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Phytochemical Potentials for Functional Food Design

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INTRODUCTION

Foods, providing health benefits in addition to their nutrition value or having a role in disease risk prevention, can be considered as functional foods. The beneficial components in functional foods have been called by various terms such as phytochemicals, phytonutrients, functional food ingredients and bioactive components. Health benefits of these foods are best obtained through the consumption of a varied diet using our normal food supply. These phytochemicals and/or health-preserving elements are present in a number of frequently consumed foods, especially, fruits, vegetables, grains legumes and seeds. In particular, medicinal plants or herbs are abundant sources for bioactive phytochemicals, although they are less consumed as compared to normal food materials.

In recent years, the number of functional foods that have potential benefits for health has grown tremendously. Scientific evidence is accumulating to support the role of phytochemicals and functional foods in the prevention and treatment of disease. Phytochemicals and functional food components have been associated with the prevention and/or treatment of at least four of the leading causes of death in this country - cancer, diabetes, cardiovascular disease, and hypertension - and with the prevention and/or treatment of other medical ailments including neural tube defects, osteoporosis, abnormal bower function, and arthritis. There is a need for further investigation of phytochemicals for potential health benefits and possible health risks.

Phytochemicals as Functional Food Ingredients

Phytochemicals are a group of nutritive components found in herbs, fruits, vegetables, grains, legumes, nuts and spices. Phytochemicals can be grouped into five families based on their chemical structure and biological activity (Table 1). The families include terpenes, organosulfur compounds, phenols, organic acids and polysaccharides and lipids.

The primary research areas of phytochemicals are the gastrointestinal system (balanced intestinal flora and function as well as reduction of risk of colorectal cancer), defense against reactive oxidative species and oxidative damage, the cardiovascular system (hypertension, heart function, serum lipoprotein levels, thrombosis, immune processes), substrate metabolism (obesity, insulin resistance syndrome and diabetes, osteoporosis), chemoprevention of cancer (development, growth and differentiation) and behavioral and psychological functions (mood state, cognitive performance).

Functional food ingredients include conventional, synthetic or extracted single components ingredients, plant extracts or complex mixture containing the ingredients and products derived from novel source or processes e.g. products of fermentation or biotechnology. The practical usage of phytochemicals varies depending on the types and efficacy of functional food ingredients (Fig. 1).

Phytochemicals or functional food ingredients from plants confer a variety of physiological functions such as antioxidants, antimutagenic and anticarcinogenic agents, antimicrobial and antiviral substances, enhancers of the gastrointestinal function, immune modulators and stimulators, inflammation-inhibiting substances, cognitive enhancers cholesterol-reducing agents, anti-allergenics, anti-diabetics, (psychrotrophic/neuroregulatory substances),

Table 1. Phytochemicals in foods and their bioactivities

Family	Bioactivities	Food Sources
(1) Terpenes		
Carotenes, Limonoids, saponins	Activae body's protective enzymes, protect eyes, act as antioxidants, modify hormones, help block cholesterol absorption, protect cellular differentiation	Green, red and yellow vegetables and fruits; grains; legumes; nuts; seeds; herbs such as ginseng, chamomile, gotu kola
(2) Organosulfur compounds		
Indol-3-carbinol, thiosul-fonates, isothiocyanates	Boost cancer-fighting enzymes, Block mutagenesis, Inhibit cholesterol synthesis, Lower blood pressure	Cruciferous vegetables; mustard family; onion family
(3) Phenols		
Polyphenols, anthocyanidins, catechins, isoflavones, tannins	Protect heart and vascular system, Protect against colon cancer, Modify hormone response, Prevent dental caries	Berries, grapes, red wine, green leafy vegetables, soy foods, green tea, herbs
(4) Organic acids, Polysaccharides		
Lactones, celluloses, arabinogalactans, pectins, fructans, glucans	Block nitrosamine effects, Promote growth of beneficial intestinal bacteria, Modulate immune system, Help prevent colon cancer	Fruit, mushrooms, yeast, herbs, spices
(5) Lipids		
Isoprenoids, oils, fatty acids, phytosterols	Reduce platelet aggregation, blood clotting, inflammation, nervous system disorders, Balance hormones Modify autoimmune conditions	Dark-green leafy vegetables, nuts, soy oil, wheat germ, herbs, animal foods

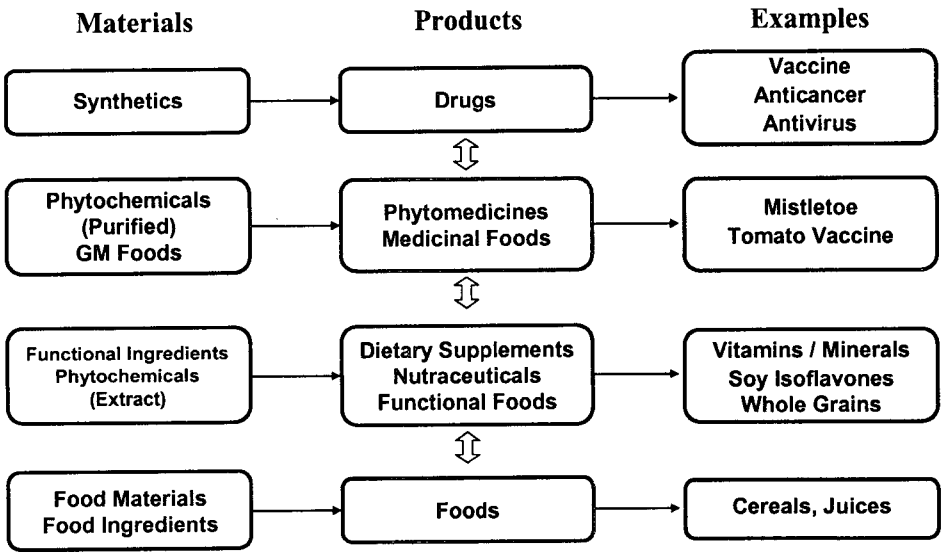

Fig. 1. Phytochemicals and functional foods.

oestrogen-modulators, blood-pressure-reducing agents, etc.

Functional Food Design by Phytochemicals

Functional foods necessitate the six key messages: (1) The food industry has the opportunity to improve the health and well-being of its customers and/or to reduce their risk of disease through foods with added activities.

(2) Functional foods are those that can be demonstrated to benefit target functions in the body in a way that improves the state of health and/or reduces the risk of disease. They are foods that are consumed as part of a normal diet rather than pills or supplements. (3) Foods based on functionality will need to link the scientific basis of such a functionality to the communication of its benefit to the general public. (4) Both the efficacy and the safety of the food components with health benefits will require evidence based on the measurement of scientific biomarkers relevant to their biological responses and health end points. (5) Sound evidence from human studies based on intermediate health end points using accepted biomarkers will provide the basis for promotional messages divided into two categories - enhanced function and reduced risk of disease. (6) Success in solving key scientific and technological challenges will only be achieved by interdisciplinary research programs to exploit the scientific concepts in functional-food science.

Functional foods can be designed by four different ways. First, physiological values for some conventional foods have been newly found, as typically exemplified by whole grain cereals, grape (resveratrol), soy (isoflavone), tomato (lycopene) etc. Second, functional ingredients such as flavonoids, carotenoids, allyl sulfur, dietary fiber, etc can be added in conventional foods to enhance their physiological function. Third, the inherent food components can be changed by enzymatic modification or microbial biotransformation during fermentation. Fourth, functional foods can be developed by removing anti-nutritional or harmful components such as allergens and toxic compounds from conventional foods.

Rice, which has been a principle grain for thousands of years in Asian countries, is herein described as an example for functional food materials. Due to bioactive components abundantly contained in rice, research and industrial applications of rice are being stimulated even in Western countries. Fig. 2 shows various functional ingredients found in rice, which includes phenolic acid (ferulic acid), phytosterol, γ-oryzanol, tocopherol, tocotrienol, phytic acid, arabinozylan, etc. These rice compounds confer a wide range of physiological functions (Table 2). In July 1999, FDA (USA) permitted the whole grain health claim that allows qualifying products to

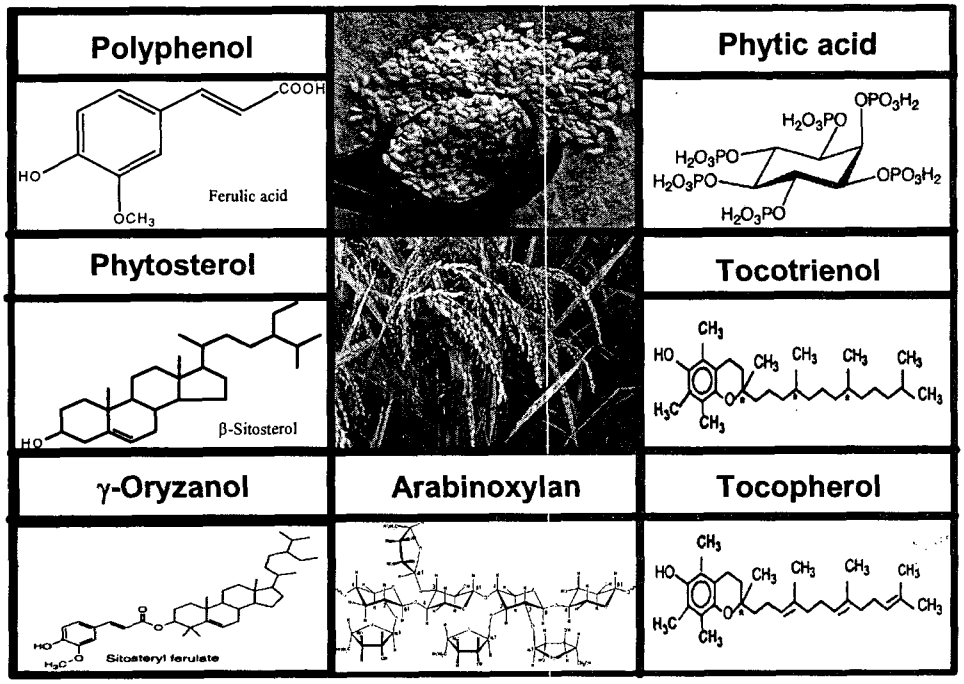

Fig. 2. Phytochemicals and functional food ingredients in rice.

Table 2. Functional compounds of rice and their biological activities

Functional compounds	Major biological activities
Phenolic acid (ferulic acid)	- Antioxidant activity - Radical scavenging activity - UV quenching activity
Phytosterol	- Hypocholestrolemic activity - Reducing risk of coronary heart disease (FDA Health Claim)
γ -Oryzanol	- Antioxidant activity - Cholesterol decreasing activity - Hypolipidemic activity
α -Tocopherol	- Antioxidant activity - UV protecting activity
α -Tocotrienol	- Antioxidant activity - Cholesterol reducing activity - Reducing coronary heart disease (FDA Qualified Hea Claim)
Phytic acid	- Anticancer (prevention & suppression) - Blocking the enzyme affecting cell proliferation
Arabinoxylan	- Immunostimulatory activity - NK (Natural Killer) cell activator

promote the potential risk reduction for heart disease and some cancer: Diets rich in whole grain food and other plant foods low in total fat, saturated fat, and cholestrol may reduce the risk of heart disease and some cancers. Whole grains contain all portions of the grain kernel, and whole grain products contain 51% whole grain ingredients or more by weight per reference amount customarily consumed. It is conceivable that rice is a good source for whole grain products, and thus rice as a whole or functional rice constituents is presently finding various industrial applications.

CONCLUSIONS

Phytochemicals can provide various promising advantages in functional foods: new scientific findings of phytochemical efficacy for human biomarkers, bioactive materials for target-based functional food design by nutri-genomics, practical application of plant genomics for secondary metabolite control, diverse use in foods,

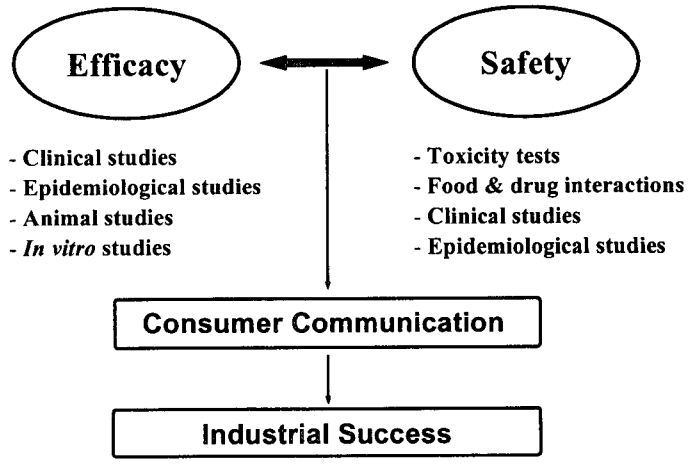

Fig. 3. Integrated approach of phytochemicals and functional foods.

cosmetics, drugs & household products, increasing consumer preference for herb-in-food concept and related products. However, limitations such as inappropriate approach for synergistic effect using the extract, low possibility to find new compound or novel lending compounds and keen competition in international phytochemical business still remains for further studies. It is noteworthy that the in-depth scientific benefit (efficacy) and risk (safety) analysis is indispensable for acquiring the consumer confidence, which will eventually lead the industrial success in the functional food business (Fig. 3).

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