BIOPROCESSES AND BIOTECHNOLOGY FOR FUNCTIONAL FOODS AND NUTRACEUTICALS

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20

Paradigm Shift: Harmonization of Eastern and Western Food Systems

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I. INTRODUCTION

Joseph Needham (1), after lifelong comparative study, wrote in his book, *Science and Civilisation in China* as follows:

> It is my conviction that the Chinese proved themselves able to speculate about Nature at least as well as the Greeks in their earlier period. If China produced no Aristotle, it was, I would suggest, because the inhibitory factors which prevented the rise of modern science and technology there began to operate already before the time at which an Aristotle could have been produced. But apart from the vision of the Taoists, there runs throughout the Chinese history a current of rational naturalism and of enlightened scepticism, often much stronger than what was found at corresponding times in that Europe where modern science and technology in fact grew up.

From the viewpoint of analytical Westerners' knowledge, the Chinese or Eastern interpretation of scientific observations probably appeared to be based on primitive theories, such as *yin* and *yang* and the Five Phases. However, in the view of Eastern people, who emphasized the harmony of human beings and nature, simplifying the natural phenomena in an equation to manipulate nature appeared to be too dangerous. For this reason, the growth of science and technology in China was often reduced or abandoned

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when it experienced friction with ethical considerations. The rational naturalism and enlightened skepticism of the Chinese, as described by Needham (1) in the 1950s, would not be merely inhibitory factors preventing the growth of science and technology, but could be considered as the safeguard against the adverse effects of science and technology that we are confronting today.

John Robbins (2) warned of the adverse effects of the so-called Great American Food Machine, created by scientific research and development during the last century. His book, *Diet for a New America*, describes the effects as follows:

> Increasingly in the last few decades, the animals raised for meat, dairy products, and eggs in the United States have been subjected to ever more deplorable conditions. Merely to keep the poor creatures alive under these circumstances, even more chemicals have had to be used, and increasingly hormones, pesticides, antibiotics, and countless other chemicals and drugs end up in foods derived from animals. The more unnaturally today's livestock are raised, the more chemical residues end up in our food.

This is an example of the consequences of scientific development achieved without ethical considerations. The conventional paradigm of scientific development is facing a new challenge—recovery of harmony between humans and nature and the world is now seeking the proper model for a new paradigm.

II. THE QUAGMIRE OF THE WESTERN FOOD SYSTEM

Modern nutritional science is based on the analytical knowledge of food components. When people began to learn about chemical composition, they tried to determine the physiological effect of each component and to segregate the useful components from harmful or useless ones. It is human nature to value useful components more and to tend to concentrate them. The foodstuffs made in this way include butter, cheese, white bread, and sugar. Vitamin pills are another example. Western food technology directed by modern nutritional science for the last century achieved significant developments in mass production of high-energy and high-protein nutritious foods that are easily digested and absorbed in the body. However, it has gone too far and aggravated mistakes. Foods made with refined ingredients contain high energy density and little to excrete from the digestive channel. An average of 30% to 40% of the energy in the Western diet is derived from fat, whereas only 10% is in the traditional Korean standard meal. Overweight and obesity are the natural consequence of consumption of this high-calorie food, and it is

considered the major cause of all the chronic diseases that most affluent people are suffering today. After removal of most of the undigestible matter from food, there is little left to travel to the large intestine, where material remains for a long period to lose water. Such a diet leads to constipation and colon cancer.

Statistics shows that about 70% of Americans consider themselves overweight and control their diet. They suffer from resisting their desire to eat in the midst of affluent tasty foods. According to the Report of the Selected Committee on Nutrition and Human Needs of the U.S. Senate in 1977 (3), one in six deaths in the United States is caused by incorrect eating habits, and the additional medical expenses due to incorrect eating habits of people were estimated to cost U.S.$70.9 billion in 1994 (4). Although it is well recognized in dietary guidelines that Americans must eat less fat and sugar and more fiber from cereals and vegetables, it is difficult to influence eating habits in a short period. Americans have instead chosen to solve the problem by using purified fiber and other isolated food components in pills as a dietary supplement.

Table 1 compares the causes of death in the United States, France, Japan, and Korea. It shows clearly the differences in causes between East and West. It is interesting to note that the people who eat more refined and nutritionally concentrated food have less stomach cancer and liver cancer and diseases but higher incidences of breast cancer and heart disease. Some speculate that the use of soybeans as food is related to the low incidence of breast cancer in Asian women. Aside from the genetic and environmental influences, the style of diet appeared to be the most important factor determining the cause of death. The calorie sources of both Koreans and

Table 1 Statistics of Cause of Death by Countries in 1994[a]

	United States	France	Japan	Korea
Total cancer	205.6	244.6	197.3	110.1
Stomach cancer	(5.2)	(10.4)	(38.7)	(28.8)
Liver cancer	(1.8)	(7.7)	(16.7)	(23.0)
Breast cancer	(32.7)	(36.3)	(11.3)	(3.8)
Diabetes	21.8	11.0	8.8	17.0
Hypertension	14.6	10.2	6.8	25.8
Heart disease	185.1	80.4	46.7	12.6
Cerebral blood vessel disease	58.6	74.7	96.8	84.4
Liver disease	9.9	16.0	13.4	29.2

[a] Number of deaths per 100,000 people.
Source: WHO, World Health Statistics 1977–1999.

Japanese are 58% to 66% from carbohydrates, 15% to 16% from protein, and 19% to 26% from fat, whereas those for Americans are 52% from carbohydrates, 15% from protein, and 33% from fat (5). Koreans eat 15% more grains, 70% more vegetables, 17% more fruits than Americans; Americans eat 46% more meat and meat products and 3.1 times more dairy products than Koreans (5).

The U.S. nutritional education and diet style have been the world model for the last half-century, and most of the developing countries have tried to follow the U.S. model. One of the first to pursue the model was Japan, and Korea followed thereafter. Despite the long tradition of a vegetarian food habit in Korea and Japan, the food pattern has changed substantially to Western style. Fig. 1 shows that the meat and dairy food consumption increased 2.2 times and 18 times, respectively, during three decades in Korea, and grain consumption decreased by 33% in the same period. The increase in animal food consumption resulted in a drastic reduction in food self-sufficiency from 80% in 1970 to 28% in 1995 (6).

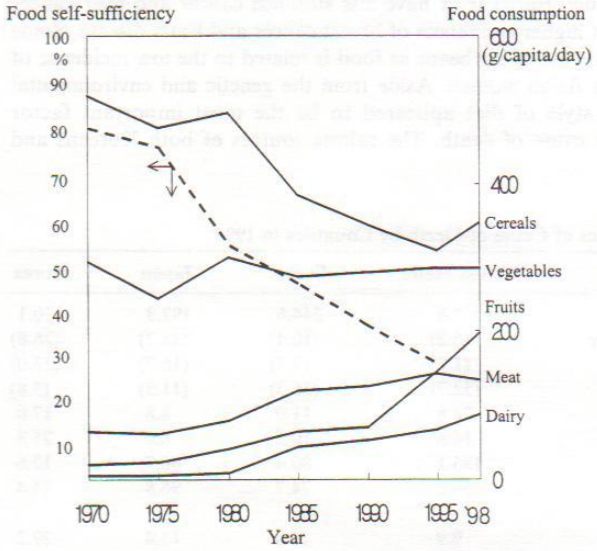

Figure 1 Changes in Korean food consumption pattern and food self-sufficiency during the past three decades. (From Refs. 6 and 7.)

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Table 2 Changes in the Causes of Death in Korea per 100,000

	1989	1998	Change, percentage
Circulatory disease	161.5	123.7	−23.4
Cancer	105.0	110.8	5.5
Stomach	31.7	23.9	−24.6
Liver	23.6	20.0	−16.0
Breast	1.6	2.1	31.3
Colon	3.9	7.0	79.5
Diabetes	9.4	21.1	124.5

Source: Ref. 18.

The Westernization of the Korean diet style has a strong correlation with the prevalence of chronic disease among the population (8). Table 2 shows that the death rate caused by stomach cancer and liver cancer decreased by 26.4% and 16%; respectively, but the rates of breast cancer and colon cancer increased substantially, by 31.3% and 79.5% in Korea during the decade from 1989 to 1998. The death rate caused by circulatory disease decreased slightly (23.4%), but that caused by diabetes increased 2.2 times for the same period.

III. HEALTH CONCEPT IN EASTERN DIETARY CULTURE

Northeastern Asian thought about life and health is based on the shamanistic folk religion Taoism, which sets as the ultimate goal a healthy eternal life. Established Taoism, as developed by early Chinese philosophers, teaches that this goal can be achieved by discipline, mainly by the control of breath, sex, and food. The principle of control is the harmony of *yin* and *yang*, the negative and positive natures of the universe (9).

According to *yin–yang* and Five Phases theory, all food materials are classified by their properties and their different tastes. The properties are cool, as *yin*, neutral, and warm, as *yang*. For example, fruits on the tree are considered to have the *yang* property, whereas root crops in the soil have the *yin* property. The *yin* property also represents material entities such as nutrients; the *yang* property represents functions, such as energy. Taste is divided into five groups, representing the Five Phases: sour–wood, bitter–fire, sweet–earth, pungent–metal, and salty–water (10). Taste can be related to the human body and its organs, senses, and feelings, and even to color, the weather, and the seasons, through classification into the Five Phases. Antag-

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onistic or affinitive relations between tastes and organs or senses are also judged or predicted by the principles of the Five Phases (10).

The basic idea of traditional Korean nutrition is to harmonize properties and tastes in the diet on the basis of *yin* and *yang* and the Five Phases. A diet that inclines toward one property or extreme taste is considered to be unhealthy. Korean meals are prepared to harmonize the properties and tastes through selecting the proper ingredients and process.

Table 3 shows a Korean meal analyzed by the *yin–yang* and Five Phases theories. The property of the main dish, cooked rice, is neutral, and the materials used for side dishes are evenly distributed among *yin* and *yang* and the Five Phases: the pattern of a balanced diet (11). The purpose of a therapeutic food in Eastern medicine is to emphasize one of the properties or tastes according to the patient's symptom of illness: cool, cold, warm, and hot. When a patient suffers from a disease caused by cool nature, a diet that emphasizes the warm property is served, and the converse.

On the basis of the philosophical ideas and medical knowledge developed in China and Korea, the Korean people have developed a standardized ideal meal, within a systematic menu program, that is called *chop bansang*.

Table 4 shows the nutritional value of a traditional Korean standard meal system in the menu of Kim Ho-Jik as calculated by the current Food Composition Table of Korean Food (12). The basic meal, which consists of a bowl of cooked rice, a bowl of soup, and a dish of kimchi, can supply 40% of the energy and 48.7% of the protein of the Recommended Dietary Allowance (RDA). When three dishes were added to the basic meal, the three-dish meal (*samchop bansang*) contained 47.2% of the energy and 94.3% of the protein of

Table 3 Analysis of a Korean Meal in Terms of *Yin–Yang* and the Five Phases

	Wood (sour)	Fire (bitter)	Earth (sweet)	Metal (pungent)	Water (salty)
Yang (warm)	Leek	Mugwort	Shepherd's purse, wheat flour	Green onion, garlic, ginger, black pepper, sesame	Salt
Neutral			Water, rice, soybeans, yellow corvina		
Yin (cool)	Vinegar	Plant root, fernbrake	Cabbage	Onion	Soy sauce, soybean paste

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Table 4 Evaluation of the Nutritional Value of the Traditional Korean Standard Meal in the Menu of Kim Ho-Jik (1944)[a]

Type of menu	Basic meal	Three-dish meal	Five-dish meal	Seven-dish meal
Composition of menu	Cooked rice, soup, kimchi	Basic meal plus spinach, roasted beef, dried fish	Three-dish meal with stew plus meat jelly, fermented fish roe	Five-dish meal plus panned oysters, radish, kimchi
Total energy (kcal)	995 (40.0)	1181 (47.2)	1320 (52.8)	1672 (66.8)
Carbohydrate (%)	77.0	64.4	60.1	53.4
Protein (%)	14.7	24.0	28.0	27.7
Lipid (%)	8.3	11.6	11.9	18.9
Total protein (g)	36.5 (48.7)	70.7 (94.3)	92.5 (123.3)	115.5 (154.0)
Animal Protein (g)	28.7	59.5	69.0	72.3
Ca (mg)	161.1 (26.9)	216.3 (36.1)	255 (42.5)	596 (99.3)
Fe (mg)	12.1 (121.9)	23 (230)	26.8 (268)	40.3 (403)
Vitamin A (IU)	426.2 (17.1)	8,7616 (350.5)	9,129 (365.2)	9,965 (398.6)
Vitamin B_1 (mg)	0.62 (47.6)	0.86 (66.2)	1,08 (8.1)	2.16 (166.2)
Vitamin B_2 (mg)	1.92 (127.9)	3.03 (202.2)	3.44 (229.3)	4.35 (290.4)
Niacin (mg)	11.6 (68.3)	28.9 (169.9)	37.1 (218.2)	45.8 (269.4)
Vitamin C (mg)	19.7 (35.9)	83.7 (152.2)	86.4 (157.2)	99.6 (181.2)

[a] ( ), Percentage of recommended dietary allowance.

the RDA. Sufficient amounts of minerals and vitamins were supplied by the three-dish meal. Carbohydrates contributed 77.0% and 64.4% of the total energy in the basic meal and the three-dish meal, respectively, whereas lipid contributed only 8.3% and 11.6%. The energy from lipid did not exceed 12% of the total energy supply until a five-dish meal, which was considered a luxury, was analyzed.

The traditional Korean meal was estimated to be able to supply from 2000 to 2500 calories and from 80 to 90 g of protein per day. The energy constituents were 73% to 77% carbohydrates, 15% to 18% proteins, and 10% to 12% lipids. Animal protein was 20% to 30% of the total protein. The contribution of lipid energy in total calorie intake did not significantly change by increasing the number of side dishes to five, but that of protein did increase. It appears that the Korean traditional meal is well balanced in the view of modern nutritional science. It could supply sufficient protein, minerals, and vitamins to nourish an adult male if the energy intake exceeded 2000 calories per day (10).

High amounts of carbohydrates, which are mainly supplied by cereals and vegetables, and low amounts of animal meat and fat are characteristics of

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a traditional Korean diet. In the traditional Korean culture, food was considered to be the fundamental source of health, and it was believed that all diseases could be cured by the control of food intake. Without knowledge of the chemical composition of foods, Koreans have developed a well-balanced diet by using their *yin* and *yang* and Five Phases theories. Whereas nutritional science in Western society is based on analytical techniques confirmed with animal experiments, the Eastern concept of food and nutrition is developed for the harmonization of human beings and nature through long experience with human trials.

On the basis of the health and nutritional concepts of Korea, Hong Seon Pyo (13) proposed dietary guidelines in his *Book of Korean Cookery*, published in 1940, as follows:

1. Eat only when hungry.
2. Eat hard materials, with adequate mastication.
3. Stop eating before achieving satisfaction.
4. Eat raw food wherever possible.

He suggested using certain principles in selecting ingredients for the preparation of healthy food:

1. Fresh
2. Raw
3. Natural
4. Long-lived plants and animals
5. Dense texture
6. Young plants and animals
7. Materials produced nearby
8. Nonstimulating foods

He also recommended the reduction of salt and refined sugar intake. His dietary guidelines and principles of selecting food materials are widely accepted today.

Considering food to be medicine, practitioners of traditional medicine studied each food ingredient for its property, taste, and medicinal effects. Their knowledge has been compiled in numerous medicinal books in China and Korea for thousands of years and has been practiced in everyday life at the household level as part of Korean dietary custom.

Food preparation was likened to prescription of medicine for the individuals in a household. The word *yaknyum,* the general term for "seasoning", means "thought of medicine." This mentality refuses to accept processed food made in a mass production system. The enormous size of the health food market today in Korea and neighboring countries reflects the tradition of "food as medicine."

A 1996 survey of consumer attitudes toward health food and their perceptions on health and food habits in Korea revealed that the people considered their food habits as the most important factor in the maintenance of health, followed by physical exercise. More than 90% of the people believed that food habits were the most important factor determining the condition of health of human beings, and that diseases could be cured by adjusting food habits (14). One-half of the subjects had the experience of using health foods, and 68% believed in their effectiveness (15).

IV. HARMONIZATION FOR PARADIGM SHIFT

Food technology and modern nutritional science have improved the well-being and health status of humankind tremendously for the last century. The chemical analysis of food components makes us evaluate not only the nutritional value of food, but also physiological function at the microgram level of minor components. Food is no longer merely an energy and essential nutrient supplier; it is now proved by modern analytical tools to be a disease-preventing and even a disease-curing agent. The border between food and medicine is obscure, as shown in Fig. 2 (16).

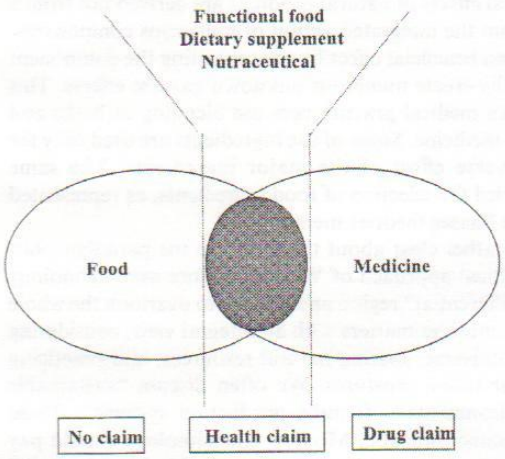

Figure 2 Definition and regulatory status of health foods.

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The regulations adopted from Western society strictly distinguish food from medicine, creating severe conflict with the general concept of food and medicine in traditional societies. The range of health claim allowances for food varies from country to country for this reason. The demand for health claims in food will increase as modern analytical techniques explore more of the physiologically effective substances in food.

It appears that the old Eastern concept of food as medicine is now being proved by Western analytical methods. However, the approaches taken to utilize natural products for health benefits of humankind are different in East and West. Western analytical science continues to identify the effective components in food materials and purify them and make into pills, as they have for vitamins. It is the main driving force of research today to produce profitable nutraceuticals and drugs from natural products. Biotechnology is being used to maximize the production of useful components in the cell and facilitate their separation. This trend of product development will probably cause the same quagmires we have experienced in Western society, such as removal of fiber from food materials, causing constipation and colon cancer, and consumption of high-protein and high-fat diet, aggravating cancer, heart disease, and osteoporosis.

The Eastern approach is blending various components to maximize beneficial effects and minimize side effects. Eastern people know that no single component can provide absolute benefit to the body, which is made of various organs and tissues that have different functions and chemical reactions. Many of the health and medicinal effects of natural products are derived not from a single component but from the integrated action of numerous components. Emphasizing only a known beneficial effect by concentrating the component responsible may potentially create numerous unknown adverse effects. This caution makes the Eastern medical practitioners use blending of herbs and other natural products in medicine. Some of the ingredients are used only for the reduction of an adverse effect of the major ingredients. The same principles have been applied for selection of food ingredients, as represented by the *yin–yang* and Five Phases theories mentioned.

Now the answer is rather clear about the direction the paradigm shift should follow. The analytical approach of Western science and technology has gone too far in the "differential" region and is likely to overlook the whole picture. It is necessary to consider matters with an integral view, considering harmony of human and universe, sparing natural resources, and practicing ethical behavior with our fellow creatures. We often discuss "sustainable development" and "environmentally friendly production systems". These tendencies are all in the same direction. Modern biotechnology should pay great attention to this proposition, so that it will not be hindered by social resistance and rejection.

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