Perspectives on the 21st century development of functional foods: bridging Chinese medicated diet and functional foods

Yue Xu

Food Technology Centre, Singapore Productivity and Standards Board, 1 Science Park Drive, Singapore 118221, Singapore

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Summary

Functional foods, also known as nutraceuticals, medical foods or nutritional foods, are driving food markets around the world and are expected to be one of the emerging trends for the food industry in the new millennium. The concept of functional foods is rooted in a tradition, particularly in Asia, where people have always believed that a balanced diet and some herbal foods are therapeutic. However, while extensive studies in biochemistry and immunology, as well as clinical trials, have been conducted on selected functional foods or ingredients, the scientific features of most traditional herbals remain almost unknown. However, the fastest growing food market in the United States is that of herbal-based nutraceuticals such as ginseng, garlic and medical mushrooms. This review describes different aspects of functional foods and the Chinese medicated diet on the basis of current knowledge, discusses the building blocks for the science of functional foods and proposes a possible way to fuse a Chinese medicated diet into functional foods.

Keywords

Chinese medicated diets, food ingredients, functional foods, herbs, nutraceuticals.

Fundamentals of Chinese medicated diet

History of the Chinese medicated diet

Health and ‘healing’ foods have a long history in Eastern cultures, particularly in China, where food and medicine are considered to be equally important in preventing and curing diseases. Hence, the saying that medicine and food come from the same origin and perform the same functions has been passed down to the present from the ancient legend which described a herbalist, Shennong, who had tasted a hundred types of herbs (Zhang, 1990). Thus, the Chinese medicated diet has been one of the important branches of traditional Chinese medicine (TCM) during its evolution in the last 2000 years.

The Yellow Emperor’s Internal Classic, probably the first classical Chinese medical book, was written in 745–221 BC. It recorded several medical diet prescriptions. This was followed by other classical TCM publications (Weng & Chen, 1996), such as ‘Treatise on Febrile Diseases (AD 210), ‘Synopsis of Prescriptions Worth Thousand Gold’ (AD 650) and ‘Compendium of Materia Medica’ (AD 1578), which described extensively many more medical diet recipes and prescriptions. Besides these TCM works, many monographs especially for medical or therapeutic foods were also documented. Many up-to-date monographs and scientific works on the Chinese medicated diet, introducing modern concepts of nutritional science, have also been published over the past few decades (Zhang, 1990).

Principles of the Chinese medicated diet

TCM has four major treatment approaches, namely acupuncture, acupressure, herbal medicine
and Qi gong-energy medicine (Lerner, 1994). The basic theories of the Chinese medicated diet (CMD) arose from the main theories of herbal medicine in TCM such as yin–yang, visceral manifestations (pathological changes in internal organs), main and collateral channels (the network to circulate vital energy and distribute acupuncture points), pathology, diagnostic methods, principles and methods of treatment (Weng & Chen, 1996). Deriving from TCM theories, the principles of CMD comprise two main parts: (1) a balanced and complete diet and (2) a tonic/therapeutic/medical diet.

The imperial TCM doctors emphasized the 'attainment of nourishment' by selecting appropriate food in a somewhat philosophical way (Ho, 1993). Accordingly, 'appropriate food' meant both a moderate intake of food and variety in the diet. In The Yellow Emperor's Internal Classic various sources in the diet were recommended for healthy intake. According to the book, five cereals (rice, sesame seeds, soya beans, wheat, millet) would provide nourishment; five fruits (dates, plum, chestnut, apricot, peach) would produce complementarity; five animals (beef, dog meat, pork, mutton, chicken) would give advantage; five vegetables (marrow, chive, bean spouts, shallot, onion) were for supplementarity (Ho, 1993). Such a concept of 'a balanced and complete diet' in CMD can be compared to theories of balanced dietary energy and nutrients in modern nutritional science.

Based on TCM theories, the human body should be in a perfectly balanced state in matters of intake and outflow, activity and rest, sleep and wakefulness, the functioning of the organs, etc. The balance points will, of course, vary from individual to individual. There are four major periods, i.e. period of gestation, childhood period, adolescence to adulthood and adulthood to death, during which this balance is affected strongly by varying factors (Shen, 1999).

Ancient Chinese doctors analyzed the physical signs and symptoms of a case by differentiating the appearances into two opposite categories (Ho, 1993): yin vs. yang. Yin and yang are used to express the strength or weakness of the internal organs in TCM. All factors including psychological, social and physiological are related to the deterioration of health (the ageing process), because they inevitably affect the immune function of the human body. Therefore, the state of health is a function of the body’s immune system. Accordingly, bad health indicates that the body’s immune function may be either in deficiency or in excess (Lu, 1991).

In TCM, several terms are used to describe the symptoms of illnesses (Shen, 1999). The first symptom is called Yin-weakness (Yin-Xu) that can occur when the internal organs malfunction, and the internal secretions are not optimal. It may be owing to the organs being made to overwork (e.g. long working hours, lack of sleep, exhaustion or nervous tension). In these circumstances, the body is said to ‘lack fluids’, which leads to the organs being ‘dry’; therefore individuals who suffer from Yin-weakness would be deemed to have sicknesses with symptoms typical of a ‘fire’ condition: the tongue and throat are dry, the tongue is red, while the pulses are weak. The second symptom is called as Yang-weakness (Yang-Xu) that can be obtained when internal organs malfunction in such a way that the human body does not absorb the nutrients as it should. For example, Yang-weakness of the stomach occurs if the stomach does not absorb its necessary nutrients. If the Yang-weakness condition persists, that will lead to the circulation being blocked. Therefore, individuals suffering from Yang-weakness are afraid of the cold or have their four limbs often cold, their tongue white and their pulse slow. In summary, Yin-weakness marks the first stage of an illness where the organ malfunctions, while Yang-weakness means that the organ is already damaged.

By using the yin–yang principle, medicinal foods were classified into ‘cold’ vs. ‘hot’, weak vs. strong, etc. Complementarity, interrelation and inter-transformation between two opposites are the basis for CMD to cure or prevent diseases. For example (Ho, 1993), cold foods may cause diarrhoea and nausea, while hot foods may lead to constipation and gut problems such as heartburn. On the other hand, complementary cold foods will combat constipation and hot foods against diarrhoea.

The concept of ‘neutral’ and tonic foods further supports the yin–yang principle in CMD. Foods that are between cold and hot are considered ‘neutral’, while foods that are used for strengthening and nourishment are ‘tonic’. Usually cold food
is cooked or consumed together with some hot foods for the purpose of neutralization. Weng & Chen (1996) reported on some foods that have cold, hot and neutral properties in CMD, whereas ginseng, mushrooms and other herbs are regarded as tonic.

Shen (1999) has described the principle of indirect causes and the treatment of disease. Chinese medical theories emphasize illnesses that affect one another, such that a damaged organ ‘A’ can affect organ ‘B’, resulting in an illness. For example, bad intestines or stomach or gall bladder may lead to a liver disease; nervous tension may lead to high blood pressure; weak lungs can cause frequent occurrences of the common cold; weak kidneys can cause nervous tension; these are all interrelated diseases. In terms of treatment, an individual with weak lungs needs nourishment to strengthen his lungs; an individual with weak kidneys needs to have his Qi nourished to strengthen his kidneys; an individual with a weak heart needs an ample supply of blood to strengthen his heart. These are the principles of indirect treatment.

Channel tropism is another TCM concept to supplement the principles of CMD. Channel tropism links the functions and sensory perceptions of various foods to the corresponding internal organs, channels or parts of the body. Weng & Chen (1996) also showed that some foods could improve the functions of their corresponding organs. Sensory perceptions such as bitter, sour, sweet, pungent and salty can also affect organs such as the heart, liver, spleen, lung and kidney, respectively.

**Current status of the Chinese medicated diet**

**Categories**

It is not easy to classify CMD scientifically because the boundary between traditional Chinese medicine and diet has always been blurred. Zhang (1990) divided the Chinese medicated diet into two types, i.e. dietetic Chinese drugs (DCDs) and medicated diet for dietetic therapy (MDDT).

**Dietetic Chinese drugs (DCDs)**

Dietetic Chinese drugs are also known as ‘edible Chinese drugs’, ‘dietetic materia medica’ or ‘medicinal food’, although the word ‘drug’ could be misinterpreted in the West. DCDs actually refer to materials that can be used either for the prevention and cure of diseases or for health care and recovery. DCDs are composed of two types of material. One is the salutary foods including cereals, fruits, nuts, vegetables, seasonings, birds and animals and aquatic products; another comprises the herbs or animal/insect origin of materia medica in traditional Chinese medicine.

**Salutary foods in DCDs**

Common salutary foods in DCDs with eight categories are shown in Table 1, among which some of those used less in the West are discussed in detail as follows (Zhang, 1990).

Millet and mung bean are two of the important cereals in DCDs. Millet contains about 60.27% of

<table>
<thead>
<tr>
<th>Table 1 Common salutary foods</th>
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<tbody>
<tr>
<td><strong>Cereals</strong></td>
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<tr>
<td><strong>Fruits</strong></td>
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<td><strong>Nuts</strong></td>
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<td><strong>Vegetables</strong></td>
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<tr>
<td><strong>Condiments</strong></td>
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<tr>
<td><strong>Birds and animals</strong></td>
</tr>
<tr>
<td><strong>Aquatic products</strong></td>
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<tr>
<td><strong>Miscellaneous</strong></td>
</tr>
</tbody>
</table>

Source: Zhang, 1990.
starch, 1.41% of fat, 2.41% of protein nitrogen, vitamin B and minerals. Millet is cool in nature and acts on the channels of the kidney, spleen and stomach under the theory of channel tropism. In every 100 g of mung bean, there are 22.1 g of protein, 0.8 g of fat, 59 g of carbohydrate, vitamins and minerals. Mung bean is also cool in nature and acts on the channels of the heart and stomach.

Hawthorn fruit, one of the most well-known fruits in China, is the fruit of *Crataegus pinnatifida* or *C. cuneata*. Hawthorn fruit contains tartaric acid, citric acid, crataegolic acid, malic acid, oleanolic acid, flavonoid, lactone, sugars, glycosides, carotene, protein, tannin, vitamin C and B2, calcium and iron. Hawthorn fruit is sour/sweet in flavour, slightly warm in nature, and acts on the channels of the spleen, stomach and liver. It enhances digestion in the stomach, strengthens blood circulation, removes blood stasis and expels worms.

A nut called Chinese torreya, the seed of *Torreya grandis*, contains oxalic acid, glucose, polysaccharides, essential oil, tannin and fatty oil. Chinese torreya is sweet in flavour, neutral in nature and acts on the channels of the lung, stomach and large intestine. It is used to treat abdominal pain owing to parasitization, malnutrition of children owing to impairment of the spleen and stomach caused by improper feeding, dry coughs, constipation and piles.

Lotus root, the fat rhizome of *Nelumbo nucifera*, is a vegetable consumed mainly in eastern and southern China. It contains protein, asparagine, vitamin C, pyrocatechol, d-gallic-catechin, nerochlorogenic acid, leucocyanidin, leucodephinidin and peroxidase. Lotus root is sweet in flavour, cold in nature, and acts on the channels of the heart, spleen and stomach. Raw lotus root can clear away heat, cool the blood and dissipate blood stasis, and thus is used to treat restlessness and thirst during the course of febrile diseases, haematemesis, nosebleed and stranguria of heat type.

Black-bone chicken, a subspecies of the normal chicken, is neutral in nature and acts on the channels of the liver and kidney. Black-bone chicken can nourish the liver, kidney and yin, and lower the fever. Edible bird’s nest contains 57.07% of total nitrogen in proteins, non-protein nitrogen and free amino acids such as arginine, cystine and histidine together with small amounts of fat, P, S, Ca, K, hexosamine and mucinoids. It is sweet in flavour, neutral in nature, and acts on the channels of the spleen, lung and kidney.

**Medicated diet for dietetic therapy (MDDT)**

MDDT refers to recipes or cuisines made from DCDs, food and condiments. Generally speaking, a medicated diet can be prepared, according to the doctor’s advice, either from edible Chinese drugs alone or from Chinese crude drugs and foods by processing and culinary skills such as stewing, braising, simmering, steaming, boiling, cooking in water, stir-frying, roasting, fricasseeing, deep-frying and so on.

In light of its form and process, the medicated diet can be divided into 11 different categories: fresh juices, medicated teas, drinks, medicated wines, decoctions, medicated gruels, honey extracts, medicated cakes, medicated pancakes and soups (Zhang, 1990). Table 3 shows a catalogue of medicated diets used to treat the common diseases and syndromes, as well as for nourishment and longevity, whereas only five recipes used in medicated diets for dietetic therapy are shown in Table 4, since such recipes can be counted in thousands.

**Healthy oral liquors/capsules (HOLC)**

In the past 25 years a new generation of healthy products, known as healthy oral liquors/capsules, has grown dramatically and dominated the market of health foods in China. Healthy oral liquors/capsules are made from ingredients such as Chinese herbs, spices and/or animals through...
modern food and pharmaceutical processing methods such as extraction, isolation, formulation, bottling, pilling or capsulation and are used for prevention and cure of diseases, or health care and recovery.

One of the major distinctions between MDDT and HOLC is the raw material used. In MDDT, recipes are formulated by using salutary foods or mixing salutary foods with edible Chinese herbal or animal drugs. On the other hand, raw materials used for HOLC are mainly those of edible Chinese herbal or animal drugs.

Another distinction is the product form. Therapeutic cuisines are the major product form of MDDT, either cooked at home according to the doctor’s advice or prepared in a hospital kitchen, whereas HOLCs are the ready-to-use products which are processed and packaged. The most popular product form of HOLC in China is ampoule-bottled oral liquors, although capsules and pilled forms are also used. Some of the commercial healthy oral liquors are presented in Table 5.

Overview of functional foods

The term ‘functional foods’ is used widely and defined as foods or food components which are designed to help modulate the human body and cure or prevent diseases. Many other terms, such as ‘medical foods’, ‘nutraceuticals’, ‘nutritional foods’ and ‘designed foods’ as well as their definitions have also emerged (Hasler, 1996; Silverglade, 1998). Well-known and developed nutraceutical ingredients fall into five categories, namely phytochemicals (O’Brien, 1990; Charleux, 1996; Dreosti, 1996; Milner, 1996; Balentine et al., 1997; Broihier, 1997; Kardinaal et al., 1997; Bidlack, 1998; Pszczola, 1998), probiotics (Lee & Salminen, 1995; Roberfroid, 1996; Salminen, 1996; Aso, 1997; Brassart &
### Table 3 Catalogue of medicated diets used for the treatment of common diseases/syndromes as well as for nourishment and longevity

<table>
<thead>
<tr>
<th>Medicated diets to treat diseases and syndromes of</th>
<th>Medicated diets for</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Cardiovascular system: hypertension, coronary heart disease, congestive heart failure, chronic hypotension</td>
<td>Nourishing qi, blood, yin and yan</td>
</tr>
<tr>
<td>(2) Respiratory system: common cold, bronchitis, pneumonia and bronchial asthma</td>
<td>Tonifying and benefiting the five viscera, i.e. spleen, lung, heart, kidney, and liver</td>
</tr>
<tr>
<td>(3) Digestive system: chronic gastritis and peptic ulcer, cirrhosis, haemorrhage of upper digestive tract, acute and chronic enteritis</td>
<td>Prolonging life</td>
</tr>
<tr>
<td>(4) Urogenital system: acute and chronic nephritis, urinary infection, prostatic hyperplasia, impotence, seminal emission, stone of urinary system</td>
<td></td>
</tr>
<tr>
<td>(5) Blood system: anaemia, thrombocytic purpura</td>
<td></td>
</tr>
<tr>
<td>(6) Metabolic and endocrine system: hyperlipaemia, adipositis, diabetes</td>
<td></td>
</tr>
<tr>
<td>(7) Nervous system: cerebrovascular diseases, neurosis</td>
<td></td>
</tr>
<tr>
<td>(8) Dermatology: impetigo, mastitis, trauma, haemorrhoid</td>
<td></td>
</tr>
<tr>
<td>(9) Obstetrics and gynaecology: menstrual disorder, dysmenorrhoea, leucorrhagia, sterility and vomiting during pregnancy, puerperal hypogalactia</td>
<td></td>
</tr>
<tr>
<td>(10) Paediatrics: enuresis in children, infantile malnutrition, pertussis, infantile diarrhoea and rickets</td>
<td></td>
</tr>
<tr>
<td>(11) Ophthalmia: acute conjunctivitis, night blindness and senile cataract.</td>
<td></td>
</tr>
<tr>
<td>(12) ENT: tinnitus, pharyngitis, tonsillitis, voice disease</td>
<td></td>
</tr>
<tr>
<td>(13) Infection and tumour: viral hepatitis, pulmonary tuberculosis and prevention of cancers</td>
<td></td>
</tr>
</tbody>
</table>

Source: Zhang, 1990.

### Table 4 Recipes of medicated diet for dietetic therapy

<table>
<thead>
<tr>
<th>Recipes</th>
<th>Ingredients</th>
<th>Preparation</th>
<th>Claimed therapeutic benefits to treat</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Soup of Tremella and Jew’s ear</td>
<td>Tremella (<em>Tremella</em>), 9–12 g Jew’s ear (<em>Auricularia</em>), 9–12 g Crystal sugar</td>
<td>Wash mushrooms in warm water; add sugar to mushrooms, then steam them for an hour</td>
<td>Hypertension</td>
</tr>
<tr>
<td>(2) Gruel of galangal rhizome and cyperus tuber</td>
<td>Galangal rhizome, 9 g Cyperus tuber, 9 g Polish short-grained rice, 100 g</td>
<td>Decoct the first two ingredients in water, sift the decoction from the dregs; then add the rice and water to the decoction to cook them into gruel</td>
<td>Chronic gastritis and peptic ulcer</td>
</tr>
<tr>
<td>(3) Decoction of dandelion herb and honeysuckle stem</td>
<td><em>Herba taraxaci</em> (dandelion herb), 30 g <em>Caulis lonicerae</em> (honesuckle), 30 g</td>
<td>Add a certain amount of water and rice wine to the mixture of two ingredients and decoct them until a thick extract</td>
<td>Mastitis</td>
</tr>
<tr>
<td>(4) Gruel of motherwort juice</td>
<td><em>Succus H. leonuri</em> juice, 10 mL <em>Succus R. rehmanniae</em> juice, 40 mL Lotus root juice, 40 mL Ginger juice, 2 mL Honey, 10 mL Polish short-grained rice, 100 g</td>
<td>Make gruel with rice first, add other ingredients to gruel, and keep cooking until thin gruel is obtained</td>
<td>Menstrual disorder</td>
</tr>
<tr>
<td>(5) Loach and tofu</td>
<td>Tofu, 100 g Living loach, 250 g Corn stigma, 30 g</td>
<td>Put loach together with corn stigma, tofu and water in earthenware pot to decoct</td>
<td>Viral hepatitis</td>
</tr>
</tbody>
</table>

Source: Zhang, 1990.

The science of nutraceuticals or functional foods is far from being established systematically as an independent discipline. It will probably be developed through absorbance and interdisciplinary penetration of elements from food nutrition, immunology, biochemistry and molecular biology (Fig. 1). Although in its early stages, the study of nutrition vs. immunology, as one of the most important recent developments in the scientific food community, is being emphasized and is progressing rapidly (Sherman & Hallquist, 1990). Thus, the reasons for human nutrition are: (1) the primary purpose is to take foods for promoting growth and maintaining a healthy life: that is, food nutrition; (2) a secondary reason for eating is for pleasure: that is, food flavour; (3) a tertiary purpose is to modulate the biodefence system which may lead to cure or prevention of diseases: that is, functional foods or nutraceuticals.

With regard to regulation of functional foods, putting health claims on labels is an ongoing battle between regulators and manufacturers. The current status of legislation of functional foods in the United States, Japan, China, the European community, Australia and Singapore has been reviewed by Jordan (1996), Kan (1996) and DNS (1998). Among the countries listed, only the United States, Japan and China allow health claims on the label and only under specific categories.

**Table 5** Some of the healthy oral liquors marketed in China

<table>
<thead>
<tr>
<th>Product types</th>
<th>Ingredients</th>
<th>Claimed health benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Ginseng and royal jelly liquors</td>
<td>Panax ginseng or Panax quinquefolius, 30% Fresh royal jelly, 30%; Honey and water 40%.</td>
<td>Anti-ageing Stimulation of immune activity</td>
</tr>
<tr>
<td>(2) Mushroom tonic liquors</td>
<td>Lentinus edode (Shiitake) Poria cocos Gannoderma (Lingzhi)</td>
<td>Anticarcinogenicity Anti-virus Lowering blood lipids</td>
</tr>
<tr>
<td>(3) Bee pollen liquors, essence, wines, teas, etc.</td>
<td>Treated bee pollen</td>
<td>Anti-ageing</td>
</tr>
<tr>
<td>(4) Ant liquors, wines, and beverages</td>
<td>Extracts of ants</td>
<td>Anti-ageing Improvement of cardiovascular function</td>
</tr>
<tr>
<td>(5) Chinese caterpillar fungus (Cordyceps sinensis)</td>
<td>Extracts of Cordyceps, 80% Extracts of Ziziphus jujuba, 5% Extracts of Gannoderma, 5% Extracts of Joponica lindl, 5% Extracts of Radix glycyrrhizae, 5%</td>
<td>Anti-ageing Improvement of cardiovascular function Lowering blood lipids and pressure Strengthening kidney</td>
</tr>
</tbody>
</table>


**Figure 1** Building blocks of nutraceutical/functional food science.

Western medical and biological science is based on ‘anatomy or dissection’, where a complicated object is fragmented into many single components that are then studied extensively *in vitro*. This is the so-called ‘reductionism’ approach. When the complete nature or function of fragments are...
understood the object is reconstructed mainly by using logic or deduction. Undoubtedly, western philosophy in science will enable us to understand, on one hand, the nature of the universe and on the other, the innate character of biological objects, resulting in an unprecedented advance of science and technology.

Conversely, Chinese philosophy focuses mainly on developing universal harmony by using a balanced approach. According to TCM, the human body is an integrated whole; treatment is based on the concept of an integral human body and is decided through differentiation of symptoms and signs. Although an over-emphasis on harmony is probably one of the reasons why traditional Chinese medicine has regressed over past centuries, new Chinese medicine or nutrition is becoming more relevant by absorbing aspects of western scientific philosophy.

Isolation of bioactive compounds and identification of their biological effects

As the molecular mechanisms of Chinese herbal drugs and medicated diets have been ignored for a long time, many studies on the isolation and characterization of active compounds from traditional Chinese medicine have recently begun in Japan, China, Taiwan, Singapore and Hong Kong, focused mainly on three Chinese herbal drugs, i.e. ginseng, *Ganoderma* and *Cordyceps* (Fig. 2).

**Ginseng**

Panax ginseng, known as white or red ginseng, and *P. quinquefolium*, known as American ginseng, are used commonly in TCM or CMD. The major bioactive components of ginseng are ginsenosides or panaxosides (Attele *et al*., 1999), a diverse group of steroidal saponins of which nine of their chemical structures (Fig. 3) have so far been identified from more than 13 isolated ginsenosides.

Efforts have been made to study the mechanisms of ginsenoside activity, but many still remain unknown. Since ginsenosides and other constituents of ginseng produce effects that are different from one another, the overall biological activity or pharmacology of ginseng is complex (Attele *et al*., 1999). The *in vitro* antitumour activity of a ginseng saponin metabolite, 20-O-β-D-glucopyranosyl-20(S)-protopanaxadiol (IH-90), was examined against four human cancer cell lines, and a high inhibitory activity of this compound was reported (Lee *et al*., 1999). Kim *et al*., (1999) reported a study to characterize the endothelium-dependent relaxation elicited by ginsenoside Rg 1 and Rg 3 in isolated rat aorta: Rg 3 was about 100-fold more potent than Rg 1. The endothelium-dependent relaxation in response to ginsenoside Rg 3 was associated with the formation of cyclic GMP. In addition to ginsenosides, Kim *et al*. (1998) isolated an acidic polysaccharide from *P. ginseng*, named as Ginsan, that inhibits the incidence of benzo[a]pyrene-induced autochthonous lung tumours in mice.

![Lingzhi](Ganoderma lucidum)

![Chinese Caterpillar Fungus](Cordyceps sinensis)

![Ginseng](Panax ginseng)

**Figure 2** The most important ingredients in Chinese medicine.
Lingzhi (Ganoderma)

Lingzhi is classified into four families, namely Ganoderma, Haddowia, Amauroderma, and Humphreya, with 86 species (Wang et al., 1993), while the most well-known Lingzhi is Ganoderma. G. lucidum (red) and G. japonicum (purple) are two common types of Ganoderma plants, although the ‘Compendium of Materia Medica’ recorded six types of plants coloured red, purple, green, yellow, white and black (Anon, 1997). G. japonicum was analyzed and contains ergosterol, organic acids, aminoglucose, polysaccharides, resins and mannitol, whereas G. lucidum contains alkaloids, lactones and coumarin, in addition to the compounds found in G. japonicum (Anon, 1997).

Four categories of active compounds, namely polysaccharides, adenosine, triterpenes and organic germanium, were recognized and identified (Zhang, 1997) in G. lucidum. Furthermore, three active protein-bound glycans named F1γ-α, F1γ-b-α and FA-1-b-α were isolated from a Lingzhi polysaccharide preparation (FI) by ion-exchange chromatography, gel filtration and affinity chromatography, and their antitumour effects have been identified against a solid cancer, sarcoma 180, in mice (Zhang et al., 1994). F1γ-α is a glycan–protein complex containing 9.3% protein and has a tetero-glyco chain of mannose and xylose. F1γ-b-α, which is a glycan–protein complex containing 25.8% protein and has a molecular weight of 10 000 dalton, shows an inhibition ratio of 61.8% against the solid cancer sarcoma 180 mice and a survival ratio of more than 194% of the control group. FA-1-b-α, a complex of glycan (42)–protein (58) with a molecular weight of 10 000 dalton, gives a tumour inhibition ratio of 56% and a survival ratio of more than 182%.

Chinese caterpillar fungus (Cordyceps sinensis)

Chinese caterpillar fungus is composed typically of 10.85% moisture, 8.4% fat, 25.32% protein, 18.53% crude fibre, 28.90% carbohydrate and 4.10% ash, together with hitherto identified compounds such as cordycepic acid (Fig. 4), quinic acid, cordycepin (Fig. 4), 5-α, 8-α-epidioxy-24(R)-methylcholesta-6, 22-dien-3-β-d-gluco-pyranoside (EMDG), 5,6-epoxy-24(R)-methycholesta-7, 22-dien-3-β-ol (EMDL), ergosteryl-3-O-β-D-glucopyranoside (EG) and 22-dihydroergosteryl-3-O-β-D-glucopyranoside (DG) (Anon, 1997; Bok et al., 1999). Cordycepin was reported to inhibit the growth of many pathogens such as Bacillus anthracis and B. mallei (Anon, 1997). EMDG, EMDL, EG and DG were found to be the inhibitors of proliferation of K562, Jurkat, WM-1341, HL-60 and RPMI-8226 tumour cell lines, whereas the glycosylated form of ergosterol peroxide showed a greater effect than EMDL (Bok et al., 1999).

Figure 3 Chemical structure of ginsenoside-Ra, -Rb1, -Rb2, -Re, -Rd, -Rc, -Rf, -Rg1, Rg2. Source: Anon, 1997.

Figure 4 Chemical structure of compounds in Cordyceps sinensis. Source: Anon, 1997.
Biological or pharmacological functions of various fractions of C. sinensis (CS), despite not being characterized at the molecular level, have attracted some investigation. Chen et al. (1997) isolated a polysaccharide fraction of CS and studied its effect on the proliferation and differentiation of human leukaemic U937 cells by using an in vitro culture system. The results showed that the conditioned medium from PSCS (10 µg mL⁻¹)-stimulated blood mononuclear cells (PSCS-MNC-CM) and had an activity that could significantly inhibit the proliferation of U937 cells, resulting in a growth inhibition rate of 78–83%. Xu et al. (1992) reported a study on the effects of the ethanol extract of CS on murine and human in vitro natural killer cell (NK) activities and on murine in vivo NK activity. Similarly, Yang et al. (1999) isolated an unidentified compound (H1-A) from CS that showed an immunomodulatory effect and was effective in improving the survival of lupus mice.

To date, initial studies have indicated that many active compounds from these herbs are bioactive proteins, polysaccharides, oligosaccharides, sterols, alkaloids flavonoids and glycoside derivatives.

Clinical trials of Chinese medicated diets/ingredients

It is incorrect to claim that many of the postulated health benefits of TCM and CMD lack the support of clinical trials. In fact, TCM and CMD has been practised ‘clinically’ for centuries although different methodologies, directions and logical structures were used compared to modern western medicine.

As reported by Lerner (1994), western medicine is concerned mainly with isolable disease categories or agents of disease, which are isolated, and attempts are then made to change, control or destroy the disease agent. The western physician starts with a symptom, then searches for the underlying mechanism – a precise cause for a specific disease. The Chinese physician, in contrast, directs his or her attention to the complete physiological and psychological individual. All relevant information, including the symptom as well as the patient’s other general characteristics, is gathered and woven together until it forms what Chinese medicine calls a ‘pattern of disharmony’.

The question of cause and effect is always secondary to the overall pattern.

However, since TCM/CMD was founded on experience, or empirical rather than in-depth science, particularly at the molecular level, curative effects of herbal or medical dietetic remedies are often seen as suggestive and intriguing but by no means definitive (Lerner, 1994). Today, as western scientific standards have been accepted universally, many clinical trials for TCM/CMD based on modern medical science have been conducted extensively but have been reported mainly in the Chinese and Japanese literature. There are a few English reports of clinical trials for TCM/CMD to treat diseases published in journals (O’Leary & Muggia, 1998; Yun & Choi, 1998) and on websites (Shen, 1999). Moreover, Zhu et al. (1998) produced a review of CS in pre-clinical in vitro and in vivo studies, using data on open-label and double-blinded clinical trials on the respiratory, renal, hepatic, cardiovascular, immunological and nervous systems, and also the effects on cancer, glucose metabolism, inflammatory conditions and toxicological studies.

Safety or toxicity of edible Chinese drugs

Table 6 shows the selected edible Chinese drugs that are generally regarded as safe by TCM/CMD based on the centuries-long ‘clinics’, some of which have been also confirmed by the modern scientific methodology based on LD50/LD50 of animal trials. However, concern over the safety of known compounds contained in edible Chinese drugs, particularly such as sterols, alkaloids and flavonoids, is still high, and cases of poisoning by these herbs are occasionally reported. In fact, the toxicity/non-toxicity of edible Chinese drugs depends upon the content and a somewhat tricky balance of potentially harmful compounds in these herbs; these compounds are variable depending upon planting regions, seasons, varieties and their effect is complicated further by the differences of allergy, immunity or genetics between human patients. Although some countries have raised the issue of establishing a QA system or specifications to regulate these edible Oriental drugs, the difficulty at present is the lack of comprehensive knowledge in relation to their composition and the setting up of such systems.
Biotechnological production of edible Chinese drugs

Plant cell suspension cultures, i.e. submerged fermentation techniques, have been used to produce ginseng saponin and polysaccharides of *P. ginseng* and/or *P. quinquefolium* (Liu & Zhong, 1998; Akalezi *et al.*, 1999; Wu & Zhong, 1999). Since the first paper was published in 1964, the suspension culture technology for ginseng cell has been commercialized. Nitto Denko Corporation in Japan has used 20 000-L and 25 000-L fermentors to produce ginseng cells, and achieved a dry cell mass productivity of 20 g L\(^{-1}\) in 4 weeks; the ginseng cells obtained showed similar chemical composition (e.g. saponin content) to that of field-cultivated ginseng, and nearly identical pharmacological effects on animals (Wu & Zhong, 1999).

Submerged cultures have also been used to produce *G. lucidum* (Hiromoto, 1991; Yang & Liau, 1998), *C. sinensis* (Taketomo *et al.*, 1996) and other mushrooms such as *Lentinus edodes* (Hiromoto, 1991).

**New approaches to the product and marketing development for functional foods**

The world-wide trend of ‘workaholics’ and snacking habits continues to promote the universal popularity of convenience foods. Food manufacturers should consider that opportunities are available to increase market share through commercializing the thousands of recipes of the traditional Chinese medicated diet by making them into convenience foods, fast foods or pre-prepared meals through modern food processes.

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Table 6  Safety and toxicity of Chinese nutraceutical ingredients in drug-food-dual-purpose

<table>
<thead>
<tr>
<th>Traditional Chinese medicine</th>
<th>Don’t or take carefully if</th>
<th>Animal tests*LD(_{50}), LD or others</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Animal origin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deer horn antler</td>
<td>Non-toxic</td>
<td>Yin in deficiency, yan in excess</td>
</tr>
<tr>
<td>Cattle gallstone bezoar</td>
<td>Non-, or little toxic</td>
<td>Pregnancy</td>
</tr>
<tr>
<td>Donkey-hide gelatin</td>
<td>Non-toxic</td>
<td>Deficiency in spleen, stomach</td>
</tr>
<tr>
<td><strong>Plant origin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ginkgo biloba</em> nuts</td>
<td>Non-toxic</td>
<td>Not clear</td>
</tr>
<tr>
<td><em>Poria cocos</em></td>
<td>Non-toxic</td>
<td>Weak kidney</td>
</tr>
<tr>
<td><em>Ganoderma</em></td>
<td>Non-toxic</td>
<td>Not clear</td>
</tr>
<tr>
<td><em>Panax ginseng</em></td>
<td>Very minor</td>
<td>Heat toxic</td>
</tr>
<tr>
<td><em>Panax quinquefolius</em></td>
<td>Non-toxic</td>
<td>Cold/damp stomach</td>
</tr>
<tr>
<td><em>Cordyceps sinensis</em></td>
<td>Very minor</td>
<td>Not clear</td>
</tr>
<tr>
<td><em>Ziziphus jujuba</em></td>
<td>Non-toxic</td>
<td>Heat or diarrhoea</td>
</tr>
<tr>
<td><em>Tremella fuciformis</em></td>
<td>Non-toxic</td>
<td>Cold and cough</td>
</tr>
<tr>
<td><em>Rhubarb</em></td>
<td>Non-toxic</td>
<td>Cold/damp stomach</td>
</tr>
<tr>
<td><em>Lycium chinense</em></td>
<td>Non-toxic</td>
<td>Not clear</td>
</tr>
<tr>
<td><em>Notoginseng</em></td>
<td>Non-toxic</td>
<td>Pregnancy</td>
</tr>
<tr>
<td><em>Gynostemma pentaphyllum</em></td>
<td>Non-toxic</td>
<td>Not clear</td>
</tr>
<tr>
<td><em>Angelica sinensis</em></td>
<td>Non-toxic</td>
<td>Diarrhoea</td>
</tr>
<tr>
<td><em>Astragalus membranaceus</em></td>
<td>Non-toxic</td>
<td>Yin in deficiency, yan in excess</td>
</tr>
<tr>
<td><em>Euphoria longan</em></td>
<td>Non-toxic</td>
<td>Heat phlegm</td>
</tr>
</tbody>
</table>

such as chilling, freezing, instantizing, snack processing, canning and bottling.

Recipes for traditional Chinese medicated diets are available to enable cooked meals to be prepared in several forms such as drinks, gruels, soups, cakes and syrups. These recipes are composed mainly of food materials and food-type herbs such as mushrooms and ginseng that are generally recognized as safe. Well-processed products are delicious and can be served either as dishes or beverages with staple foods or as snacks for eating to promote health or aid medical treatments. The latest product releases such as ‘lotus root chrysanthemum tea’ and ‘ginseng chrysanthemum’ by a leading beverage company in Singapore are good examples of the development of new uses for the traditional Chinese medicated diet.

Combined therapy using Chinese and western medicine has been practised widely in China, western scientific standards have penetrated into TCM so that related theories can be described by using physiology, immunology, pathology and biology. Isolation and identification of physiologically active compounds are expected to attract more attention from the scientific community. Chinese edible drugs, after they are understood in regard to their composition, chemical structure and biochemical properties of bioactive compounds, animal LD tests and human trials, can thus be used as functional food ingredients in an effective and safe way.

In all modern societies, snacking is becoming a way of life. Even snacks can be healthy, and in Europe and Australia a large area of development is in the fruit snacks sector. Many recipes of the traditional Chinese medicated diet, e.g. water chestnut and hawthorn jelly, with physiological functions of invigorating the spleen, regulating the stomach, clearing sputum and arresting coughs (Zhang, 1990), are candidates ready to be transformed to western-type health snacks.

The culinary art based on the skills of stewing, braising, simmering, steaming, boiling, cooking in water, stir-frying, roasting, fricasseeing, deep-frying and so on is at the core of Asian foods. Are the refined western ingredients suitable to be used in such culinary processes for health promotion? The answer is positive if food scientists and technologists are ready to work on it.

It is worthwhile for leading carbohydrate ingredients producers to study the application of oligosaccharides or dietary fibre such as resistant starch to Asian breakfast meals rice gruels/porridges, noodles and even curry gravy. These studies should include the contribution and effectiveness of healthy oligosaccharide ingredients to the texture and flavour of Asian meals, as well as marketing. Fusion of physiologically functional dairy ingredients with healthy soy or rice foods is another interesting area.

In the new millennium, we are experiencing two important trends in the food industry. First, there is a wide acceptance of diversity. While ethnic food is now becoming popular in the western world, US and European foods have also become widely accepted in the eastern world, resulting in a great development of mixed or fused cuisines and flavourings around the world (Sloan, 1996). Secondly, there is a new global awareness of the concept of functional foods beyond simple nutrition, as people in the developed western and newly developed Asian countries are ageing and becoming more health-conscious. So, the melting-pot boils and health foods will dominate the food industry and consumer trends in the 21st century (Sloan, 1998).

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