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Current microalgal health food R & D activities in China

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Abstract

The major microalgal genera presently cultivated in China are *Spirulina* and *Chlorella*. They are initially manufactured in the form of algal biomass or extracts by the food industry. The biomass is then used for producing a variety of health products such as tablets, capsules, powder or for extracting bioactive ingredients such as beta-carotene, and phycocyanin. The algal biomass is supplemented to noodles, breads, biscuits, candies, ice cream, bean curd and other common foods as food additives so as to enhance their nutritive and health values. The extracts are mainly used to enrich liquid foods such as health drink, soft drink, tea, beer or spirits.

Introduction

Edible microalgae such as *Chlorella* and *Spirulina* are rich in protein, lipid, polysaccharide, edible fiber, microelements and bioactive substances (Li & Li, 1997). They have such health and pharmacological properties that can help to prevent and cure peptic ulcer and anemia, enhance immunity, anti-tumor, anti-radiation, anti-pathogenic activities against microorganisms, decrease blood lipid and some as anti-arteroclerosis agent (Sonoda, 1972; Sano & Tanaka, 1987; Hasegawa et al., 1995; Singh et al., 1995; Hayashi & Hayashi, 1996; Tanaka et al., 1997, 1998). They can be used to develop nutritional and health foods (Liu & Liang, 1999; Becker, 1988).

In fact, microalgae have been used for food long time ago. For example, *Spirulina* naturally grew in Chad Lake was used as food by Kanembu who lived around the lake since hundreds, or even thousands of years ago. In 1964, health food was produced with microalgae cultivated in artificial media in Japan. *Chlorella* tablets made from dry powder were sold in the markets. In 1975, *Spirulina* tablets were marketed (Yamaguchi, 1997).

Microalgal biotechnology in China has a good developmental momentum, though it started late. The first pilot cultivation base was constructed at Chenghai Lake in Yunnan, China in 1989 (Li & Qi, 1997). In 1991, the first microalgae corporation, Shenzhen Lanzao Biotechnology Corporation was founded in Shenzhen. Now there are more than one hundred research institutes and manufacturing enterprises concerned with the study and development of microalgae as food. The output of *Spirulina* powder has reached 1000 t in 1996. China has now the most extensive cultivation of *Spirulina* in the world.

The College of Food Engineering and Biotechnology of South China University of Technology (SCUT), in cooperation with the Research Center of Biological Fermentation and Food Technology of Hong Kong University and Jangmen Biotech. Center, has successfully conducted pilot research on suspension cultivation of *Chlorella* in fermentors. The production of *Chlorella* has reached a dry weight of 20 kg m^{-3}. It is expected to realize the industrial production of edible microalgae by high-density heterotrophic culture in reactors and to provide cheap raw material for the food industry.

Along with the development of microalgal biotechnology in China, the utilization of microalgae has also developed very rapidly. The major microalgal genera presently cultivated in China are *Spirulina* and *Chlorella*. They are initially manufactured in the form of algal biomass or extract by the food industry. Up to now, a series of nutritional and health microalgal food has been developed.

Nutritional and health microalgal food

Microalgal tablet or capsule

Microalgal tablet (or capsule) is made from dry microalgal powder directly. For example, Qizheng *Spirulina* Tablet and Mingxing Hukangbao Tablets are made from *Spirulina* powder and sticky material. The former is produced by Shenzhen Lanzao Biotechnology Corporation and Guangzhou Guanghua Pharmaceutical Company Ltd, and sold by Guangzhou Maoyuan Imp. & Exp. Corporation. Guangzhou Mingxing Pharmaceutical Factory produced the latter. The only microalgal health drug is *Spirulina* capsule, manufactured by Yunan Green-A Biotechnology Co., Ltd.

Microalgal tablets find favors in consumers' eyes because they are rich in protein, vitamins, polysaccharide, polyunsaturated fatty acids (PUFAs), microelements and edible fiber. For example, Green-A *Spirulina* Tablets have the following nutritional compositions (per 100 g): Protein 55–70 g, carbohydrates 15–25 g, fat 2–6 g, dietary fiber 2–4 g, moisture 4–9 g; chlorophyll 0.6–1 g, carotenoids 0.1–0.4 g, phycocyanin 3.6 g; Mineral nutrition (calcium 0.5–1 g, magnesium 0.2–0.6 g, iron 30–100 mg, zinc 2–4 mg selenium 10–30 μg, germanium 40–80 μg), Vitamins (A 100–200 mg, B_1 1.5–4 mg, B_2 3–5 mg, B_3 10–30 mg, B_6 0.5–0.8 mg, B_{12} 0.05–1.5 mg, E 5–10 mg, PP 200–400 mg, folic acid 0.05–0.1 mg, pantothenic acid 0.5–1.5 mg). They are believed to improve health, prevent disease and reduce weight (Liu & Liang, 1999).

Microalgal nutrition liquid

Up to now, although microalgal tablets are still the most popular algal products, diversification of other microalgal products must be encouraged to ensure the development of microalgal biotechnology. Microalgal extract is one of the important microalgal products. It is convenient to drink, easy to digest, and suitable for all ages. It has now occupied some share of the market. Microalgal extracts, produced from edible microalgae as the main material, will have good development and market prospects.

Some reports showed that *Chlorella* growth factors (CGF) could activate the growth of other organisms and enhance their immunity (Konishi et al., 1985). The main bioactive component of *Chlorella* is glycoprotein with D-galactose, MW 63 000. Similarly, *Spirulina* and its hot water extract can also achieve the function of activating the growth of target organism, reducing weight, preventing disease infection and curing sickness (Belay et al., 1993). In order to preserve the health function and to reduce the unfavorable algal flavor, extracts from traditional Chinese medicinal food can be added to the microalgal extracts.

The development of microalgal extract is in an experimental or small production scale. Wuhan Plant Research Institute, in cooperation with Wuhan Pharmaceutical Factory, studied and produced in lot size the *Spirulina* Oral Liquid. On the other hand, in collaboration with Guangzhou Maoyuan Imp. & Exp. Corporation, SCUT developed the health and nutritional *Spirulina* Liquid with *Spirulina* extract and honey (Liang et al., 2001). The liquid has the nutrition and health function of *Spirulina* and the flavor of softdrink. We also made some progress in the study of *Chlorella* growth factor.

Other microalgal health and functional foods

There are other microalgal health and functional foods produced with microalgal powder as the main ingredient besides microalgal tablet (or capsule) and microalgal extract (or nutrition liquid). Examples of these include Yingkang *Spirulina* Cosmetic Cake and Show & Me Complete Nutrient. The former was researched and developed by the College of Food Engineering & Biotechnology of SCUT and Guangdong Maoyuan Imp. & Exp. Corporation and produced by Guangdong Guanghua Pharmaceutical Factory. It was made from *Spirulina* powder (food grade) and mixed with traditional Chinese medicinal food such as the seed of Job's tears and malt, bean dregs and milk powder (Liang et al., 1998). The latter, a powder food with more than 22% protein, has abundant and balanced nutrients. It is produced by Tianjin Meilin Health Products Co., Ltd. with *Spirulina* powder and extracts of more than ten natural plants and microorganisms as ingredients.

Health foods such as *Spirulina* Cosmetic Cake not only have abundant and balanced nutrients, they also have the flavor of traditional food as well. This is because these foods are produced with microalgae as the main ingredient and mixed with other nutritional foods such as milk powder or other food additives with natural flavor as supplements. So these products find favors in consumers' eyes, and have good economic benefits and development prospects.

Common microalgal foods

Although microalgae such as *Spirulina* and *Chlorella* are mainly used in the production of microalgal tablets (or capsule) and extract, they are also utilized in the processing of common foods in recent years. To date, there are various general foods produced with the addition of edible *Spirulina* and *Chlorella* powder, extracts, pigment of microalgae (e.g. phycocyanin and carotene) and vitamins. They are new and possess the nutritional and health properties of microalgae and the flavor of common foods.

Microalgal noodles

Among the application of microalgae in common food processing, the largest quantity of microalgae is being used in instant noodles or general noodles. Microalgal noodles, produced with flour, *Chlorella* and *Spirulina*, will have abundant nutrients, good color, smell and taste and strong ductility with the color and flavor of microalgae. Examples of microalgal noodles include *Spirulina* noodle cakes, produced by Guangzhou Nanfang Flour Factory, and are marketed in China. Chinese Educational Ministry recommended it as the ideal lunch for the primary school pupils and secondary school students.

To produce microalgal noodles with light color, 0.1–1.0% of microalgal powder is added to flour. Xu studied the manufacturing of instant *Spirulina* noodles and applied a patent for it in China (Xu, Chinese Patent 1993). Similar result was reported by Chen & Li (1999).

Microalgal bread

To improve the nutritional value of bread, the microalgal powder can be added to it. Microalgal bread has the color and flavor of microalgae, contains more vitamins, microelements, and special bioactive substances present in microalgae. With the help of water retention function of microalgae, the valid duration time of the product will be longer (Liang, 1999).

Microalgal biscuits

Biscuits are always made of the main ingredients like flour, sugar, cream, edible oil, essence, leavening agent and phospholipids, so their nutrients are always insufficient for human body. In recent years, biscuits with vegetables or fiber have received favorable acceptance by consumers. If green algae or blue-bacteria are added to the biscuit, they can increase the nutritional value of the food. There are some microalgal (*Spirulina*) nutrition biscuits for children and microalgal (*Spirulina*) soda biscuits in the market of China produced by the Shenzhen Haiwang Food Factory or are being developed (Lu & Wang, 1998).

Microalgal drink

Theoretically, microalgae can be added to many drinks to strengthen their nutritional value. In fact, a series of microalgal drinks such as microalgal health drink, microalgal sour milk, microalgal green tea has been developed. In order to keep the clear color or homogeneity of these drinks, microalgae must be used in the form of microalgal extract (green algae extract, *Spirulina* extract or phycocyanin). Because of the nutritional value of microalgae, they are frequently utilized in the development of drinks in recent ten years. Feng and Zeng reported *Spirulina* drink (Feng & Peng, Chinese Patent 1991; Zeng & Liang, 1995). *Spirulina* drink powder was also produced (Bai et al., 1996). We are researching on and developing *Chlorella* and *Spirulina* nutrition drink. Some *Spirulina* drink, for example, *Spirulina* drink produced by Guangzhou Jingxiutang Pharmaceutical Factory, is sold in the markets.

Microalgal green tea

Tea, especially green tea, the leading health drink, is rich in vitamin C, while microalgae such as *Spirulina* and *Chlorella* contain less vitamin C but abundant protein, chlorophyll, carotenoids, PUFA, polysaccharide and micro-elements. If microalgal biomass is mixed with green tea, the nutritional components could be complementary. Foods containing more and balanced nutrients can be acquired. Thanks to low molecular protein, lipid and polysaccharide, microalgae can change the dispersion feature of green tea micropowder in water, and bring up good foam (Zhou et al.,

1999). Microalgae are rich in chlorophyll and phycocyanin. These pigments can change the color of tea into green. In addition, microalgal protein and polysaccharide can decrease the irritation brought about by caffeine in green tea. Hence, microalgal green tea can serve the function of health protection and help to alleviate fatigue.

Microalgal beer

Shandong Shuyi Group Corporation, in cooperation with China Aquaculture Science Research Institute, produces *Spirulina* beer. This health *Spirulina* beer keeps the nutritional components and flavor of traditional beer, and also increases its nutrient content derived from *Spirulina* (Chen & Ying, 1998).

Microalgal candy

Guangzhou Dongguan Zhenshanmei Food Factory produces *Spirulina* candy and iodine-rich crunchy candy with granulated sugar, pectin, *Spirulina* powder, peanut and agar-agar. In addition, South China Ocean Research Institute produces phycocyanin from *Spirulina* as edible pigment on a trial basis. EPA, DHA and polysaccharide from microalgae can also be used as functional food additives.

With the increase in the demand for health food products and the acceptance of more and more consumes for microalgal food, it is expected that the research and development of microalgal health foods, flavor foods and additive will speed up in China. The utilization of microalgae in food industry will become widespread in this country. *Spirulina*, *Chlorella* and other edible microalgae will play an important role in the health and nutrition of human beings.

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