hens fed with organic Se yeast product (Cantor and Scott, 1974). Se enriched eggs are marketed in various countries like UK, Ireland, Mexico, Columbia, Malaysia, Thailand, Australia, Turkey, Russia and the Ukraine (Fisinin *et al*., 2009). Bennett and Cheng, (2010) in their study on the production of Se enriched egg concluded that feeding hen up to 5.1 μg/g of Se will increase the concentration of Se in egg without affecting egg production. Se-enriched chicken, pork and beef can also be produced by feeding organic Se in the diet of poultry and farm animals (Fisinin *et al*., 2009).

Antioxidant enriched eggs

The nutritional quality of the egg was also improved by enhancing levels of antioxidants such as vitamin E, omega-3 fatty acids such as DHA, carotenoids and Se (Surai and Sparks, 2001). In a double-blind, placebo-controlled trial by Surai *et al*. (2000) to evaluate the ability of designer eggs enriched in vitamin E, lutein, Se and DHA in delivering micronutrients to the human found that consumption of designer eggs enriched in vitamin E, lutein, Se and DHA significantly increased the levels of α-tocopherol, lutein and DHA in plasma as compared to the normal table eggs, but did not change Se concentration in plasma, blood pressure and plasma lipid profile. From the results the authors concluded that dietary intake of designer eggs enriched with vitamin E, lutein, Se and DHA will be a beneficial approach in supplying those nutrients. Designer egg with enhanced vitamin A and β—carotene concentration was also developed (Jiang *et al*, 1994). Sook wong *et al.* (2008) developed Tocotrienol (T3)-fortified eggs (0.62 mg of T3/egg) by adding rice bran scum oil to the feed, whereas normal egg contains 0.11 mg of T3/egg.

Development of resistance to antibiotic leads to failure of antibiotic therapy (Malekshahi *et al*., 2011). Roe *et al.* (2002) developed a egg-yolk immunoglobulin (IgY) against *H. pylori* whole-cell lysate, which reduces gastric inflammation due to H. pylori-infection in Mongolian gerbils. Later various researchers found that administration of anti-urease specific IgY was effective passive immunization against *H. pylori* infection and its related gastrointestinal disorders (Shin *et al*., 2003, 2004; Nomura *et al*., 2005). Malekshahi *et al*. (2011) in their study developed recombinant IgY from by using hens immunized with recombinant UreC and found that UreC-induced IgY is specifically successful in inhibition of H. pylori infection. Genetic immunization of ducks with a plasmid expressing H. pylori UreB produced UreB induced IgY polyclonal and mono specific antibodies against recombinant H. pylori urease (Kazimierczuk *et al*., 2005). Consumer acceptance of these designer eggs are similar to that of normal eggs (Scheideler *et al*.,1997).

Macro and micronutrient enriched designer foods

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.

Role of bio-technology in designer food

Bio-technology 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

Global population is growing at the rate of 1.4 % per year, i.e. 8 billion by 2030, to meet the the nutritional needs of fast growing population ,there is a need for 50 % more food grains with higher and more stable yields (Khush, 2002; 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). Bio-fortification 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 by 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 substantial. National family Health Survey-3 (NFHS 2007) in India showed that 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, dhals, etc. can be positively explored for designer food approach in improving health of the society.

Prior 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 and also creating consumer awareness among people about their health benefits through nationwide programs.

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