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Red Bayberry (*Myrica rubra*), a Promising Fruit and Forest Tree in China

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Abstract

Red Bayberry(*Myrica rubra* Sieb. et Zucc) called arbutus, Chinese tree berry or Yangmei is an important native fruit and forest tree in China. It has eight classes of cultivars and the characteristics of some promising cultivars are described. 'Biji', 'Dongkui' , 'Ding-ao' and 'Wandao' are the main cultivars and have been planted throughout the country. In China, red bayberry can be used as fruit, medicinal plant, forest and garden tree and has a great economic, ecological and social value. The market outlook of red bayberry is very bright.

Introduction

Red bayberry (*Myrica rubra* Sieb. et Zucc.) is an important native fruit representing an endemic species of China. It is a stone fruit with a berry-like edible portion developed from the exocarp and consisting of capsule-like cellules termed flesh segments. The rich red colors and appealing flavor make this juicy fruit popular with consumers in China. In the last ten years, red bayberry developed very quickly in China. In 2003 the cultivated area in China was 233,000 ha, which is more than 2.6% of the total fruit area and had increased by 44.2% as of 1995 (130,000 ha), and its area in China will likely increase rapidly in the future (1,9).

The commercial cultivation of red bayberry is mainly restricted to China and most of the literature was published in Chinese, so it is less familiar abroad. Li et al. (11) and Chen et al. (1) published reviews in English on the botany and horticulture of red bayberry based on Chinese publications. In the previous reviews, little or no description about the germplasm resources and cultivars were published. This review will mainly introduce germplasm resources, promising cultivars and uses of red bayberry in China.

Distribution

Red bayberry originated in southern China and the geographic distribution is the same as that of citrus, loquat, tea and bamboo, but it is more resistant to cold than citrus and loquat. The range of of *M. rubra* distribution lies from the eastern coastal area of Taiwan in the east to Ruili county of Yunan Province in the west and from Sanya city of Hainan Province in the south to the Hanzhong district of Shanxi Province in the north, approximately 97° to 122°E longitude and 18°to 33°N latitude. The major commercial production area is concentrated in Zhejiang, Jiangsu, Fujian, Gongdong, Jiangxi, Anhui, Hunan and Guizhou provinces (Fig.1). Zhejiang ranks first in China in terms of acreage, yield, cultivars and quality of red bayberry (1, 9,10,13,14,20).

Besides China, red bayberry is also grown in Thailand, Japan, South Korea, Philippines, Europe and America, mainly for ornamental purposes.

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Germplasm resources

There is little agreement on cultivar classification. Fruit color, ripening date and growth of tree have been common and main criteria for cultivar classification of red bayberry (16, 18, 20). Red bayberry cultivars are grouped into eight classes as follows: *M. rubra* var. *sylvestris* Tsen, *M. rubra* var. *typica* Tsen, *M. rubra* var. *rosea* Tsen, M. *rubra* var. *alba* Tsen, *M. rubra* var. *nana* Tsen, M. *rubra* var. a*stropurea* Tsen, M. *rubra* var. *praemafurus* Li and M. *rubra* var. *conservatus* Li (10, 13, 16, 18, 20).

So far, there are 305 cultivars and 120 clones of red bayberry in China. Of these, 268 cultivars have been evaluated on agronomic characteristics and quality (1, 19, 20). Fruit characteristics vary widely among these cultivars, as shown by the ripening date, fruit color, fruit weight and quality (Table 1).

Table 1. Representation of 268 cultivars fruit attributes of red bayberry.

Ripening date		Flesh		Fruit size		Fruit quality	
Month	Rep[z]. (%)	Color	Rep. (%)	Weight(g)	Rep. (%)	Quality	Rep. (%)
April	1.1	White	9.3	<6	6.3	Low	6.3
May	6.3	Pink	5.6	6.1-9	25.8	Below mid	17.9
Early June	13.7	Red	17.2	9.1-13	46.6	Middle	38.1
Mid June	18.7	Deep red	7.8	13.1-15	14.9	Plus middle	16.4
Late June	47.8	Purple	37.3	>15	6.3	High	16.4
Early July	4.9	Deep purple	3.4			Excellent	4.9
Mid July	7.5	Purple black	13.8				
		Jet black	5.6				

[z] Representation. (Source: 1, 19.)

Cultivars

Eighteen cultivars have been approved for commercial cultivation by the Provincial Government in China while 'Biji', 'Dongkui', 'Ding-ao' and 'Wandao' (Fig.2) are main cultivars and have been planted throughout the country (19, 20). The characteristics of 12 very promising cultivars are listed in Tables 2 and 3..

Habitat (1,9,13)

Red bayberry is a cold tolerant evergreen fruit tree which can survive through the winter in the areas where the lowest temperature reaches 9°C and grows well in tropical, subtropical, and temperate zones with optimum temperature range of 15-21°C. For high yields and better quality, the growing conditions should include annual average temperature of 14°C and accumulation of 4500 degree days (10°C base).

Because red bayberry requires a warm and humid climate, water is an important factor. For normal growth and development, the red bayberry requires above 1,000 mm annual precipitation. June is the main fruit development period and the amount of moisture in June can directly influence both production and fruit quality. In general, 160 mm is the optimum precipitation in June. In addition, flowering and pollination are influenced by humidity.

A shady and moist environment is ideal for red bayberry; light is not a key factor. The fruit flavor and tree vigor of red bayberry planted on northern slopes is better than that planted on southern slopes and it can also thrive well in the valleys, where the tree may have a stable supply of moisture and shade. However, sunny days during the end of summer to early autumn favor the formation of flower buds and improve the fruit color.

Red bayberry is adapted to the lateritic soil, loess-like loam and sandy loam of mountainous lands with pH 4.5-6.0. The mountainous regions where the fern, rhododendron, pine and China fir grow well,

are quite suitable for red bayberry. Because red bayberry can fix nitrogen in symbiosis with *Actinomyces Frankia*, it can also grow in barren land or sterile soil and grows better in mountainous soils than on the fertile flat lands.

In addition, elevation can also affect the growth habits of red bayberry. Fruits mature 4-5 days later at an elevation of 500-700 m than that planted on the elevation of 50 m.

Table 2. Tree characteristics of cultivars and their main production zones[z].

Cultivar	Characteristics	Yield /tree (kg)	Origin	Main production zone
Wusuhe	Extremely vigorous	130	Guangdong	Guangdong
Zaojimimei	Medium vigor, small leaves Resistant to unfavorable conditions	50-60	Zhejiang	Zhejiang
Zaodamei	Medium vigor, high disease resistance	50-65	Zhejiang	Zhejiang
Zaose	High vigor, erect branches highly adaptable high disease and insect resistance	70-100	Zhejiang	Zhejiang
Guangyemei	Medium vigor	60-80	Hunan	Hunan
Ersemei	High vigor, highly adaptable two colored fruit (purple-black and red)	40-50	Fujian	Fujian
Ding-aomei	Extremely vigorous , large leaves	75	Zhejiang	Southern China
Biji	Medium vigor, sparse branches highly adaptable, high disease resistance	55-65	Zhejiang	Southern China
Dongkui	Extremely vigorous, large leaves and fruit high wind and disease resistance	100-150	Zhejiang	Southern China
Xidiwumei	Vigorous, dense branches	40-50	Jiangsu	Jiangsu
Wanjimimei	High vigor , large leaves high resistance, high heat tolerance	50-60	Zhejiang	Zhejiang
Wandao	High vigor, high resistance	50-100	Zhejiang	Southern China

[z]Sources: Ref. 9, 13, 19.

Table 3. Fruit characteristics of high quality red bayberry cultivars[z].

Cultivar	Color	Length (cm)	Width (cm)	Weight (g)	EP[y] (%wt)	TSS[x] (%)	Acidity (%)	Ripening date
Wusuhe	Purple black	2.3	2.6	11.5	94	13.4	0.80	Early June
Zaojimimei	Deep purple	2.5	2.6	9.0	95	12.4	1.26	Early and Mid June
Zaodamei	Purple	2.9	3.2	15.7	94	11.0	1.06	Mid June
Zaose	Purple	2.6	2.8	12.6	95	12.5	1.25	Mid June
Guangyemei	Purple	2.4	2.6	12.5	92	12.5	0.56	Mid June
Ersemei	2/3Purple black 1/3 red	2.7	2.9	13-15	92	9.5	0.16	Late June
Ding-aomei	Purple	2.7	2.9	11.3	96	11.1	0.83	Mid and Late June
Biji	Jet black	2.6	2.7	10.0	96	13.0	0.90	Mid June-Early July
Dongkui	Deep purple	3.7	3.4	25.0	95	13.4	1.10	Late June-Early July
Xidiwumei	Purple	2.9	3.0	14.7	95	12.3	0.60	Late June-Early July
Wanjimimei	Purple black	2.7	2.8	13.0	96	13.0	1.00	Early July
Wandao	Jet Black	2.6	2.7	11.7	95	12.6	0.85	Early and Mid July

[z]Source: Ref. 1, 9,13, 19 [y]Edible portion [x]Total soluble solids.

Table 4. Yield and price of red bayberry in Zhejiang Province (2003).

Cultivar	Primary bearing (Years)	Mean yields (T/ha)	Production costs ($US/ha)	Wholesale price ($US/kg)	Retail price ($US/kg)
Dongkui	5—6	12.5—15.0	300—380	2.0	2.5—3.2
Biji	3—5	11.5—13.0	275—320	0.5	0.75—1.0
Ding-ao mei	4—5	12.5—14.0	300—350	0.63	1.0—1.25
Wandao mei	5—6	11.5—13.0	275—320	0.5	0.75—1.0
Orange	3—4	20.0	1000	0.25	0.38
Mandarin	3—4	22.0	1100	0.25	0.38

Uses

A "money-making" fruit. Due to its long lifespan, great economic value, low production costs and nitrogen-fixing activity, red bayberry is regarded as "a green factory" and "a money-making tree" and has been an important economic source for people living in mountainous regions (7,9). People prefer red bayberry to citrus and beautiful packages of fresh red bayberry fruits are used as precious gifts in Zhejiang Province. It has a strong social value in the life of Chinese people. The yield and price of some red bayberry cultivars are listed in Table 4.

Besides use for table purposes, various products have been produced from its fruit such as juice, jam, brandy, candy, canned fruit, salted and dried fruit. It has an edible seed with 40% oil content of kernel; the seed can be roasted or used for extraction of oils (1, 7, 9, 13).

Nutritional and medicinal uses. Red bayberry in China is organic food and the fruit of red bayberry is very nutritious, succulent and aromatic. It has an agreeable sub-acid taste. The rich color, juicy pulp and delicious taste make it attractive. The nutrient components of ripe red bayberry were summarized by Chen et al. (1). Fresh fruit contains 9.8%-11.7% sugars, 11.6%-13.4% soluble solids, 0.11-1.14 mg/g vitamins, 0.42-1.28% organic acids, 1.41mg/g potassium, 0.075mg/g trace elements (including Fe, Mn, Zn, Cu and Mg) and 0.33% protein. Potassium content in this fruit is the highest as compared to all other kinds of fruits. Fruit kernels contain 32% protein, 21% fatty acids and vitamin B_{17} which can inhibit or kill cancer cells (1, 9, 13, 15).

The fruit, seed, bark, leaf and root of red bayberry are important components of traditional Chinese medicine. The fruit and leaf are beneficial for treating congestion, coughs, digestive problems, and diarrhea and the bark is used for the treatment of arsenic poisoning, skin diseases, wounds and ulcers (1, 7,9, 13). In recent years, a number of pharmaceutically active ingredients (flavonoids and polyphenols) have been identified from the different parts of red bayberry trees (2, 3, 4, 8, 12, 17, 21, 22).

A better forest tree. Red bayberry has extensive adaptability. Since the root of red bayberry can fix nitrogen in symbiosis with *Frankia*, it is regarded as 'a fertilizer generating tree' and is easily cultivated on barren lands (7, 9, 13). The red bayberry trees can increase water and soil conservation, adjust the climate of micro-environments and decrease flood disaster. It is an ideal selection for soil conservation and forest ranges. Six years after red bayberry trees were planted instead of pine on barren lands in Nan an town, Fujian province, water flow and soil erosion decreased from 1900-2000 t/1000m^2/year to about 50-60 t/1000m^2/year, which is far lower than the permissible limit of 500t/1000m^2/year and increased water conservation of soil by 4.1% (9). The red bayberry tree also has good fire resistance and is resistant to heavy metals (5, 6, 9). Due to these characteristics, red bayberry has been selected as one of the forest trees for soil conservation and barren land reclamation by the China National Forestry Bureau.

A beautiful garden tree. Red bayberry is a large, tall tree with a beautiful shape . It

can resist disease and pest damage and is tolerant of smog and sulfur dioxides. It has been used as ornamental tree planted in parks, along the roadsides and in industrial areas (7, 9, 13). It is an evergreen plant and its leaves are used in floral arrangements in winter (9). As the fruit mature, tourists visit the groves to sit under the trees and enjoy eating fresh fruits.

Important industrial materials. The cortex of red bayberry has abundant tannin (10-27%) which is used as a dyeing material; the pigment can be used as yellow and brown dyes in clothes (7,9,13). A water-soluble red pigment which is used as food additive was also extracted from the fruits of red bayberry (4).

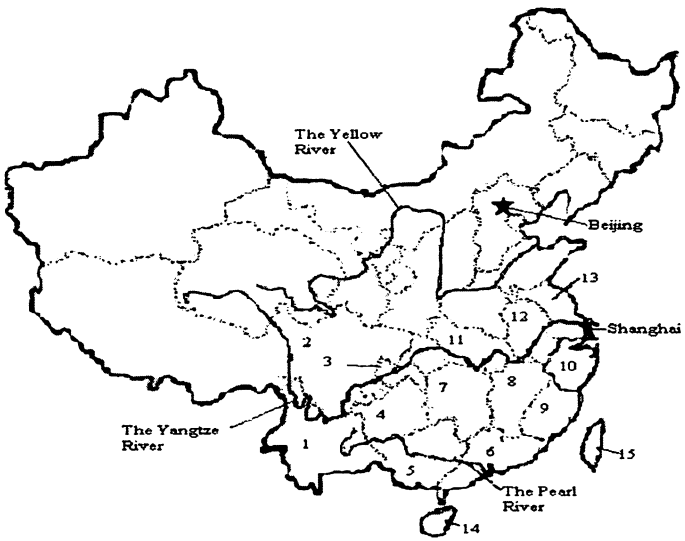

Fig. 1. Range of red bayberry distribution in China.
Arabic numbers represent (1)Yunnan, (2)Sichuan, (3)Chongqing, (4)Guizhou, (5)Guangxi, (6)Guangdong, (7)Hunan, (8)Jiangxi, (9)Fujian, (10)Zhejiang, (11)Hubei, (12)Anhui, (13)Jiangsu, (14)Hainan and (15)Taiwan provinces where the red bayberry is grown.

Fig.2. Fruits of red bayberry.
Arabic numbers stand for red bayberry cultivars (1)'Dongkui', (2)'Biji', (3)'Ding-ao' and (4)'Wandao' (semi-ripened). Photos by Forestry Bureau of Zhejiang

Outlook of red bayberry in China

Being a fruit and forest tree, red bayberry is paid special attention in China. It has rich germplasm resources, extensive usages and enormous market potential. Its cultivation has been increasing rapidly and it has become an important economic tree for rural people. Due to its unique characteristics, more attention is needed for its further exploitation in the age of modern science and technology. There is a great potential to develop by-products from the fruit of red bayberry and the market outlook for fresh fruits and its products is very bright.

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