

FUNCTIONAL FOODS: ITS ROLE IN PREVENTION OF NON-COMMUNICABLE DISEASES¹Labonya Mandal and ^{2*}Dolan Das¹Ph.D., Assistant Professor, Department of Physiology, Raja Peary Mohan College, Uttarpara, University of Calcutta.²Ph.D, Assistant Professor, Department of Physiology, Kalyani Mahavidyalaya, Kalyani, University of Kalyani.***Corresponding Author: Dolan Das**

Ph.D, Assistant Professor, Department of Physiology, Kalyani Mahavidyalaya, Kalyani, University of Kalyani.

Article Received on 14/08/2021

Article Revised on 03/09/2021

Article Accepted on 24/09/2021

ABSTRACT

There has been a shift in the pattern of diseases afflicting mankind owing to rapid changes in food habit, life style and environment. Globalization has led to the prevalence of non-communicable diseases (NCDs) like cardiovascular diseases such as heart attack and strokes, diabetes, obesity, chronic respiratory diseases, etc. They are often termed 'lifestyle diseases'. Food has been recognized as one of the major factor in the emergence of a variety of diseases and there is a growing demand for food that helps prevent disease, boost mental health, and improve the quality of life. A concept of 'functional foods' has emerged which are foods and food components that supply health benefits on top of basic nutritional needs. Most of these functional foods are of plant origin and some are of fermented products of microbes. Functional foods contain many bioactive compounds which have significant health promoting effects. They have the capacity to scavenge free radicals and also show effects contributing to anti-inflammatory, antimicrobial, anti-mutagenic, anti-tumour and neuroprotective properties. This review will throw some light that how by choosing our daily dietary pattern we can prevent NCDs and promote health, maintain metabolic homeostasis, and fulfil energy requirements.

KEYWORDS: Functional foods, Non-communicable diseases, Bioactive components, Dietary supplements, Plant foods.

INTRODUCTION

Health is the sign of quality life and prosperity of mankind. As per WHO definition of health is 'a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity and fundamental rights of every human being without distinction of race, religion, political belief, socio-economic condition'.^[1] In the last few decades there has been a huge shift in the pattern of diseases afflicting humans owing to a somewhat hasty transition to urbanization and globalisation, causing changes in food habit, life style and environment.

Foods contain various substances that can control the physiological functions of the body and changes in dietary consumption leads to genesis of several non communicable diseases. Recognition of 'food' as one of the major factor in the emergence of various diseases, has led to the growing demand of food that helps prevent disease, boost mental health, and improve the quality of life. It has been proved that there is a strong relationship between 'functional' components of food, health and well-being.^[2] Consumption of vegetarian or nonvegetarian diet results in different bowel microorganisms,^[3] which may have some advantageous

connotation for diabetes, cardiovascular disease, and some cancers.

'FUNCTIONAL FOODS'

'Functional foods' are defined as foods and food components that supply health benefits further than basic nutritional needs. These foods are similar in appearance to usual conventional foods and are consumed as part of the normal diet. Functional foods represent a range of items that include constituents or natural component in conventional, fortified, enriched, and enhanced foods. Most of the functional foods are of plant origin. Interestingly some functional foods are fermented products of microbes. Such foods are thought to have physiological benefits and/or reduce the risk of several chronic diseases beyond their basic nutritional functions.^[4] The concept of functional food emerged in Japan during the 1980s,^[5] and it is the only country which has specific regulatory approval procedure for functional foods.^[6] A more appropriate definition states that 'a food can be regarded as functional if it is satisfactorily demonstrated to affect beneficially one or more target functions in the body, beyond adequate nutritional effects, in a way that is relevant to either improved stage of health and well-being and/or reduction of risk of disease'.^[7]

Functional components of such food have various health promoting effects at different stages of many disease control, from initiation to development. There are numerous reports of successful and effective application of functional food in the treatment and prevention of several diseases.^[2,8,9] ‘Microbial medicines’ i.e., prebiotics and probiotics have been used to target several non-communicable diseases as well as oxidative cellular damage.^[10] The awareness of functional food is growing, and its demand is increasing even in developing countries. Several factors are there to propel the demand for functional food; among which increasing health consciousness, growing health cost and awareness about the value of functional food are the primary drivers.

Traditional diet is “functional” as it contains high amounts of dietary fiber (whole grains and vegetables), antioxidants (spices, fruits, and vegetables), and probiotics (commonest include lactic acid bacteria group such as Lactobacilli, Enterococci, Bifidobacteria and Leuconostoc spp. and yeasts such as Saccharomyces spp.)^[11] In addition to providing adequate nutrition, many of these traditional food ingredients like, dietary fiber, vitamins and minerals, oligosaccharides, lignins, essential fatty acids, flavonoids, diverse phytochemicals, and lactic acid bacterial cultures impart beneficial effects on human physiology. They ensure normal physiological functions in the body by improving gastrointestinal health, enhancing the immune function and managing body weight. They also help to reduce gastrointestinal inflammation and oxidative stress, and keep non-communicable diseases cardiovascular diseases, various types of cancers, diabetes, and neurodegenerative diseases at bay.^[12]

NON-COMMUNICABLE DISEASES

Non-communicable diseases (NCDs) include cardiovascular diseases such as heart attack and strokes, diabetes, obesity, chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma) and cancer, which are the most noteworthy problems at present days both globally and regionally for the general population regardless of age, region, or gender. NCDs, are also known as chronic diseases, inexplicably affect people in low- and middle-income countries where more than three quarters of global NCD deaths, 32 million, occur.^[13] In 2015, NCDs were responsible for 40 million deaths, representing 70% of all deaths worldwide and contribute to around 5.87 million deaths in India, accounting for 60% of all deaths in the country.^[14] Because of changes in dietary habits and lifestyle as well as rapid population ageing in developing countries, major NCDs – such as stroke, heart attacks, cancers, diabetes, major psychiatric disorders, and chronic respiratory diseases – are now rapidly adding to the worldwide burden of disease. As per United Nations, the incidence of diabetes and CVD in China and India, the two countries which represent about one-third of the world population, is projected to double with a total number exceeding 100 million by year 2025.^[15] NCDs

are interconnected; majorities of them share many of the same risk factors and also act as risk factors for each other. Excessive body weight and obesity considerably increase the risk for cardiovascular disease, many cancers and diabetes. The risk for cardiovascular disease increases many fold due to diabetes.

Due to globalization and urbanization in the developing countries the lifestyle and food habits get changed, which is the major cause for the growing problems of NCDs. Among all the risk factors of NCDs many of them are modifiable; of which most important are diet, physical inactivity, alcohol and tobacco use.^[13] It is because of these risk factors the NCDs are often termed ‘lifestyle diseases’. These modifiable risk factors are, in turn, linked with the biological risk factors like overweight, high blood pressure, high blood lipids and blood glucose. Reducing the burden of NCDs will require a reduction in both the biological and modifiable risk factors.

THE PROTECTIVE EFFECT OF DIET IN NCDS

Food habits and dietary patterns have health, environmental, and social impacts. An unhealthy diet is one of the major risk factors for all NCDs and other conditions linked to obesity. It was reported that excessive consumption of foods that are calorie dense, nutritionally poor, highly processed, and rapidly absorbable can lead to systemic inflammation, reduced insulin sensitivity, and a bunch of metabolic abnormalities, including obesity, hypertension, dyslipidemia, and glucose intolerance.^[16] Inflammation, oxidative stress and dysregulated autophagy are common features in NCDs that participate in the genesis and progression of these diseases.^[17] It has been suggested that oxidative stress is involved in the etiology of several chronic diseases including CVD, diabetes, stroke, some cancers, and neurodegenerative disorders.^[18]

Though it is still not well understood that how functional food enriched diets reduce inflammatory risk, high intakes of food items containing antioxidants and polyphenols that reduce free radicals concentrations throughout the tissues may be the reason behind it.^[4] Populations consuming a large proportion of plant-based foods, including fruits and vegetables, or those with high intake of seafood are known to have a lower incidence of CVD and certain types of cancer.^[19] It was well recommended that nutritional interventions, at both population and individual levels, are beneficial to reduce cardiovascular risk.^[16] Based on numerous scientific reports it is now evident that functional foods have wide range of physiologic effects in vivo that minimize inflammatory cascades and vascular reactivity. It is well established that different types of foods can be used in diet to prevent diseases other than CVD like cancer diabetes, neurological diseases, immunological disorders, to improve quality of life.^[20]

Bioactive Dietary Compounds of Functional Foods with NCD-Protective Potentials

A functional food can be a natural food or food from which a component has been removed biotechnologically. Based on food type or active components added or naturally present in the foods, like fibre, flavonoids, vitamins, minerals, fatty acids, carotenoids, and so on, functional foods are classified into various groups.^[10] Plant foods contain many bioactive compounds known as phytochemicals. Phytochemicals those which have significant health promoting effects are carotenoids, phenolic compounds (flavonoids, phytoestrogens, phenolic acids), phytosterols and phytostanols, tocotrienols, organosulfur compounds, and nondigestible carbohydrates (dietary fiber and prebiotics).^[20] Isoflavones are found in high concentration in soybean, soybean products (e.g., tofu), and red clover. Lignans are mainly found in flaxseed.^[21] and consumption of lignans is associated with decreased risk of CVD.^[22] These compounds have the capacity to scavenge free radicals and show synergistic effects contributing to anti-inflammatory, antimicrobial, anti-mutagenic, anti-tumour and neuroprotective properties.^[23, 24, 25, 26,]

Grains have also been found to reduce the risk of CVD.^[27] In addition, these also provide sufficient quantities of dietary fibre which is important for the maintenance of intestinal health as well as prevention of cardiovascular diseases, cancer, obesity and diabetes.^[28] Reports were already there that dietary fibre reduces total and low-density lipoprotein (LDL) cholesterol and it produces short-chain fatty acids that inhibit the synthesis of cholesterol.^[26,29,30] The high antioxidant activity of polyphenols present in fruits and vegetables can prevent lipid peroxidation and DNA damage and capable of quenching ROS (reactive oxygen species) and toxic free radicals formed by the peroxidation of lipids and thus have anti-inflammatory and antioxidant properties in human metabolism. Moreover, when specific foods are combined in diet like fruits (raspberry, blackberry, and apple), vegetables (broccoli, tomato, mushroom, and purple cauliflower), and legumes (soybean, adzuki bean, red kidney bean, and black bean) or diets are supplemented with vitamin, mineral, herb or other botanical, a synergistic antioxidant interaction could occur resulting in an affirmative physiological effect on cardio-health.^[31, 32]

Fish is one of the main food components in major Asian diet. It was already recommended in the most important national and international nutritional guidelines that the regular consumption of fish is beneficial for health.^[33] One very recent study reported that higher fish consumption is associated with lower rates of CVD, CHD, and cerebrovascular mortality like stroke, myocardial infarction and sudden cardiac death and has potentially beneficial effects of the anti-aging process and well-being in the elderly population.^[34]

Probiotics are now well accepted to boost the immunity of humans by protecting against gastrointestinal pathogens. Intestinal epithelial barriers are well maintained by probiotic organisms to protect against certain intestinal diseases like obesity, inflammatory bowel diseases, and irritable bowel syndrome. Their beneficial effects on the host are exerted by secreting antimicrobial substances, competitive exclusion for adhesion sites and nutritional sources, enhancement of intestinal barrier function, and immunomodulation.^[11] Prebiotics play important roles in the metabolic processes associated with immunomodulation. Those indigestible fibrous compounds that passed through the upper gut in order to stimulate probiotics growth are commonly called dietary prebiotics. Researches show that prebiotics immune boosting effects are associated with probiotics stimulation and their metabolites produced such as short chain and branched chain fatty acids; and may also be derived from other uncommon microbial taxa.^[10] Production of acetic and lactic acids for acidification is also another way to inhibit the growth of pathogens in intestine. Gut barrier dysfunction allows movement of various inflammatory mediators like the bacterial lipopolysaccharide (LPS) from the gut into the blood stream, which might be an important factor in the development of obesity and diabetes in mice model.^[35] So by maintaining the normal gut physiology and reducing the inflammation of the intestine with proper diet one can be able to shape the immune status systemically thereby reducing the incidence of all NCDs.

Avoidance of certain types of foods has health benefits. From many years of research it is now evident that reduction of total fat, saturated fat, cholesterol, and trans-fat in the diet can reduce the risk of certain chronic diseases, such as CVD and stroke.^[36]

Future of Functional Foods

Functional foods is a promising category that is gaining considerable thrust presently as there is an increasing awareness about the benefits of proper nutrition. Eating habits can considerably cut down the healthcare expenditures if individuals were to adjust their diets that provide appropriate nutrition. Food bioactives are more and more emerging to be in a position to play this preventive role. They include a large class of molecules such as polyphenols, non-fermentable carbohydrates, omega-3 fatty acid, beta-carotene, sulfur-rich compounds and many more. Presently more than 5000 phytochemicals have been identified as polyphenols while many more still remain unknown.^[37] Currently newer technologies are continuously developing for processing of various cereals to improve their nutritional value in relation to their acceptability by the consumers. But certain major issues associated with the development of food bioactives for disease prevention will must have to be in the focus before bringing the bioactives from the bench to bedside in the near future. These include, (i) the nature of food bioactives in functional foods, (ii) maximum purity without losing functionality of food

bioactives (iii) maximum purity without losing shelf life of the food bioactives and (iv) to deliver efficiently and maximize half-life in vivo.^[23]

CONCLUSION

In modern-day societies, the consumption of cheap, easily available and energy dense foods has led us to serious metabolic imbalances. This habit increases the risk of various lifestyle and non-communicable diseases such as heart attack, stroke, obesity, type 2 diabetes, hypertension, food allergies and intolerances, and gastrointestinal and inflammatory disorders. But since last few decades people are more concerned and getting aware about the health benefits of a wide variety of foods that promote health, maintain metabolic homeostasis, and fulfil energy requirements. The role of healthy diet in preventing non-communicable diseases is now well accepted. Unfortunately, there is no favourable diet that may be fit for everyone due to the extensive variation in human genetics, phenotypes, and cultures. Under such circumstances, it will be beneficial to have traditional food and food ingredients in our daily diet which are locally available with nutritive value and not always exotic to prevent non-communicable diseases. However, improving dietary habits is not only an individual problem, but a societal issue. It is difficult for individuals to make healthy choices over a lifetime when the underlying environments continue to promote the unhealthy choices. Therefore it requires a population-based, multi-sectoral, multi-disciplinary, and culturally significant approach like prohibitions of advertisement of unhealthy foods, popularisation and attractive marketing of conventional food and involvement of policy makers and government legislations.

Conflicts of Interest: There are no conflicts of interest.

REFERENCES

- World Health Organization/Web site Available at <https://www.who.int/about/governance/constitution>.
- Abuajah CI, Ogbonna AC, Osuji CM. Functional components and medicinal properties of food: a review. *J Food Sci Technol*, 2015; 52(5): 2522–29. <https://doi.org/10.1007/s13197-014-1396-5>.
- Wong JM. Gut microbiota and cardiometabolic outcomes: influence of dietary patterns and their associated components. *Am J Clin Nutr*, 2014; 100(Suppl 1): 369S–77S.
- Alissa EM, Ferns G A. Functional foods and nutraceuticals in the primary prevention of cardiovascular diseases. *J Nutr Metab*, 2012; 569486. <https://doi.org/10.1155/2012/569486>.
- Encyclopedia of Meat Sciences Reference Work. Second Edition; 2014.
- Iwatani S, Yamamoto N. Functional food products in Japan: A review, *Food Sci Hum Wellness*, 2019; 8(2): 96–101. <https://doi.org/10.1016/j.fshw.2019.03.011>.
- Roberfroid MB. A European consensus of scientific concepts of functional foods. *Nutrition* (Burbank, Los Angeles County, Calif.), 2000; 16(7–8): 689–91.
- Wildman REC, editor. *Handbook of Nutraceuticals and Functional Foods* (1st ed.). CRC Press; 2001. ISBN 0-8493-8734-35.
- Boeing H, Bechthold A, Bub A, Ellinger S, Haller D, Kroke A, *et al.* (2012). Critical review: vegetables and fruit in the prevention of chronic diseases. *Eur J Nutr*, 2012; 51(6): 637–63. <https://doi.org/10.1007/s00394-012-0380-y>
- Ashaolu TJ. Immune boosting functional foods and their mechanisms: A critical evaluation of probiotics and prebiotics. *Biomed Pharmacother*, 2020; 130: 110625. <https://doi.org/10.1016/j.biopha.2020.110625>.
- Wan MLY, Forsythe SJ, El-Nezami H. Probiotics interaction with foodborne pathogens: a potential alternative to antibiotics and future challenges. *Crit Rev Food Sci Nutr*, 2019; 59(20): 3320–33.
- Landete JM, Arqués J, Medina M, Gaya P, de Las Rivas B, Muñoz R. Bioactivation of Phytoestrogens: Intestinal Bacteria and Health. *Crit Rev Food Sci Nutr*, 2016; 56(11): 1826–43.
- GBD 2015 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet*, 2016; 388(10053): 1659–1724.
- WHO Global Conference on Noncommunicable diseases: Enhancing policy coherence between different spheres of policy making that have a bearing on attaining SDG target 3.4 on NCDs by 2030, Montevideo, Uruguay, 18-20 October 2017.
- King H, Aubert RE, Herman WH. Global burden of diabetes, 1995-2025: prevalence, numerical estimates, and projections. *Diabetes Care*, 1998; 21(9): 1414–31.
- Srinath RK, Katan MB. Diet, nutrition and the prevention of hypertension and cardiovascular diseases. *Public Health Nutr*, 2004; 7(1A): 167–86.
- Peña-Oyarzun D, Bravo-Sagua R, Diaz-Vega A, Aleman L, Chiong M, Garcia L, *et al.* Autophagy and oxidative stress in non-communicable diseases: A matter of the inflammatory state? *Free Radic Biol Med*, 2018; 124: 61–78.
- Ferrari CK, Torres EA. Biochemical pharmacology of functional foods and prevention of chronic diseases of aging. *Biomed Pharmacother*, 2003; 57(5-6): 251–60. [https://doi.org/10.1016/s0753-3322\(03\)00032-5](https://doi.org/10.1016/s0753-3322(03)00032-5).
- Block G, Patterson B, Subar A. Fruit, vegetables, and cancer prevention: a review of the epidemiological evidence. *Nutr Cancer*, 1992; 18(1): 1–29.
- Prior RL, Cao G. Antioxidant phytochemicals in fruits and vegetables: diet and health implications. *Hort Science*, 2000; 35(4): 588–92.

21. Muir AD, Westcott ND. Flax, the Genus *Linum*. Taylor & Francis; London, UK: 2003.
22. Prasad C, Imrhan V, Juma S, Maziarz M, Prasad A, Tiernan C, *et al.* Bioactive plant metabolites in the management of non-communicable metabolic diseases: looking at opportunities beyond the horizon. *Metabolites*, 2015; 5(4): 733–65. <https://doi.org/10.3390/metabo5040733>.
23. Kang J, Xie C, Li Z, Nagarajan S, Schauss AG, Wu T, Wu X. Flavonoids from acai (*Euterpe oleracea* Mart.) pulp and their antioxidant and anti-inflammatory activities. *Food Chem*, 2011; 128: 152–57.
24. Fujita A, Borges K, Correia R, de Melo Franco BDG, Genovese MI. Impact of spouted bed drying on bioactive compounds, antimicrobial and antioxidant activities of commercial frozen pulp of camu-camu (*Myrciaria dubia* Mc. Vaugh). *Food Res Int*, 2013; 54: 495–500.
25. Zielinski AAF, A'vila S, Ito V, Nogueira A, Wosiacki G, Haminiuk CWI. The association between chromaticity, phenolics, carotenoids, and in vitro antioxidant activity of frozen fruit pulp in Brazil: an application of chemometrics. *J Food Sci*, 2014; 79: C510–C516.
26. Singh JP, Kaur A, Singh N, Nim L, Shevkani K, Kaur H, Arora DS. In vitro antioxidant and antimicrobial properties of jambolan (*Syzygium cumini*) fruit polyphenols. *LWT-Food Sci Technol*, 2016; 65: 1025–30.
27. Jacobs DR, Pereira MA, Meyer KA, Kushi LH. Fiber from whole grains, but not refined grains, is inversely associated with all-cause mortality in older women: the Iowa women's health study. *J Am Coll Nutr* 2000; 19(3 Suppl): 326S-30S.
28. Elleuch M, Bedigian D, Roiseux O, Besbes S, Blecker C, Attia H. Dietary fibre and fibre-rich by-products of food processing: characterisation, technological functionality and commercial applications: a review. *Food Chem*, 2011; 124: 411–21.
29. Lattimer JM, Haub MD. Effects of dietary fiber and its components on metabolic health. *Nutrients*, 2010; 2(12): 1266-89.
30. Satija A, Hu FB. Cardiovascular benefits of dietary fiber. *Current Atherosclerosis Reports*, 2012; 14(6): 505-14.
31. Wang S, Meckling KA, Macrone FM, Kakuda Y, Tsao R. Can phytochemical antioxidant rich foods act as anti-cancer agents? *Food Res Int*, 2011; 44: 2545–54.
32. Kalra EK. Nutraceutical--definition and introduction. *AAPS Pharm Sci*, 2003; 5(3): E25.
33. Nesheim MC, Oria M., Yih PT. National Research Council. Institute of Medicine. Food and Nutrition Board. Board on Agriculture and Natural Resources. Committee on a Framework for Assessing the Health, Environmental, and Social Effects of the Food System. Dietary Recommendations for Fish Consumption. The National Academies Press (USA); Washington, DC, USA: 2015; Center for Food Safety and Applied Nutrition Advice about Eating Fish. [(accessed on 18 March 2021)]; 2020 Available online: <https://www.fda.gov/food/consumers/advice-about-eating-fish>
34. Jamioł-Milc D, Biernawska J, Liput M, Stachowska L, Domiszewski Z. Seafood Intake as a Method of Non-Communicable Diseases (NCD) Prevention in Adults. *Nutrients*, 2021; 13(5): 1422. <https://doi.org/10.3390/nu13051422>
35. Cani PD, Possemiers S, Van de Wiele T, Guiot Y, Everard A, Rottier O, *et al.* Changes in gut microbiota control inflammation in obese mice through a mechanism involving GLP-2-driven improvement of gut permeability. *Gut*, 2009; 58(8): 1091–1103.
36. Bazzano LA, He J, Ogden LG, Loria CM, Vupputuri S, Myers L, *et al.* Fruit and vegetable intake and risk of cardiovascular disease in US adults: the first National Health and Nutrition Examination Survey Epidemiologic Follow-up Study. *Am J Clin Nutr*, 2002; 76(1): 93-99.
37. Shahidi F, Naczki M. Food phenolics: An overview. In: Shahidi F., Naczki M., editors. *Food Phenolics: Sources, Chemistry, Effects, Applications*. Technomic Publishing Company Inc.; Lancaster, PA, USA, 1995; 1–5.