Plant diversity and human health

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Plant biodiversity builds up a sustainable supply of essential compounds for human health. As a consequence of plant diversity, plant metabolites also possess a great extend of diversity. Instead of reckless utilization of wild plant resources, studies of the biology of those plants with desired phytochemicals, and development of new technologies for utilization, as well as conservation, of plant resources, are among the key issues for sustainability and better life of humans.

Chronic diseases and malnutrition, two of the biggest health problems in front of humans today, are related to each other. For example, overnutrition or undernutrition can cause cardiovascular disease (CVD), obesity, diabetes, vitamin A deficiency (VAD), and iron deficiency. Healthy diet can effectively prevent and control chronic diseases, and resolve the micronutrient insufficiency problem. In fact, all human foods are supplied directly or indirectly by plants. Plant products (seeds, fruits, leaves, roots, etc.) contain almost all of the organic and mineral nutrients which are established as essential nutritional components, as well as a number of unique specialized phytochemicals that have been confirmed for the maintenance and promotion of a good health status of humans (Grusak & DellaPenna 1999).

As the primary producers in the ecosystems, plants not only play a pivotal role in nourishing and improving our living space, but also synthesize a large variety of different nutritional substances through their primary and secondary metabolisms. In addition to the well-known staple food components of carbohydrates, proteins and lipids, plants also produce a great number of small molecular secondary metabolites, or 'plant specialized metabolites' (Gang 2006), such as flavonoids, phytosterols, terpenoids, alkaloids, and phenolics, most of which are closely related to human health promotion or disease prevention (Kurzer & Xu 1997). The following three examples can easily elucidate the importance of plant metabolites to human health: (1) Vitamins are well-known low-molecular-weight compounds which are essential for human health. Vitamins regulate metabolism, promote growth, and maintain many physiological functions of our bodies. Except for a few vitamins that are produced by microorganisms in the intestine, most vitamins are obtained from food resources, especially from vegetable foods. (2) Phytoestrogens, which mainly consist of fabaceous isoflavones and lignans in various fruits and vegetables, are natural active compounds with estrogen-like biological functions; they have been proved to be effective in the suppression of tumours (such as mammary cancer and prostate cancer), reducing cardiovascular disease and osteoporosis (Sarkar & Li 2003, Cotterchio *et al*. 2006). (3) Celluloses, the non-starch polysaccharides, have been shown to be beneficial to human health since 1980s, for they may improve the sugar tolerance, promote balanced metabolism, help to reduce weight, and prevent diabetes and CVD.

With the improvement of living standards, more and more attention has been paid to the nutrition value and the safety of foodstuffs. People have realized that plant metabolites, particularly the secondary metabolites, are a huge natural treasury for the exploitation of nutritional, as well as medicinal, products. In recent years, molecular elucidation of biosynthetic pathways, metabolomics and metabolic engineering have become hot spots of plant research (Dixon *et al*. 2006). Plant primary metabolic pathways are on the whole clear, and studies on the biosynthesis of vitamins and other major secondary metabolite groups (e.g., flavonoids and terpenoids) are deepening today (e.g., Van der Meer *et al*. 2001, Maeda *et al*. 2006). Data gathered from comprehensive metabolite profiling, in combination with those from genomics, transcriptomics and proteomics, have the potential to generate a more and more detailed network of the dynamic composition of food and feed stuffs, to optimize crop trait development, and to enhance diet nutrients for improving human health.

Higher plants have rich biodiversity, with more than 248,000 species having been recorded (Wilson 1992). The recently updated book of *Flowering Plant Families of the World* contains comprehensive entries on 504 angiosperm families (Heywood *et al*. 2007). It is a feature of plant secondary metabolites that the distribution of a special group of compounds is often taxon-specific. For a few examples, isoflavonoids are mainly found in legumes; the sesquiterpene lactone artemisinin, a valuable anti-malaria natural product, is found in *Artemisia annua* only, although the genus *Artemisia* contains more than 350 species worldwide; even the 'model plant' *Arabidopsis thaliana*, which has a relatively small genome in plant kingdom and a short lifespan, accumulates a large number of secondary metabolites (D'Auria & Gershenzon 2005), especially under stress conditions. As a consequence of plant diversity, plant metabolites also possess a great extent of diversity. It was estimated that plants produce more than 200,000 metabolites and most of them are secondary metabolites (Schauer & Fernie 2006). Most of plant secondary metabolites are diversified from certain basic structures, as a result of the existence of different modifying enzymes (or enzyme systems) among plant groups. For example, plant genomes are especially rich in P450 monooxygenase genes such, many of which participate in plant secondary metabolisms (e.g., Luo *et al*. 2001).

Besides serving as foods, plant metabolites have been utilized in many other styles for thousands of years. From the early traditional medicines, condiments, and cosmetics, to modern medicines and health-promotion products, all of them exemplify the value of the diversity of plant metabolites. Recently, in order to discover new nutritional compounds beneficial to human beings, many wild plants, such as *Hippophae rhamnoides*, *Huperzia serrata*, *Artemisia annua* and species of *Actinidia*, *Vaccinium*, *Rubus*, etc., have been exploited with appreciable commercial success. However, being useful is sometimes a bad news for plants, as plant resources could be destroyed carelessly (Raven 2002). Once their functions are proved, many plants, especially those with medicinal importance, are likely to be harvested extensively, and they may rapidly become endangered. This is due to several reasons. One of them is that those wild plants usually neither grow fast nor accumulate a sufficient amount of desired compounds that can meet the market demand (Jennewein & Croteau 2001). And the commercial profit makes it hard for people to wait until a reasonable (bio)technology has been developed for protecting the plant resource. *Huperzia serrata* of Huperziaceae is a typical example. This widespread plant grows slowly, with a very small final biomass. Since the alkaloid Huperzine A for Alzheimer's disease was isolated from this plant, it has become an endangered species with badly depleted wild resources. Even for *Glycyrrhiza uralensis*, a medicinal plant which is easy to proliferate and stress-tolerant, is in short supply in its native China. Knowing that plant metabolites are essential for human health, and plant diversity conservation is the foundation of sustainable utilization and exploitation of metabolites, it goes without saying that plant biodiversity should be protected in time. Fortunately, people already realize that their own health depends on a healthy environment and founded the Society for

Conservation Biology in 1985. The countries all over the world have gradually increased and strengthened research on biodiversity.

Mere protection is by far insufficient, because the better protection is to make the best use. In order to let the plentiful nutrients of plants serve for human health in a sustainable manner, we should step up the scientific research on the following two aspects, on the premise of protecting the original plants effectively. First, to further investigate the wild plant resources. It is estimated that about 7,000 plants are edible and 5,000 plants have health-promoting metabolites and can be used as traditional medicines, but up to now only a small number of plant species have been analyzed for their metabolites. The known secondary metabolites are probably the tip of the iceberg. There is no doubt that this buried treasure is waiting for further exploration, conservation should be considered a priority. Second, to further strengthen plant biological studies and develop biotechnology for efficient utilization of plant metabolites in a sustainable manner. Isolation of valuable compounds from wild plants possesses a terrible threaten to the natural reservation of those species. Although cultivation has been successful for a small group of species, such as *Artemisia annua*, certain species, which may be already endangered, grow extremely slowly. Furthermore, in a country with a big population like China, agriculture is of paramount importance and farmland is limited. A better understanding of biology of these special plants, and development of biotechnology for more efficient production of plant metabolites, will provide solutions to both plant conservation and human health.

Humans live on plants. As Peter Raven pointed out, we must find new ways to provide for a human society that presently has outstripped the limits of global sustainability (Raven 2002). A well preserved plant biodiversity builds up the sustainable supply of various valuable phytochemicals for human health. Study of the biology of those plants with health-promoting importance, and development of new technologies for utilization as well as conservation of plant resources, are among the key issues for sustainability and a better life.

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