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Review of the Resources and Utilization of Bamboo in China

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Abstract

China has made a breakthrough in the development and scientific cultivation of bamboo. At present, China ranks first in bamboo research worldwide, because of numerous research units and strong technical force. This chapter focuses on the utilization of bamboo resources such as food, roofs and walls of houses, fences, and domestic and agricultural implements such as water containers, food and drink container hats, arrows, quiver, etc. A total of 861 species and infraspecific taxa belonging to 43 genera have been reported and include 707 species, 52 varieties, 98 forma, and 4 hybrids, which are naturally distributed in 21 provinces. The national bamboo forest covers 6.01 million ha, including 4.43 million ha of Moso bamboo and 1.58 million ha of other bamboo species. As the country develops and new economic activities emerge, bamboo production has shifted from harsh processing, such as bamboo basket, to finished machining, such as bamboo flooring. The bamboo industry has attracted new opportunities as a new energy source, particularly renewable energy, and may be considered a lignocellulose substrate for bioethanol production because of its environmental benefits and high annual biomass yield.

Keywords: China, bamboo resources, utilization, Moso bamboo

1. Introduction

Bamboo belongs to the subfamily Bambusoideae and may be grown in any temperate climate zones in Asia, Africa, and Latin America [1]. The total area of bamboo forests is 22.0×10 ha, which account for about 1% of the total global forest area [2]. Over the last 3 decades, bamboo has evolved from being a raw material for basic goods into a material base of an increasingly diversified array of products; recently, bamboo has been recognized as a potentially important

source of cultural and environmental services [3]. Bamboo species, particularly the large clump bamboo, have enormous potential as an energy source. The bamboo industry plays an important role in economy and society development in China and other countries worldwide [4]. With the expansion of bamboo forests, their importance in people's lives has also increased. Hence, scholars have focused on developing bamboo forest production, increasing the bamboo forest yield, and establishing methods for rational use of bamboo resources in global forestry production.

China has the most abundant bamboo resources worldwide and the richest bamboo culture. Bamboo greatly influences not only the Chinese history and culture but also people's daily life. Although the total forest area in many countries has decreased drastically, the area of bamboo forests has consistently increased at a rate of 3% annually [5].

In recent years, significant advances have been achieved in bamboo cultivation and development, carbon fixation and storage, and ecological and environmental functions in China. This chapter reviews the traditional utilization methods of bamboo resources in China.

2. Basic situation of bamboo resources in China

Bamboo is a rapidly developing, renewable, widely distributed, low-cost, environment-improvement resource. It has the potential to improve poverty alleviation and environment conservation [6]. Bamboos are plants belonging to the subfamily Bambusoideae. According to the data collected, there are 116 genera and 1439 species worldwide [7], of which 62% are native to Asia [8]. China has the most abundant and diverse bamboo species. In China, a total of 861 species and infraspecific taxa in 43 genera have been reported, including 707 species, 52 varieties, 98 forma, and 4 hybrids. Bamboo is naturally distributed in 21 provinces (municipalities or Autonomous Regions) [9]. These taxa include 10 genera and 48 species of endemic bamboo [10]. According to the Eighth National Forest Inventory from 2009 to 2013, statistics shows that the national bamboo forest area covers 6.01 million ha, including 4.43 million ha of Moso bamboo and 1.58 million ha of other bamboo species.

The bamboo forests in China are mainly distributed in 18 provinces. The major provinces with more than 300,000 ha of bamboo forest are Fujian, Jiangxi, Zhejiang, Hunan, Sichuan, Guangdong, Guangxi, Anhui, and the eight provinces (autonomous regions), accounting for 89.10% of the total bamboo forest area. From 1980 to 2013, the bamboo forest area in each province increased annually (**Table 1**).

It is worth noting that the area of bamboo forest resource distribution in Yunnan is not large in China, but Yunnan is considered as one of the original bamboo centers not only in Asia but also worldwide. In Yunnan, 28 genera and at least 250 bamboo species have been found, half of which are of ancient origin [11]. Yunnan has 26 minority nationalities, and people of all nationalities widely use bamboo in clothing, food, shelter, transportation, and in all its aspects in the long-term practice. Bamboo has a profound and unique influence on life and China has a unique special ethnic bamboo culture.

Provinces	1980	1995	2005	2013	Provinces	1980	1995	2005	2013
Fujian	56.71	64.08	91.07	106.75	Guangxi	8.60	13.80	16.32	34.09
Jiangxi	58.20	70.93	93.47	99.89	Guizhou	2.40	3.87	4.43	15.69
Hunan	53.30	68.35	88.80	77.83	Jiangsu	1.80	2.23	2.87	3.37
Zhejiang	45.20	62.45	72.60	83.34	Sichuan	1.60	1.90	2.60	54.90
Anhui	15.30	20.34	24.53	33.72	Taiwan	0.50	0.63	0.80	—
Guangdong	11.27	31.80	17.80	44.62	Yunnan	0.30	—	0.48	11.04
Hubei	8.60	8.60	13.80	14.40	Henan	0.29	0.47	1.67	2.74

Table 1. Statistics of increase in bamboo resources in major provinces and autonomous regions in China (unit: 10,000 ha).

3. Utilization types of bamboo resources in China

Bamboo plays an important role in the development of Chinese historical culture. Through the ages, bamboo has been gaining an increasing attention from Chinese people. As one of the fastest growing plants, bamboo has become one of the most important forest resources and has a high commercial value and ecological function. Bamboo is indispensable in the manufacturing industry and daily life of Chinese people.

China is a developing country that has a large number of population dependent on agriculture. Many of their production equipment and supplies are made of bamboo, especially in the southern rural areas.

Since ancient times, bamboo has been widely used in the daily life of people in rural China. Therefore, most of the bamboos produced in China are used in rural and agricultural production. Bamboo resources in China were traditionally utilized by local farmers as minor forest products with weak linkage in the market. In recent years, with the fast pace of modernization, bamboo plants have replaced wood because of their advantages, such as fast growth, high yield, short rotation, and easy management. The bamboo processing industry has gathered momentum and entered a new stage. By the end of the twentieth century, dozens of countries established bamboo-based paper milling, with annual output of more than 1 million tons of bamboo paper and bamboo pulp production capacity of 4 million tons. Fine processing of bamboo has also gained increasing attention to produce a new type of artificial bamboo board with features similar to those of wood. Research and production of bamboo products have reached the practical level and production scale. The wood-based panel industry has been in the forefront in terms of variety and scale worldwide. Furthermore, the quality and process of mechanical production of bamboo have continuously improved.

Table 2 shows the methods for utilizing bamboos. The main application of bamboo in China is divided into two parts: economic use and ecological utilization. Economic utilization can be roughly divided into timber bamboo, shoots bamboo, skin bamboo, and art and crafts bamboo. Ecological value can be divided into water conservation forest and ecological forest tourism.

Value	Utilization	Specific purpose	Bamboo species
Economic	Timber	Bamboo flooring	<i>Phyllostachys edulis</i>
		Pulp and paper	<i>Dendrocalamus giganteus</i>
		Construction material	
		Bamboo chopsticks	
	Shoot	Fresh shoot	<i>Ph. edulis</i>
		Drying shoot	<i>D. brandisii</i>
		Canned shoots	<i>D. latiflorus</i>
		Flavored Shoot	<i>Ph. praecox</i>
	Skin	Tables and chairs	<i>Neosinocalamus affinis</i>
		Basket	<i>Bambusa textilis</i>
Wall of house		<i>B. chungii</i>	
Arts and crafts	Musical instruments	<i>Qiongzhueta tumidissinoda</i>	
	Bonsai	<i>Chimonobambusa quadrangularis</i>	
	Root carving	<i>Pseudosasa amabilis</i> <i>Ph. nigra</i>	
Ecological	Water conservation	Water conservation forest	<i>Ph. edulis</i> <i>D. giganteus</i>
	Ecotourism	Scenic spot	<i>Ph. aurea</i> <i>B. ventricosa</i> <i>Thyrsostachys siamensis</i>

Table 2. Utilization of bamboo in China.

In terms of timber bamboo by roughing to finishing gradually, mainly using rough machining in building, not only can be used as scaffold material, scaffold and all simple bamboo house beam, column, wall, and bamboo ladder; deep processing of bamboo integrated from 80s, it began to gradually shift plywood, bamboo lattice plywood, bamboo particleboard, bamboo flooring and other, this is a new way for the utilization of bamboo.

The representative bamboo species of timber bamboo is *Phyllostachys edulis*. This species is generally known as Maozhu and is called Moso in the West. *P. edulis* is a major economic species grown in subtropical regions, which constitutes the largest artificial bamboo formation and has been thoroughly exploited and studied [12]. The topography varies from mountain-sides, rolling hills, and plains. This species is largely spread because of human cultivation. *P. edulis* covers a total area of 240×104 ha throughout China. Large forest areas are found in plains and mountain sides, approximately from 800 m above sea level to 1200 m in vertical distribution in some southward places(as shown in **Figure 1a**).

Another famous timber bamboo is *Dendrocalamus sinicus*. This species, also called “huge dragon bamboo” by Chinese locals, exhibits a unique feature of large thermal axis sympodial bamboo and is only located in the Southern and Southwestern Yunnan. *D. sinicus* can grow 30 m tall and 35 cm in diameter and is the world’s biggest bamboo with great development value and utilization. The “huge dragon bamboo” provides excellent ecological protection and soil and water conservation because of its developed rhizome root system that reaches 5~10 m (as shown in **Figure 1b** and **c**).



Figure 1. The importance of bamboo species. (a) *Phyllostachys edulis*—bamboo forests—this Moso bamboo constitutes the largest artificial bamboo formation and has been thoroughly exploited and studied; (b) *Dendrocalamus sinicus* bamboo—it is the largest bamboo in the world, and it can be used to build houses; (c) bamboo sheath of *D. sinicus*—this sheath can be used to make hat and sole of shoe; (d) *Neosinocalamus affinis*—it is a very good weaving material; (e) culm bud of *N. affinis*—looks like Chinese word “山”; (f) *Fargesia fungosa*—*Fargesia* is an ecological and ornamental scenery species, and also is the main food source of panda. It also plays an important ecological role in soil and water conservation; (g) *Qiongzhusa tumidissima*—this bamboo has a high ornamental value and process value, and can be used to make cane. This species is distinguished for use in both art and crafts and for edible shoot production. Moreover, *C. tumidissima* is sold to other countries in South Asia since the Han and Tang dynasties and is listed in the first group of specially protected plants in China.

Bamboo shoots are used as traditional food by the Chinese people. The shoots can be used to make up for the nutrient deficiencies in the diet because of their nutritional and therapeutic values [13]. There are about more than 50 species of bamboo shoots used in China. Among them, the cultivation area is large, the number of shoots is high, and the bamboo shoots which are of good quality are available such as *P. edulis*, *P. dulcis*, *D. latiflorus*, *D. hamiltonii*, *Chimonobambusa quadrangularis*, and so on [14].

Bamboo can do some kind of woven material because of the long bamboo fiber and good tenacious, thus all kinds of bamboo can be used for weaving. People use bamboo to weave baskets, tables, and chairs. *Neosinocalamus affinis* is the most widely cultivated bamboo, which is used to weave. Other bamboo varieties such as *Ph. nigra. var. henonis*, *Bambusa textilis*, *B. chungii*, and so on are also good weaving materials.

4. The traditional utilization

Bamboo has a tensile strength of 28,000 per square inch, which is higher than that (23,000 per square inch) of steel and is thus an essential material for structures that can withstand earthquakes. Bamboo is also used to construct buildings. In remote southern mountains of China, some ethnic minorities live in bamboo houses. Bamboos are used as roofs and walls of houses, fences, domestic, and agricultural implements, such as water containers, food, and drink containers, hats, arrows, quiver, etc. The Chinese people eat bamboo shoots, which are a good source of dietary fiber and have low fat content and calories. Fresh, dried, canned, and flavored shoots are consumed as delicacies. In fact, bamboo shoots as food were used traditionally by tribal communities worldwide. To enhance the application of bamboo shoots, scholars have investigated them as food in Japan, Taiwan, Thailand, and other Asian countries and have developed several commercially available products in the market [15]. **Figure 2** shows some of the products made of bamboo.

5. Availability and potential use of bamboo resources

Bamboos are multipurpose plants of high economic and environmental value. Bamboo is one of the Non-Timber Forest Products (NTFPs) that has considerable potential as a wood substitute because of its high growth rate, good mechanical properties, and broad range of applications, especially in industrial fields. Bamboo has become a high-tech industrial raw material and substitute for wood.

According to data collected in this chapter, China contains the most abundant and diverse bamboo forest worldwide. A total of 861 species and infraspecific taxa belonging to 43 genera have been reported and include 707 species, 52 varieties, 98 forms, and 4 hybrids, which are naturally distributed in 21 provinces in China. The national bamboo forest area is 6.01 million ha, which include 4.43 million ha of Moso bamboo and 1.58 million ha of other bamboo species. The bamboo forest is mainly distributed in 18 provinces and mostly comprises Moso bamboo.



Figure 2. Uses of bamboo: (a) Bamboo wine—bamboo wine is an original ecological food with zero contamination and is produced by injecting the finest sorghum wine into a young bamboo pole. After 3 years of brewing, the natural essence of wine is produced; (b) bamboo straw hat is made of woven bamboo leaves and wicker. The hat is sturdy and beautifully designed; (c) back basket—this backpack is a clothing worn by Huayao Dai minority endemic to Yunnan. This basket is worn at the back, can be decorated, and can hold small things. It has a role in beautification; (d) bamboo flute—the flute is a popular musical instrument in Chinese classical music and is made of natural bamboo; (e) bamboo pendant—Chinese words or pictures are engraved in these pendants for good luck; (f) bamboo shoot—bamboo shoot is used in Chinese traditional dishes and has a long history of eating and cultivation; and (g) bamboo charcoal—bamboo charcoal is widely used as fuel because it cannot be easily burned. Bamboo charcoal is also widely used in food, cooking, baking, storage, and preservation.

Although Yunnan has only 110.4 thousand ha of bamboo forest, it has the most diverse bamboo species (220 species), with many rare and endangered bamboo species. This province is one of the world's center of bamboo distribution. Bamboo forests can be divided into three types, namely cool temperate bamboo forests, warm and temperate bamboo forests, and hot bamboo forests. Different types of bamboos have various uses, commercial values, and ecological functions. Bamboo plays an immense role in the development of Chinese historical culture and the formation of Chinese ideology.

China has made a breakthrough in the development and scientific cultivation of bamboo. At present, China ranks first in bamboo research worldwide, because of its numerous bamboo research units and strong technical force. A bamboo research institute has been established in China Academy of Forestry Sciences, Southwest Forestry University, Nanjing Forestry University, Zhejiang Academy of Forestry, Jiangxi Academy of Forestry, and other forestry research institutions. In this chapter, we introduced the "International Bamboo and Rattan Center." The main duties and tasks of this center are as follows: to set up a national key laboratory for biological technology and material processing and utilization; to conserve bamboo and rattan; to build a world bamboo gene library; and to conduct international technology cooperation on bamboo resource protection, cultivation, material research, and development. In addition, many of the key bamboo timber-producing provinces and counties and large bamboo handicraft factories have set up a group of full-time staff engaged in bamboo science and technology work. Bamboo research covers a wide range of topics including the classification of germplasm resources, the application of bamboo, and the improvement in the aspects of high-yield cultivation, processing, and utilization [16].

Scholars must focus on discovering plants/crops that can be used as a new energy resource, particularly renewable energy. Energy development and utilization have become inevitable for sustainable development of economy and society. At present, China has limited energy supply, which is much lower than the world average supply of only 19.4% [17]. Bamboo is a renewable resource with many uses and may be considered as a lignocellulose substrate for bioethanol production because of its environmental benefits and high annual biomass yield [18]. Biological bamboo resources are mainly used in two ways. First, bamboos are used as raw materials in bioethanol production. Second, bamboos are used as raw materials for power generation [17]. The use of bamboos as new raw materials for energy supply in the bioenergy industry has opened up novel strategies and growth points for the development of the bamboo industry. Using bamboos to provide bioenergy is an important area to be explored in the future. This phenomenon requires careful and strategic planning based on adequate knowledge on the availability and potential use of bamboo resources for society and environment and on their production and growth behavior [19].

6. Conclusion

China has the most abundant bamboo resources worldwide and the richest bamboo culture. Bamboo greatly influences not only the Chinese history and culture but also every aspect of

people's production and life, in clothing, foodstuff, lodging, transport, and tools. In the future, the bamboo industry will be one of the pillar industries of the southern mountainous area's economic development; in addition, more than 80% of the bamboo forests in China are located at the source of river system, playing an important ecological function of soil and water conservation. Therefore, how to rationally protect and utilize the abundant bamboo resources in China will be a major problem to be solved in the future.

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