Functional Foods and Dietary Supplements
PROCESSING EFFECTS AND HEALTH BENEFITS

EDITED BY
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WILEY Blackwell
Functional Foods and Dietary Supplements
## Contents

List of Contributors vii
Preface ix

### I Fundamentals of Functional Food Processing

1 Functional Foods, Nutraceuticals and Probiotics as Functional Food Components 3
   Athapol Noomhorm, Anil Kumar Anal and Imran Ahmad

2 Bioactive Components in Foods 21
   Anil Kumar Anal, Kishore K. Kumaree and Mridula Thapa

### II Major Sources of Functional Foods

3 Processing Effects on Functional Components in Cereals and Grains 63
   Binod K. Yadav and J. Jerish Joyner

4 Tropical Fruits 91
   Mandeep Kaur and H.K. Sharma

5 Bioactive Compounds in Meat and their Functions 113
   Punchira Vongsawasdi and Athapol Noomhorm

6 Bioactive Materials Derived from Seafood and Seafood Processing By-products 139
   Ratih Pangestuti and Se-Kwon Kim

7 Food Processing By-products as Sources of Functional Foods and Nutraceuticals 159
   Nina Karla M. Alparce and Anil Kumar Anal

8 Functionality of Non-starch Polysaccharides (NSPs) 187
   Kelvin K.T. Goh, Ramesh Kumar and Shen-Siung Wong
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Resistant Starch: Properties, Preparations and Applications in Functional Foods</td>
<td>Taslima Ayesha Aktar Nasrin and Anil Kumar Anal</td>
<td>227</td>
</tr>
<tr>
<td>10</td>
<td>Isoflavones – Extraction and Bioavailability</td>
<td>Khoomtong Atcharaporn, Pananun Thawunporn and Buddhi Lamsal</td>
<td>255</td>
</tr>
<tr>
<td><strong>III</strong></td>
<td><strong>Processing Effects on the Functional Components during Product Development</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Thermal and Non-thermal Processing of Functional Foods</td>
<td>Jiraporn Sripanyowanich Jongyingcharoen and Imran Ahmad</td>
<td>297</td>
</tr>
<tr>
<td>12</td>
<td>Changes of Properties and Functional Components of Extruded Foods</td>
<td>Vilai Rungsardthong</td>
<td>325</td>
</tr>
<tr>
<td>13</td>
<td>Recent Advances in Applications of Encapsulation Technology for the Bioprotection of Phytonutrients in Complex Food Systems</td>
<td>Alisha Tuladhar and Anil Kumar Anal</td>
<td>363</td>
</tr>
<tr>
<td>14</td>
<td>The Effect of Irradiation on Bioactive Compounds in Plant and Plant Products</td>
<td>Nantarat Na Nakonpanom and Porntip Sirisootalalak</td>
<td>387</td>
</tr>
<tr>
<td>15</td>
<td>Nanoparticles and Nanoemulsions</td>
<td>Anges Teo, Kelvin K.T. Goh and Sung Je Lee</td>
<td>405</td>
</tr>
<tr>
<td><strong>IV</strong></td>
<td><strong>Health Benefits and Bioavailability of Functional Foods</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Pharmacology and Health Benefits of Bioactive Food Sources</td>
<td>Maushmi S. Kumar and Shruti Mishra</td>
<td>439</td>
</tr>
<tr>
<td>17</td>
<td>Potential Cardio-protective Effects of Functional Foods</td>
<td>Eman M. Alissa and Gordon A. Ferns</td>
<td>463</td>
</tr>
<tr>
<td></td>
<td>Index</td>
<td></td>
<td>489</td>
</tr>
</tbody>
</table>
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Growing evidence supports the observation that functional foods containing physiologically active components, either from plant or animal sources, may enhance health. Health-conscious consumers are increasingly seeking out functional foods in an effort to improve their own health and well-being. Publishing in functional foods is mostly limited to the health benefits of functional foods, such as their antioxidant and anticancer activities. In fact, identification of the suitable extraction or processing techniques for these functional components is imperative in maximizing their beneficial activities. For instance, most functional plants or herbs should be dried and ground to facilitate the extraction process. In order to extract curcuminoids, which are the major antioxidant compounds in turmeric, different drying methods have been found to affect the extracted content of curcuminoids. Among hot air, vacuum, infrared, infrared-convection, infrared-vacuum and fluidized bed drying methods, significantly the highest curcuminoid content was obtained from infrared-vacuum drying. This is an example of how processing affects the physiologically active components of functional foods.

This book, therefore, is written with the aim of highlighting the processing effects on active ingredients in various functional food materials, such as turmeric, pomegranate, drumstick leaves, jackfruit seeds, brown rice, etc. The book will be of interest to food scientists and the food industry, particularly those who are working on products for which health claims are being made.

The first section of the book introduces some of the fundamentals of functional ingredients; definitions and classification; prebiotics and probiotics, biochemical pathways; critical steps in processing the functional food; product developments and industrial trends. The second part focuses on the major sources of functional foods. Here the emphasis is again on the impact of processing, for example the effect of drying temperature on the activity of isoflavones from soybeans and the changes in γ-aminobutyric acid (GABA) from germinated brown rice, etc. In the third part, the challenges faced during the extraction, processing and application of functional ingredients are addressed. Dedicated chapters cover various techniques such as extrusion, drying, thermal and non-thermal processing as well improvements to processes like, encapsulation, among others.

One of the objectives of writing this book was to compile the available evidence on the health benefits and disease prevention claims for functional foods. This is a major challenge faced by the industry today. The chapters included in the fourth section address the pharmacology of bioactive compounds and their cardioprotective effects.
Finally, we have tried to make the book interesting to people from varied scientific and clinical backgrounds with the assumption that the readers will have a basic knowledge of nutrition and food processing. We, therefore, hope that the book will be of use to those interested in dietary supplements and the development of products that have a beneficial health claim.

Athapol Noomhorm
Imran Ahmad
Anil Kumar Anal

Editors
I
Fundamentals of Functional Food Processing
1.1 Functional food

Eating food is no longer limited to just satisfying the appetite or providing basic nutrition. Consumers are driven by many issues related to health concerns, the negative effects of unhealthy food and a desire to have a healthier lifestyle, which have significantly changed modern attitudes towards food habits. Functional food can thus be summarized as the complete package of fundamental needs plus additional food ingredients that can play an important role in decreasing health risks and also improving health. The modern thirst for a healthy life through food was visualised 2500 years ago by Hippocrates in his famous doctrine ‘Let food be thy medicine and medicine be thy food’.

The term ‘functional food’ was first used by the Japanese in the mid 1980s. But in the past decade the market has expanded to the United States, northern Europe and central European countries (Menrad, 2003). Functional foods fall into two broad categories: plant origin and animal origin.

1.1.1 Functional components from plant origin

A plant-based diet can help to cure chronic diseases, especially cancer. A review conducted in 1992 showed that the risk of cancer among people consuming fruits and
vegetables is only half that of those consuming lesser amounts of these foods (Block et al., 1992). This proves that plant-based foods have some components that act against such lethal diseases. Such chemicals were classified by Steinmetz and Potter (1991) as phytochemicals. They identified a few such active plant components.

**Oats**  Oats is the most studied dietary supplement that is capable of lowering cholesterol as it contains β-glucan. The food with the highest amount of β-glucan was reported in oats (Wood and Beer, 1998; Manthey et al., 1999). Decreasing the level of low density cholesterol (LDL) can reduce the chances of coronary heart disease (CHD). Researchers have also shown that the hypocholesterolaemic effect of β-glucan can result in a 20–30% reduction of LDL-cholesterol, hence the chance of getting heart problems also decreases.

**Flax seed**  The use of flaxseed (*Linum usitatissimum*) as a suitable additive in functional food has become more widespread because of its potential health benefits, such as reducing the risk of heart disease (cardiovascular disease, CVD) (Bloedon and Szapary, 2004), diabetes (Haliga et al., 2009) and also in cancer. Phipps et al. (1993) have shown that the daily intake of 10g of flaxseed can elicit several hormones which can reduce the risk of breast cancer. The health qualities of flaxseeds are mainly due to the presence of high omega-3 fatty acids; almost 57% of its oil is α-linoleic acid (ω-3). As well as this it contains a high amount of dietary fibre (both soluble and insoluble), proteins and antioxidants such as lignan. The presence of phenolic compounds in flaxseed such as lignan, secoisolariciresinol diglucoside (SDG) and ferulic acid gives flax seed its antioxidant properties (Kasote et al., 2011).

**Garlic**  This has been widely quoted as a plant with medicinal properties. The medicinal components of garlic have been shown to inhibit tumour genesis. It has also the potential to reduce the risk of cancer (Dorant et al., 1993) by protecting against carcinogenic agents. The main factor contributing to this are its sulfur constituents, which can suppress tumour formation in breast, colon, skin or lung cancer (Amagase and Milner, 1993). It has been reported that garlic has ten different types of natural sugars. Garlic can help reduce blood sugar levels (Sheela et al., 1995; Augusti and Sheela, 1996). It has been suggested that it is the best source of the nucleic acid adenosine, a building block of DNA and RNA (Blackwood and Fulder, 1987). Nearly 33 different sulfur compounds, enzymes, 17 amino acids and minerals have been reported in garlic (Newall et al., 1996).

Fibre is also added to food products to help maintain a healthy digestive tract, for example Yugao Bijin from Tokyo Tanabe Co. is a fibre enriched pasta, and Caluche is a snack product from Nissin Foods that is rich in fibre.

### 1.1.2 Functional components from animal resources

A vast number of components naturally present in animal sources are potentially beneficial to health.

**Fish oil**  Omega-3 fatty acids are a major component of polyunsaturated fatty acids (PUFA) from fish oil. Omega-3 has many health benefits. It has been found that a
daily intake of docosahexaenoic acid (DHA) up to 0.5–0.7 g decreases the chances of CHD (Kris-Etherton, Harris and Appel, 2002). Omega-3 supplements can be taken if our everyday food is deficient in omega-3. Omega-3 FA also has beneficial effects in rheumatoid arthritis, inflammatory diseases such as asthma (Reisman et al. (2006), cystic fibrosis and bowel diseases. A high DHA content in the body can help decrease the risk of Alzheimer’s disease.

**Dairy products**  Dairy products are undoubtedly a good source of functional components, one major ingredient being calcium, a nutrient required to prevent osteoporosis and possibly also colon cancer. Milk has potential probiotic components which are a good source of food for the beneficial microbial flora inside the gut. The term probiotics was defined by Gibson and Roberfroid (1995) as ‘non-digestible food that beneficially affect the host by selectively stimulating the growth of gut microbial flora’. These may include different dietary fibres, starches, sugars that do not get absorbed directly, sugar alcohols and oligosaccharides (Gibson et al., 1996).

### 1.1.3 Examples of functional foods widely popular in the market

The development of drinks as functional foods has grown widely in and is an easy way to satisfy consumer demand for these foods. Most of these drinks contain dissolved fibres, minerals and vitamins. For example, Pocari Sweet Stevia from Ootsuka, is a sport drink that contains a glucose substitute sweetener (a glycoside from the Stevia plant); and Fibi, a soft drink from Coca-Cola, contains a high amount of fibre, is mainly focused on improving the digestive system.

The first probiotic product launched in market was Yakult from Yakult Honsha, a probiotic yoghurt drink, which contains *Lactobacillus* and *Bifidobacterium*. The health benefits related to these probiotic products are increased digestive control, inhibition of pathogenic flora, immune power stimulation, reduced risk of tumour genesis, production of vitamins (especially B vitamins) and generation of bacteriocins (Potter, 1990; Sanders et al., 1991). For example, Yoplait’s low-fat yoghurt Yo-Plus, with probiotic bacteria (*Bifidobacterium lactis*) mixed with probiotic (inulin) provides a perfect symbiotic combination, and a live active natural cheese product launched by Kraft contains probiotic strains *Lactobacillus lactis* for better digestive health.

### 1.2 Nutraceuticals

Nutraceuticals are a type of dietary supplement that delivers a concentrated form of a biologically active component from a food, presented in a non-food matrix, to enhance health in dosages that exceed those that could be obtained from regular food (Zeisel, 1999). A nutraceutical is a product isolated or purified from foods that is generally sold in medicinal forms not usually associated with food. A nutraceutical is demonstrated to have a physiological benefit or provide protection against chronic diseases (DeFelice, 1992).

The term ‘nutraceuticals’ was first coined by the Foundation for the Innovation in Medicine.
The actual boundary between functional food and nutraceuticals is not clear. It can be explained with the help of a simple example: if a phytochemical extract with medicinal value is included in a food product, i.e. 200 mg of the extract needs to be incorporated into 1 litre of orange juice, we get a new functional food. The same 200 mg extract can be marketed in the form of a capsule as a new nutraceutical.

A major source of nutraceuticals is omega-3 fatty acids (PUFA) from fish oils. These contain high amounts of eicosapentanoic acid (EPA) and docosahexaenoic acid (DHA), categories of fatty acids that have a protective effect against cardiovascular disease and inflammatory disease and also affect other chronic diseases. Fish oil mainly prohibits the end-organ effects of tumour-derived lipolytic and proteolytic factors, influencing the action of many receptors as well as enzymes which function during cellular signalling.

The non-essential amino acid arginine has received much attention as it has efficient immune stimulation properties. Arginine was also effective in some clinical conditions in improving the cellular immune system, increasing phagocytosis and the proper maintenance of T cells. Arginine enhances the suppressed immune response of individuals that have injury diseases, surgical trauma or malnutrition (Kirk and Barbul, 1990; Evoy et al., 1998).

Table 1.1 lists functional components extracts and the effects of applying them in medicinal form, so that their consumption becomes easier.

**Table 1.1** Functional component extracts and the effect of applying them in medicinal form

<table>
<thead>
<tr>
<th>Supplement</th>
<th>Composition</th>
<th>Dose (per day) and assay period</th>
<th>Subjects</th>
<th>Effect</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grape seed extract</td>
<td>Oligomeric procyanidins</td>
<td>200–300 mg/day; 1 year</td>
<td>3 patients with chronic pancreatitis</td>
<td>Reduction of chronic pancreatitis, vomiting and pain</td>
<td>Banerjee and Bagchi, 2011</td>
</tr>
<tr>
<td>Mixture of grape, bilberry and cranberry extract (capsule)</td>
<td>Oligomeric procyanidin</td>
<td>320 mg/day</td>
<td>13 menopausal women</td>
<td>Reduction of fluid retention</td>
<td>Christie et al., 2004</td>
</tr>
<tr>
<td>Soya supplement</td>
<td>Isoflavones</td>
<td>60 mg (3 months)</td>
<td>33 postmenopausal women</td>
<td>Significant cognitive improvement</td>
<td>Duffy et al., 2003</td>
</tr>
<tr>
<td>Red clover supplement</td>
<td>Isoflavones</td>
<td>80 mg (90 days)</td>
<td>60 postmenopausal women</td>
<td>Decrease of menopausal symptoms. Positive effect on vaginal cytology and triglycerides</td>
<td>Hidalgo et al., 2005</td>
</tr>
<tr>
<td>Red clover extract capsule</td>
<td>Isoflavones</td>
<td>100 mg (6 months)</td>
<td>30 postmenopausal women</td>
<td>Hypoglycaemic</td>
<td>Cheng et al., 2004</td>
</tr>
</tbody>
</table>

1.3 Functional food market

Research indicates that there is an estimated global market for functional foods of US$33 billion (Hilliam, 2000c). Functional foods account for 2% of the US food market. Another competing market is Japan, which focuses mainly on health claims. The concept of ‘functional foods’ was first introduced by Japan in 1984 (Hosoya, 1998), and between 1988 and 1998 (Heasman and Mellentin, 2001) the number of functional food products reached nearly 1700, with an estimated turnover of US$14 billion in 1999 (Hilliam, 2000). Within the European market, functional foods have a monetary value of US$4–8 billion (Hilliam, 2000). Figure 1.1 illustrates the main categories of functional foods in Germany.

Functional benefits may provide added value to consumers but cannot outweigh the sensory properties of foods. By purchasing functional foods in general consumers may achieve a modern and positive impression of themselves. These products provide consumers with an alternative way to achieve a healthy lifestyle that differs from conventional healthy diets defined by nutrition experts. In general, the attitude both to functional foods and to their consumers is positive, so such a concept represents a sustainable trend in a multi-niche market (see Table 1.2).

1.4 Probiotics

The market of functional food is growing through the continuous development of technology. Functional food with added probiotic has gained the attention of many researchers. The use of probiotics in combination with prebiotic has been very effective against several chronic diseases. Probiotics have been defined as the ingested live
Table 1.2 Some commercial examples of probiotic products

<table>
<thead>
<tr>
<th>Brand/trade name</th>
<th>Description</th>
<th>Producer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actimel</td>
<td>Probiotic drinking yogurt with <em>L. casei</em> Imunitas® cultures</td>
<td>Danone, France</td>
</tr>
<tr>
<td>Activia</td>
<td>Creamy yogurt containing <em>Bifidus ActiRegularis</em>®</td>
<td>Danone, France</td>
</tr>
<tr>
<td>Gefillus</td>
<td>A wide range of LGG products</td>
<td>Valio, Finland</td>
</tr>
<tr>
<td>Hellus</td>
<td>Dairy products containing <em>Lactobacillus fermentum ME-3</em></td>
<td>Tallinna Piimatööstuse AS, Estonia</td>
</tr>
<tr>
<td>Jovita Probiotisch</td>
<td>Blend of cereals, fruit and probiotic yogurt</td>
<td>H&amp;J Bruggen, Germany</td>
</tr>
<tr>
<td>Pohadka</td>
<td>Yogurt milk with probiotic cultures</td>
<td>Valaˇsk´e Meziˇr´ıˇc´ı Dairy, Czech Republic</td>
</tr>
<tr>
<td>ProViva</td>
<td>Refreshing natural fruit drink and yogurt in many different flavours containing <em>Lactobacillus plantarum</em></td>
<td>Skåne mejerier, Sweden</td>
</tr>
<tr>
<td>Rela</td>
<td>Yogurts, cultured milks and juices with <em>L. reuteri</em></td>
<td>Ingman Foods, Finland</td>
</tr>
<tr>
<td>Revital Active</td>
<td>Yogurt and drink yogurt with probiotics</td>
<td>Olma, Czech Republic</td>
</tr>
<tr>
<td>Snack Fibra</td>
<td>Snacks and bars with natural fibers and extra minerals and vitamins</td>
<td>Celigüeta, Spain</td>
</tr>
<tr>
<td>SOYosa</td>
<td>Range of products based on soy and oats and includes a refreshing drink and a probiotic yogurt-like soy-oat product</td>
<td>Bioferme, Finland</td>
</tr>
<tr>
<td>Soy treat</td>
<td>Kefir type product with six probiotics</td>
<td>Lifeway, USA</td>
</tr>
<tr>
<td>Yakult</td>
<td>Milk drink containing <em>Lactobacillus casei</em> Shirotia</td>
<td>Yakult, Japan</td>
</tr>
<tr>
<td>Yosa</td>
<td>Yogurt-like oat product flavoured with natural fruits and berries containing probiotic bacteria (<em>Lactobacillus acidophilus, Bifidobacterium lactis</em>)</td>
<td>Bioferme, Finland</td>
</tr>
<tr>
<td>Vitality</td>
<td>Yogurt with pre- and probiotics and omega-3</td>
<td>Müller, Germany</td>
</tr>
<tr>
<td>Vifit</td>
<td>Drink yogurts with LGG, vitamins and minerals</td>
<td>Campina, the Netherlands</td>
</tr>
</tbody>
</table>

Source: Siró et al., 2008. Reproduced with permission from Elsevier B. V.

bacteria which are responsible for providing a healthy life. The gut microflora plays an important role in maintaining stable health and disease protection (Steer et al., 2000). The metabolic activity of the gut flora provides up to 50% of the energy required by the host body’s gut wall through the fermentation of carbohydrates into organic acids (Figure 1.2).

### 1.4.1 Role of probiotics

Probiotics and prebiotics provide an alternate source for the management of different intestinal disorders. It was demonstrated that the bacterial count in the faecal matter of children is more than in adults, with high amounts of *Lactobacillus* and *Bifidobacterium*. Disorders such as gastroenteritis unbalance the biochemical environment of the gut, but the intake of probiotic functional food can stabilize the colonic microflora and also help in their maintenance against the adverse effect of antibiotics. Figure 1.3 shows a recent study of the probiotic mechanism on health enhancement.

The major contributions associated with the work of probiotics on human health are proper colonic function and increased metabolism. They are also responsible for the enhancing the expression of short chain fatty acids, the increase in faecal weight, decreased colon pH, reduced release of nitrogenous material from the body
1.5 Prebiotics

Prebiotics are foods that are beneficial but cannot be digested by the host’s metabolism and can help in the growth and other activities of beneficial bacteria residing in the human gut. This indirectly improves the host’s health (Gibson and Roberfroid, 1995).

Widely used prebiotics are inulin, fructo-oligosaccharide (FOS), lactulose and galacto-oligosaccharides (GOS). They improve the composition of the gut microbiota to give enhanced numbers of beneficial bacteria. Though there is no fixed recommendation for the daily intake of prebiotics, one study has shown that 4–20 g/day gives good results (K.M. Tuohy et al., unpublished data). Research data on inulin and reductive enzymes (Bournet, Brouns, Tashiro and Duvillier, 2002; Forchielli and Walker, 2005; Qiang, YongLie and QianBing, 2009). Table 1.3 shows some contributions of probiotics.
Figure 1.3 Some probiotic mechanisms that induce several beneficial host responses. Most effects consist of (1) Exclusion and competing with pathogen to epithelial cells adhesion, (2) innate immune stimulation, (3) competition for nutrients and prebiotic products, (4) production of antimicrobial substances and thereby pathogen antagonism, (5) protection of intestinal barrier integrity and (6) regulation of anti-inflammatory cytokine and inhibition of pro-inflammatory cytokine production. IEC, intestinal epithelium cells; DC, dendritic cell; IL, interleukin; M, intestinal M cell. Source: Saad et al., 2013. Reproduced with permission from Elsevier. For colour details, see the colour plates section.

or FOS intake suggest that 4 g/day is needed to increase *Bifidobacteria* (Roberfroid et al., 1995).

### 1.5.1 Sources of prebiotic

Prebiotics are mainly obtained from plant sources and algae polysaccharides. The extraction is carried out either by a chemical process which hydrolyses the polysaccharides or by an enzymatic process of synthesis from disaccharides (Nugent, 2000; Mussamatto and Mancilha, 2007). The main prebiotics in use are FOS, GOS, isomaltooligosaccharides (IMO) and xylo-oligosaccharides (XOS). Primarily oligosaccharides, such as soy oligosaccharides (SOS), GOS and XOS are also marketed in Japan (Ouwehand, 2007).

Currently, inulin is the major prebiotic made. It is produced by chemical synthesis using transglycosylation, which produces polysaccharides from monosaccharides and disaccharides. Figure 1.4 shows a brief description of the process of transglycosylation (Delattre et al., 2005; Barreteau et al., 2006).
Table 1.3 The contributions of probiotics

<table>
<thead>
<tr>
<th>Disease type</th>
<th>Contribution by the probiotics</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intestinal flora</td>
<td>Inhibits the growth of pathogenic species like <em>S. dysenteriae, S. typhosa and E. coli</em> and this results in reduced diarrhoea and vomiting</td>
<td>Asahara <em>et al.</em>, 2001</td>
</tr>
<tr>
<td>Lactose intolerance</td>
<td>Lactose supplement could help in the digestion of lactose by helping in its fermentation.</td>
<td>Jiang and Savaiano, 1997</td>
</tr>
<tr>
<td>Preventing cancer</td>
<td>Recent research showed that butyric acid production by the fermentation of probiotics plays a lead role in cancer prevention. This acid helps in the chemoprevention of carcinogenesis, and also against colon cancer by the promotion of differentiation of cell. Another breakthrough is that propionate has an anti-inflammatory effect on colon cancer cells. In another study, probiotics showed the inhibition of colon tumor forming azoxymethane by the probiotics in association with prebiotics (inulin)</td>
<td>Femia <em>et al.</em>, 2002; Pool-Zobel, 2005; Munjal <em>et al.</em>, 2009; Verghese <em>et al.</em>, 2002; Kim <em>et al.</em>, 1982</td>
</tr>
<tr>
<td>Lipid metabolism</td>
<td>Probiotics have been proven to show a positive effect on the hepatic lipid metabolism. Experiment of RTS has shown a decrease in cholesterol and triglycerides levels by 15% and 50% respectively due to the suppression of lipogenic enzyme activity</td>
<td>Delzenne <em>et al.</em>, 2002; Fiordaliso <em>et al.</em>, 1995; Delzenne and Kok, 2001; Williams and Jackson, 2002</td>
</tr>
</tbody>
</table>

Figure 1.4 Synthesis of oligosaccharides by glycosylation using (a) a chemical process and (b) an enzymatic process with glycosyltransferases. *Source: Saad et al.*, 2013. Reproduced with permission from Elsevier
### Table 1.4  Potential probiotic traditional fermented foods

<table>
<thead>
<tr>
<th>Product</th>
<th>Probiotic microorganisms</th>
<th>Substrates</th>
<th>Published references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adai</td>
<td>LAB</td>
<td>Cereal, legume</td>
<td>Farnworth, 2005</td>
</tr>
<tr>
<td>Agbelima</td>
<td><em>Lb. plantarum</em>, <em>Lb. brevis</em>, <em>Lb. fermentum</em>, <em>Leuc. mesenteroides</em></td>
<td>Cassava</td>
<td>Amoaa-Awua et al., 2005</td>
</tr>
<tr>
<td>Atole</td>
<td>LAB</td>
<td>Maise</td>
<td>Escamilla-Hurtado et al., 1993</td>
</tr>
<tr>
<td>Ben-saalga</td>
<td>LAB</td>
<td>Pearl millet</td>
<td>Tou et al., 2006</td>
</tr>
<tr>
<td>Boza</td>
<td><em>Lb. plantarum</em>, <em>Lb. brevis</em>, <em>Lb. rhamnosus</em>, <em>Lb. fermentum</em>, <em>Leuc. mesenteroides</em> subsp. <em>dextranium</em></td>
<td>Cereals</td>
<td>Hancioglu and Karapinar, 1997; Moncheva et al., 2003; Botes et al., 2007; Todorov et al., 2008</td>
</tr>
<tr>
<td>Dosa</td>
<td><em>Leuc. mesenteroides</em>, <em>Lb. fermentum</em>, <em>Sacch. cerevisiae</em></td>
<td>Rice and Bengal gram</td>
<td>Soni et al., 1986</td>
</tr>
<tr>
<td>Idli</td>
<td><em>Leuc. mesenteroides</em>, LAB, yeast</td>
<td>Cereal, legume</td>
<td>Agrawal et al., 2000; Aidoo et al., 2006; Balasubramanian and Viswanathan, 2007</td>
</tr>
<tr>
<td>Ilambazi lokubilisa</td>
<td>LAB</td>
<td>Maize</td>
<td>Farnworth, 2005</td>
</tr>
<tr>
<td>Kecap</td>
<td>LAB</td>
<td>Wheat, soybeans</td>
<td>Roling et al., 1999</td>
</tr>
<tr>
<td>Kimchi</td>
<td><em>Lb. plantarum</em>, <em>Lb. curvatus</em>, <em>Lb. brevis</em>, <em>Lb. sake</em>, <em>Leuc. mesenteroides</em></td>
<td>Vegetables</td>
<td>Chin et al., 2006; Lee et al., 2006; Lee and Lee, 2006</td>
</tr>
<tr>
<td>Kishk</td>
<td>LAB</td>
<td>Cereal and milk</td>
<td>Tamime and McNulty, 1999</td>
</tr>
<tr>
<td>Kisra</td>
<td>Lactobacillus sp., <em>Lb. brevis</em></td>
<td>Sorghum</td>
<td>Mohammed et al., 1991</td>
</tr>
<tr>
<td>Koko</td>
<td><em>Lb. fermentum</em>, <em>Lb. salivarius</em></td>
<td>Millet</td>
<td>Lei and Jacobsen, 2004</td>
</tr>
<tr>
<td>Mahewu</td>
<td><em>Lb. bulgaricus</em>, <em>Lb. brevis</em></td>
<td>Maize</td>
<td>McMaster et al., 2005</td>
</tr>
<tr>
<td>Mawe</td>
<td><em>Lb. fermentum</em>, <em>Lb. brevis</em>, <em>Lb. salivarius</em>, <em>Sacch. cerevisiae</em></td>
<td>Maize</td>
<td>Hounhouigan et al., 1999</td>
</tr>
<tr>
<td>Ngari</td>
<td><em>Lactococcus lactis</em> subsp. <em>cremoris</em>, <em>Lactococcus plantarum</em>, <em>Enterococcus faecium</em>, <em>Lb. fructosus</em>, <em>Lb. amylophilus</em>, <em>Lb. corynformis</em> subsp. <em>torquens</em>, and <em>Lb. plantarum</em></td>
<td>Fish</td>
<td>Thapa et al., 2004</td>
</tr>
<tr>
<td>Ogi</td>
<td><em>Lb. plantarum</em>, <em>Lb. fermentum</em>, <em>Leuc. mesenteroides</em>, and <em>Sacch. cerevisiae</em></td>
<td>Maize</td>
<td>Odunfa and Adeyele, 1985; Adeyemi, 1993; Ijabadeniyi, 2007; Omenu et al., 2007</td>
</tr>
<tr>
<td>Sauerkraut</td>
<td><em>Leuc. mesenteroides</em>, <em>Lactococcus lactis</em>, LAB</td>
<td>Cabbage</td>
<td>Harris et al., 1992; Lu et al., 2003; Johanningsmeier et al., 2005</td>
</tr>
<tr>
<td>Som-fug</td>
<td>LAB</td>
<td>Fish</td>
<td>Riebroy et al., 2007</td>
</tr>
<tr>
<td>Tarhana</td>
<td>Streptococcus thermophilus, <em>Lb. bulgaricus</em>, <em>Lb. plantarum</em></td>
<td>Parboiled wheat meal and yogurt</td>
<td>Blandino et al., 2003; Patel et al., 2004; Erbas et al., 2006; Ozdemir et al., 2007</td>
</tr>
<tr>
<td>Tempeh</td>
<td>LAB, <em>Lb. plantarum</em></td>
<td>Soybean</td>
<td>Ashenafi and Busse, 1991; Feng et al., 2005</td>
</tr>
<tr>
<td>Uji</td>
<td>LAB</td>
<td>Maize, sorghum cassava, finger millet</td>
<td>Onyango et al., 2003, 2004</td>
</tr>
</tbody>
</table>

1.5.2 Functional probiotic products

**Traditional probiotic products**  The reason for opting for probiotic food can best be explained as an easy way to maintain daily health. Eating junk foods, drinking chlorinated water, work stress and irregular diet can have a serious impact on the gastrointestinal tract by destroying the beneficial microbial flora. So the ready availability of probiotics in the market helps resolve the problem to a great extent.

Kefir is a traditional milk product containing lactic acid bacteria and yeasts, which have a symbiotic relationship. Fermented milk products (kefir, yoghurt or sour milk) have higher nutritional values and a high nitrogen content compared with milk.

Kombucha is a fermented tea product and a symbiotic culture of yeast and bacteria. It is a traditional product that has been used for centuries and has recently gained attention globally, especially in the United States.

Another traditional Japanese food with probiotics is made from soybeans – a fermented product of fungi called koji. Table 1.4 shows examples of potential probiotic traditional fermented foods.

**Present day commercial products**  Products available in market with combined probiotics and prebiotics are now widely accepted. In 2008, Beyaz Peynir cheese from Turkey, a traditional cheese with nutritional value, was available with the addition of *Lactobacillus plantarum*.

The very first product marketed as a probiotic rather than a traditional product was Yakult by Yakult Honsha, Japan. Other commercial probiotic products available in market are shown in Table 1.5.

1.6 Probiotic market

The probiotic market is a growing industry, with lactic acid bacterial drinks accounting for 10% of the market. As health awareness increases, health-vigilant consumers are increasingly choosing probiotic functional products and as a result the market is growing at a rate of 5–30% (percentage varies with the country and product types).

The distribution of the probiotics application is shown in Figure 1.5.

The probiotic market was estimated to be around US$24.33 billion in 2011. A survey by marketsandmarkets.com (2013) says that more than 500 probiotic food and

<table>
<thead>
<tr>
<th>Table 1.5</th>
<th>Probiotic foods in present market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brand name</td>
<td>Food type</td>
</tr>
<tr>
<td>Yakult Honsha Co., Ltd.</td>
<td>Dairy beverage</td>
</tr>
<tr>
<td>Attune Food</td>
<td>Chocolate bar</td>
</tr>
<tr>
<td>Kevita</td>
<td>Probiotic non-diary drinks</td>
</tr>
<tr>
<td>Amul</td>
<td>Prolife (yoghurt and ice-cream)</td>
</tr>
<tr>
<td>GoodBelly</td>
<td>Probiotic fruit juice</td>
</tr>
<tr>
<td>Life way</td>
<td>Kefir drink</td>
</tr>
<tr>
<td>Ombar</td>
<td>Probiotic chocolates</td>
</tr>
<tr>
<td>Dannon</td>
<td>An Active dairy drink</td>
</tr>
</tbody>
</table>
drink products have been marketed in past 10 years. Different categories of products have gained varying levels of success. The most accepted product was probiotic chocolate. The highest sales were from the food and beverage section, which makes up 85% of the total probiotic products. Among all the probiotic products, 80% of probiotic sales in 2011 came from dairy products.

According to the report published by ‘Markets and Markets’ (http://www.marketsandmarkets.com), ‘probiotic market was valued at $24.23 billion in 2011 and is expected to grow at a CAGR [compound annual growth rate] of 6.8% from 2012 to 2017’.

The growing health consciousness and awareness of food safety are promoting further success in an already lucrative probiotic market.

References


REFERENCES


