

SEAFAST Center and Department of Food Science and Technology



FUNCTIONAL FOOD AND GUT HEALTH CONCEPT FOR CONSUMER IN SOUTH EAST ASIA

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Outline

- Introduction
- Functional food in Southeast Asia
- Functional food for the future
- Importance of gut health for overall wellbeing
- Role of Pro and Pre-biotic in gut health improvement







INTRODUCTION





The concept of functional foods





Functional foods in global markets





- Functional foods created a lucrative market and becoming an emerging products in food markets
- There is no universally accepted definition of the evolving food category.
 - Many institutions have individual definitions.

Some examples of definition of functional foods



- ILSI: a food can be considered functional if it can demonstrate satisfactorily that it has beneficial effect on one, or improve
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The concept of functional foods embraces those that provide a health benefit beyond basic nutrition as demonstrated to have physiological benefits and/or reduce the risk of chronic diseases

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form of food,

whole foods

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quantities necessary for normal maintenance, growth, and development, and/or other biologically active components that impact health benefits"

General classified of functional foods



- Natural food with improved composition → employing particular agronomic conditions and GE
- Food including a health-promoting component.
- Food from which a component with adverse effect has been removed
- Food in which the nature of one or more of its components has been chemically improved
- Food in which the bioavailability of one or more of its components has been increased

Functional foods may include:

- Conventional foods:
 - Natural
 - Processed
- Modified foods:
 - fortified,
 - enriched or enhanced foods

Bioactive compounds





The functionality of functional foods is derived from bioactive compounds

- Bioactive compounds: extranutritional constituents that typically occur in small quantities in foods.
- Bioactive compounds in functional foods help in:
 - the prevention of (chronic) diseases or
 - the enhancement of performance and wellbeing of the individual beyond their established role in nutritional function: antioxidants, antiinflammatory, antifungal, and various additional preventative properties
- Example: phytochemical, marine-based, animal-based bioactive compounds, microorganisms

The most popular functional food ingredients worldwide

Gut health

Prevention

CHD

Antioxidant

- Probiotics, prebiotics
- Dietary fiber
- Omega 3 fatty acids, oleic acids and phytosterols
- Phytoestrogens
- Phenolic compounds: flavonoids, phenolic acids, and tannins.



Ann Nutr Food Sci. 2018; 2(1): 1015









hiddening rose . That Phillips

Health benefit of fiber



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Class/Components	Source(s) [*]	Potential Benefits(s)
Dietary (functional and	total) Fiber	
Insoluble fiber	wheat bran, corn bran, fruit skins	may contribute to maintenance of a healthy digestive tract; may reduce the risk of some types of cancer
Beta glucan	oat bran, oatmeal, oat flour, barley, rye	may reduce risk of coronary heart disease (CHD)
Soluble fiber	psyllium seed husk, peas, beans, apples, citrus fruits	may reduce risk of CHD and some types of cancer
Whole grains	cereal grains, whole wheat bread, oatmeal, brown rice	may reduce risk of CHD and some types of cancer; may contribute to maintenance of healthy blood glucose levels



Ramesh et al. 2012. IJPRD Vol 4(06):273-290

Potential health benefits of flavonoids



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Class/Components	Source(s) [*]	Potential Benefits(s)		
Flavonoids				
Anthocyanins – Cyanidin,	berries, cherries, red grapes	bolsters cellular antioxidant defenses;		
Delphinidin, Malvidin		may contribute to maintenance of brain		
		function		
Flavanols - Catechins,	tea, cocoa, chocolate, apples,	may contribute to maintenance of heart		
Epicatechins,	grapes	health		
Epigallocatechin,				
Procyanidins				
Flavanones – Hesperetin,	citrus fruits	neutralize free radicals, which may		
Naringenin		damage cells; bolster cellular		
		antioxidant defenses		
Flavonols – Quercetin,	onions, apples, tea, broccoli	neutralize free radicals which, may		
Kaempferol, Isorhamnetin,		damage cells; bolster cellular		
Myricetin		antioxidant defenses		
Proanthocyanidins	cranberries, cocoa, apples,	may contribute to maintenance of		
	strawberries, grapes, wine,	urinary tract health and heart health		
	peanuts, cinnamon			

Ramesh et al. 2012. IJPRD Vol 4(06):273-290

FUNCTIONAL FOODS IN SEA



- In Asia: functional foods have been regarded as integral part of traditional culture:
 - Herbs and spices: Indonesian Jamu
 - Cereals, soybeans and tuber
 - Fruits and Vegetables
 - Tea
 - Mushroom
 - Fermented foods:
 - Soybean based
 - Milk based
 - Fruits and vegetables based



Pre-packed foods and RTE: Snacks (high fiber, probiotic containing snacks etc) Dairy products (mostly beverages) Fruits-vegetables based and high fiber drinks

Fermented food of SEA countries



Substrate	Starter	Products	Country	
Soybean	Mold and natural	Tempe, Tauco	Indonesia, Malaysia	
Milk	Natural	Dadih	Indonesia	1. 1. 1
Vegetables (Mustard)	Natural	Sawi asin, Dakguadong, Dua muoi	Indonesia, Thailand, Vietnam	
Vegetables (Chine leaf)	Contain he	neficial microorganis	m	
Fruits (Durian)			esia, Malaysia	A REAL PROPERTY
Fruits (pak-sian)	and bio	bactive compounds	ind	22.3.3
Fish, shrimp				
Rice/glutinuous rice	Mold, yeast and LAB	Alcoholic foods:Tapai (Indonesia, Malaysia), chao (Cambodia), khaomak (Thailand), basi binubran (Philippines)	SEA	
Sap coconut,	Natural	Alcoholic drink	SEA	
			Lilis Nuraida, 2	21 August 2020

Bioactive compounds and beneficial microorganism of tempe





Also present LAB, Yeast and other bacteria: *C. freundii* dan *K. pneumoniae*

Bioactive compounds	Health Beneficial Effect
Isoflavone aglycone (daidzein, geniestein, glysistein)	Antioxidant, exhibits estrogen-like function
Peptide	Antioxidant and ACE inhibitor
Phenolic compounds	Antioxidant
Vitamin B12 (produced by <i>Citobacter freundii</i> dan <i>Klebsiella pneumonia</i>)	Enrich nutrition
GABA	Antihypertensive
SOD (Superoksida Dismutase),	Free radical scavenger
Carbohydrate containing arabinose	Antimicrobial against diarrhea causing bacteria
Factor 2 (6,7,4¢-trihydroxyisoflavone)	Antioxidant
Fiber/Oligosachahrides	Hypocholesterolemic, prevention CHD
Lactic Acid Bacteria	Immunobiotic, Postbiotic, Paraprobiotics,

Bioactive compounds and beneficial microorganism of fermented milk







Depends on species and/or strains of LAB

Bioactive Compounds	Health Beneficial Effect
Bioactive peptides	Immune modulatory, Antihypertensive, Antimicrobial/bacteriocins Antioxidative
Conjugated linoleic acid (CLA)	Antiinflammatory Antiatherogenic Antioxidant Prevention of cardiometabolic
Microbial exopolysaccharides (EPS); Oligosaccharides	Prebiotic, modify immune system
Vitamins (B12, biotin, and folic acid)	Enrich nutrition
Gamma-aminobutyric acid (GABA)	Antihypertensive
B-galactosidase/lactase	Alleviation lactose intolerance
Lactic acid bacteria	Probiotic, Immunobiotic, Postbiotic, Paraprobiotic

Bioactive compounds and beneficial microorganism of fermented vegetables





- Kimchi contains various health-promoting components, including β-carotene, chlorophyll, vitamin C, and dietary fibre.
- Activities of bioactive compounds: antimutagen, antioxidation, and angiotensin-converting enzyme inhibitor
- Source of LAB (probiotic, postbiotc and paraprobiotic)

Swain et al. 2014. Biotechnology Research International. Article ID 250424.



LAB-fermented fruit juices: apple, pomegranate, appricote and vegetables: tomatoes, red cabbage contains phenolic compounds, GABA, peptides, CLA and folates (vitamin B9) \rightarrow antioxidant activity (Melini et al. Nutrients **2019**, 11, 1189)



Driving force for functional foods:

- Risk of chronic diseases because of stress and changes in eating habits
- Increasing awareness of potentially beneficial effect of healthy foods
- Increased consumer interest in controlling their own health
- The ageing population
- Escalating health care costs
- Increase in disposable income
- Evidence-based science linking diet to chronic disease risk reduction



- Food is as a route to optimal wellness, for prevention of potential disease and health enhancement → demand for more premium products
- Challenges for food manufacturers:
 - produce products that are not only fulfill gastronomic pleasure but will also help reduce the risk of developing different metabolic diseases.
 - personalized nutrition to provide precise solutions to different health problems.

Functional foods and gut microbiota





Alters the microbial metabolites: short-chain fat acids (SCFAs), bile acids (BAs), trimethylamine (TMA) and others

IMPORTANCE OF GUT HEALTH FOR OVERAL WELLBEING





Lilis Nuraida, 21 August 2020

Actinobacteria.

Healthy gut microbiota functions





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Protective Functions Pathogen displacement Nutrient competition Receptor competition Production of anti-microbial factors





Structural Functions Barrier fortification Induction of IgA Apical tightening of tight junctions Immune system development Metabolic Functions Control of epithelial cell differentiation and proliferation Metabolism of dietary carcinogens Synthesis of vitamins Fermentation of non-digestible dietary residue and epithelial-derived mucus Ion absorption Salvage of energy

Grenham et al. 2011. Frontier in Physiology. Vol. 2 Art. 4

Gut microbes are key to many aspects of human health including immune, metabolic and neurobehavioural traits

The role of the gut microbiota in health and disease

- Gut microbiota influences many areas of human health from innate immunity to appetite and energy metabolism
- The gut microbiota affects other organs by produces metabolites (SCFA, Indole propionic acid, TMA) that bring about changes when they reach other organs





Gut-brain-axis



- The concept of the gut-brain axis: a bidirectional channel of communication between the "big brain" and the "little brain"
- There are several routes of communication between the brain and the gut microbiota
 - The vagus nerve;
 - The immune system;
 - Short chain fatty acids (food for the brain);
 - Tryptophan (the precursor to serotonin, which is the primary neurotransmitter)
- An abnormal microbiota: release of inflammatory mediators and other neuroactive molecules result in changes in cognition and behavior.

Alternately, stress can lead to gut dysfunction.



Microbial diversity and relative abundance

(Toribio-Mateas. Microorganisms 2018, 6(35) and Quigley. J. Clin. Med. 2018, 7, 6)

Gut-lung Axis



- Emerged Gut-Lung axis less studied than GBA
- GLA concept involves host—microbe as well as microbe—microbe interactions, based both on localized and long-reaching effects.
- There is a link between gut microbiota and lung immunity.
- Dysbiosis in gut microbiota is associated with lung disorders and respiratory infections.
- The dysbiosis in lung microbiota is also accompanied by disturbances in gut microbiota due to movement of bacteria from their lung into the bloodstream



SCIENCE CHINA Life Sciences, Volume 60, Issue 12: 1407-1415(2017)

Microbiota diversity and health





- A healthy balanced GIT marked by **high diversity** and abundance of microbial population.
- Lactic acid and volatile fatty acid producing bacteria

- Loss of microbial diversity, a pathogenic state of the GIT.
- Disease, infection causing bacteria, toxin production

Preventing dysbiosis is the key, as modulating gut bacteria after infection proves difficult





Alterations in the gut commensal bacterial diversity leads to pathogenesis

Probiotics and prebiotics have prominent roles in restoring commensal gut microbiota. The commonly used probiotics for the treatment are *Lactobacillus, Bifidobacterium*

ROLE OF PRO-PREBIOTICS IN GUT HEALTH



Manipulating gut microbiota

- Probiotics:
 - live microorganisms that, when administered in adequate amounts, confer a health benefit to the host (WHO 2002).
 - Have to go through evaluation in vitro, in vivo and clinical trials: proven beneficial
 - They are usually added to food (both fermented and non-fermented) or taken as food supplements.
- Prebiotics:
 - Definition has evolved
 - Expert panel statement: a substrate that is selectively utilized by host microorganisms conferring a health benefit (ISAPP in 2015)
 - Although all compounds considered prebiotics are microbiota accessible carbohydrates or fermentable dietary fibre, the reverse is not true.

Synbiotics contain a mixture of prebiotics and probiotics

Concept of probiotics





- The concept of traditional probiotics was initially based on the observations of Elie Metchnikoff
 - Suggested that the regular consumption of fermented dairy products with lactic acid bacteria (LAB), such as yogurt, was associated with enhanced health and longevity in elderly Bulgarian people.
 - Some of the bacterial organisms present in the large intestine were a source of toxic substances that contributed to illness and aging
- Acid producing microorganisms in fermented dairy product could lead to a prolongation of the life span of consumers
- It possible to adopt measures to modify the flora in the bodies and to replace the harmful microbes by useful microbes
- The scientific rationale was published in his book "Prolongation of life" (1907)

Beneficial Effect of Probiotic





Probiotic microorganisms



- Originally probiotics have been isolated from healthy human
- Many sources of probiotics are evident such as traditional fermented foods.
- They mostly belong to a limited list of genera, basically, *Lactobacillus spp*. and *Bifidobacterium spp*. Many of them have received GRN and listed on QPS.
- Probiotic properties is strain dependent:
 - Not all species/strains are equal
 - Not all yoghurts or fermented foods are equal

GRN No.	Substance	Date of closure
171	Many others LAB strair	S mber 7,
463	that have been	, 2014
	permitted and used	
	commercially includin	g
357	non-lactic acid bacteria	, 2011
502	Saccharomyces	€,
758	cerevisiae (boulardii)	, 2018
	and Bacillus coagulan	S
	Rosell®-71 (R0071)	

Example of probiotic potency of LAB isolated from Indonesian foods



LAB	Source	Potency
<i>L. plantarum</i> BSL	Indonesian sauerkraut	Protect the gastrointestinal from infection in rats by <i>L. monocytogenes</i> ATCC 7644, reduced all type of liver and spleen damage (Meiyasa, 2019); down-Regulate gluconeogenesis gene expression in streptocozin-induced diabetic rats (Farida et al. 2020)
<i>L. rhamnosus</i> R23	Breast milk	Preventing diarrhea in rats infected by EPEC (Nuraida et al. 2012); down- Regulate gluconeogenesis gene expression in streptocozin-induced diabetic rats (Farida et al. 2020)
<i>L. acidophillus</i> 2B4, L. plantarum 2C12	Raw meat	Preventing diarrhea in rats infected by EPEC (Arief et al. 2010&2012
<i>L. plantarum</i> IS- 10506	Dadih	Increased secretory IgA and immune respon in children younger than 2 yeas (Kusumo et al. 2019); increase SCFA of women with functional constipation (Kusumo et al. 2019),
<i>L. plantarum</i> Dad 13	Dadih	decreased the number of Enterobacteriaceae, Coliform non <i>E. coli</i> and <i>Esherichia coli</i> (Rahayu et al. 2016); decreased <i>E. coli in feces</i> (Banin et al., 2019)





ISAPP 2017: a substrate that is selectively utilized by host microorganisms conferring a health benefit. https://www.nature.com/arti cles/nrgastro.2017.75.pdf Selective utilization Substances that by host microorganisms affect the microbiome Prebiotic* Not Prebiotic Dietary fibre Probiotics CLAs and Human milk Readily less Proteins PUFAs oligosaccharides fermentable fermentable and fats Oligosaccharides Phenolics and e.g. FOS, Inulin, Vitamins GOS, MOS, XOS Antibiotics phytochemicals

Prebiotics and their effect

- Prebiotics require selective utilization by live host microorganisms, to sustains, improves or restores host health.
- The criterion of selective utilization distinguishes prebiotics from many of these other substances

htps://www.nature.com/art cles/nrgastro.2017.75.pdf

Table 1 Health end points targeted in human	n trials of orally administered prebiotics
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Health end point	Prebiotic used
Metabolic health: overweight and obesity; type 2 diabetes mellitus; metabolic syndrome and dyslipidaemia; inflammation	Inulin, GOS, FOS
Satiety	FOS
Stimulation of neurochemical-producing bacteria in the gut	GOS
Improved absorption of calcium and other minerals, bone health	Inulin, FOS
Skin health, improved water retention and reduced erythema	GOS
Allergy	FOS, GOS
IBD	Inulin, lactulose
Urogenital health	GOS
Bowel habit and general gut health in infants	GOS, FOS,
Infections and vaccine response	FOS, GOS, polydextrose
Necrotizing enterocolitis in preterm infants	GOS, FOS
IBS	GOS
Traveller's diarrhoea	GOS
Constipation	Inulin
Immune function in elderly individuals	GOS
FOS, fructooligosaccharides; GOS, galactooligosaccharides.	

Prebiotic mechanisms



Current health benefit prebiotics are evolving (ISAPP, 2017) to:

- the GIT: inhibition of pathogens, immune stimulation,
- Cardiometabolism: reduction in blood lipid levels, effects upon insulin resistance,
- mental health: brain function and cognition

• Bone: mineral

bioavailability



Natural sources of prebiotics



Prebiotics

Fructo-oligosaccharides Inulin

Isomalto-oligosaccharides Lactulose Lactosucrose Galacto-oligosaccharides

Soybean oligosaccharides Xylo-oligosaccharides Fructo-oligosaccharides Arabinoxylan Arabinoxylan oligosaccharides Resistant starch-1,2,3,4

Onion, Leek, Asparagus, Chicory, Jerusalem artichoke, Garlic, Wheat, Oat Agave, Banana/Plantain, Burdock Camas, Chicory, Coneflower, Costus, Dandelion, Elecampane, Garlic, Globe artichoke, Jerusalem artichoke, Jicama, Leopard's bane, Mugwort root, Onion, Wild yam, Yacón Miso, Soy, Sauce, Sake, Honey Skim milk Milk sugar Lentil, Human milk, Chickpea/hummus, Green pea, Lima bean, Kidney bean Soybean Bamboo shoot, Fruits, Vegetables, Milk, Honey Onion, Chicory, Garlic, Asparagus, Banana, Artichoke Bran of grasses Cereals Beans/legumes, Starchy fruits and vegetables (e.g. bananas), Whole grains

Kerry et al. 2018. J Food and Drug Analysis 2 6:927-939

Effect bioactive compounds as prebiotic toward gut microbiota composition

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Dietary element	Effect on gut microbiome	Effect on health outcomes mediated by gut microbiome	Reference
Fiber and prebiotics	Increased microbiota diversity and SCFA production	Reduced type 2 diabetes and cardiovascular disease	Valdes et al. BMJ 2018;36
Polyphenols (eg, from tea, coffee, berries, and vegetables such as artichokes, olives, and asparagus)	Increased intestinal barrier protectors and butyrate producing bacteria Decreased lipopolysaccharide producers	Gut micro-organisms alter polyphenol bioavailability resulting in reduction of metabolic syndrome markers and cardiovascular risk markers	1:k2179
No-digestible Carb (Dietary fiber, whole barley, Resistant strach)	Increase butyrate producing bacteria	Reduced inflammation	Anand&Mand e, 2018
Non-digestible Carb (FOS, GOS, polydextrose)	Reduce Enterococcus and Clostridia	Reduced inflammatory respon	



Combintion



Mixtures of probiotics and prebiotics: improving the survival and implantation of live microbial dietary supplements in the gastrointestinal tract

Syndiotics	
Prebiotics	Probiotics
Fructo-oligosaccharides	Bifidobacteria, Bacteroides fragilis, Peptostreptococcaceae, Klebsiellae
Inulin	Bifidobacterium animalis, Lactobacillus acidophilus, Lactobacillus paracasei
Isomalto-oligosaccharides	Bifidobacteria, Bacteroides fragilis group
Lactulose	Bifidobacteria lactis, Lactobacillus bulgaricus, L. acidophilus, L. rhamnosus
Lactosucrose	Zymomonas mobilis
Xylo-oligosaccharides	Bifidobacterium adolescentis, L. plantarum
Galacto-oligosaccharides	Bifidobacterium longum, B. catenulatum
Fructo-oligosaccharides	Bifidobacterium bifidum, B. lactis
Arabinoxylan and Arabinoxylan oligosaccharides	Bifidobacterium sp.
Resistant starch-1,2,3,4	Bacteroides, Eubacterium rectal

Kerry et al. 2018. J Food and Drug Analysis 26: 927-939

Application probiotics in foods





Prebiotic and bioactive compounds may be added \rightarrow synbiotics

Summary



- Functional foods further solidify Hippocrates's idea to "let thy food be thy medicine"
- The probiotic concept was coined to reflect Elie Metchnikoff's idea.
- Health of human digestive system is closely link to their overall health, as it interacts and influences so many systems and processes in the body, including immune, metabolic and neuro-behavioral traits
- Gut microbiota interact with the health status of other organs, new area studied: Gut-brain axis and Gut-lung axis.
- Bioactive compounds in functional foods affect microbial diversity and are metabolized to produce beneficial substances by gut microbiota
- The benefits of probiotics and prebiotics has been expanded to the site other than gastrointestinal tract, including cardiometabolism, mental health, and immune system.







Thank you



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