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中国悬钩子属植物的利用价值概述*

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提　要　主要报道中国悬钩子属植物作为果树种质资源和药用植物的利用价值及果实色素和香味成分的利用潜力。经过十余年的调查、引种栽培和观测评价，发现一些种类可以作为野生小果类果树直接利用，其中23种4变种是悬钩子类果树选育种的优良种质。据文献记载和民间调查发现，45种4变种悬钩子植物可以作为中草药治疗多种疾病。对灰白毛莓、高粱泡、蓬蘽、掌叶复盆子和黑莓果实色素的研究结果表明：悬钩子果实色素以醇提法为佳，水提法效果较差；其主要是矢车菊色素、天竺葵色素、飞燕草色素及糖苷等花色素类物质，其中紫红—紫黑类果实中以矢车菊色素及糖苷为主，兼含少量飞燕草色素及糖苷；橙红—红色类果实中以天竺葵色素、飞燕草色素及糖苷为主；作者认为灰白毛莓和高粱泡果实的色素提取物色泽和稳定性较好，值得进一步研究和开发利用。另外，悬钩子类果实中还含有一些黄酮类物质，值得开发。运用GC/MC技术分别从蓬蘽、高粱泡、掌叶复盆子和黑莓果实中鉴定了83、21、29、51个香味成分。综合分析表明：甲氧基次乙基乙酸酯、乙酸乙酯、甲酸乙酯、α-蒎烯、β-蒎烯、莰烯及桧烯、柠檬烯、对伞花烃、芳樟醇、萜品醇类等化合物是4种悬钩子类果实的主要香味成分。作者认为，通过研究挥发性成分可以为抗病抗虫育种及提高果实品质提供线索。

关键词　悬钩子，果树种质资源，药用价值，色素，香味

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AN OUTLINE ON THE UTILIZATION VALUE OF CHINESE BRAMBLE (*RUBUS* L.)

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Abstract　The utilization value of *Rubus* plants as fruit germplasm resources and medicinal plant, and utilization potential of pigment and flavor constituents in the fruit is reported in this paper. According to the studies on horticultural purpose, 23 species and 4 varieties are considered as excellent resources for breeding of raspberry and blackberry. Some species with high fruit quality and vast reserves can be used directly for fresh market or proccessing. Forty-five species and 4 varieties are used as medicinal plants for more than 40 diseases. Investigation on the physical and chemical properties, stabilities and components of the

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pigments extracted from the fruits of *R. tephrodes* Hance, *R. lambertianus* Ser., *R. hirsutus* Thunb. and cultivated blackberry reveals that the pigments in bramble fruit can be extracted more readily with alcohol than with water. Their anthocyanidins including cyanidin, pelargonidin, delphinidin as well as their glycosides are the principal pigments in the fruits of bramble, of which, cyanidin, delphinidin and their glycosides are the main pigments in purple red- purple black colored fruits whereas cyanidin, pelargonidin and their glycosides are the main pigments in orange red- bright red colored fruits. Some flavonoids exist in bramble fruits also. *R. tephrodes* Hance and *R. lambertianus* Ser. be considered good natural resources of edible pigments because of the good color and stability. Their anthocyanidins study on the flavor in fruit resulted that 83, 21, 29 and 51 flavorous components have been identified from the fruits of *R. hirsutus* Thunb., *R. chingii* Hu, *R. lambertianus* Ser. and cultivated blackberry by GC-MC respectively, among them, methoxy, sec-ethyl acetate, ethyl acetate, ethyl formate, α-pinene, β-pinene, camphene, junipene, limonene, p-cymene, linalool and terpinol are regarded as the key flavorous components causing the peculiar smell and taste in the fruits of bramble.

Key words Bramble (*Rubus* L.), Fruit germplasm resources, Medicinal value, Pigment, Flavor

With 202 species and 92 varieties totally 294 taxa distributed in 27 provinces and districts, China is exceptionally rich in *Rubus* species and is considered to be a major center of diversity for this genus [1~4]. The history of using *Rubus* plants as medicines is more than 2000 years. However, as horticultural plantations or genetic resources for breeding, in China, *Rubus* plants have been used very little, though traditionally people have collected the fruits of these abundant wild *Rubus* species for personal use such as fresh fruit. This paper reviews the medical value of Chinese *Rubus* and reports the results of studies on Chinese *Rubus* for horticultural and industrial purposes.

1 Medicinal value of Rubus plants

Brambles have a long history in Chinese traditional medicines. The ancient classical medicinal works such as *Shennong Bencao Jing*, *Bencao Gangmu*, *Mingyi Bielu* and recent publications recorded many species of *Rubus* for their medical value. In Chinese traditional medicines, FU PEN ZI, the unripe fruits of *R. chingii* Hu or *R. coreanus* Miq. has been commonly known to be used in prescriptions to invigorate the liver and kidney, preserve essence and improve visual acuity. To most of medicinal bramble, their roots and shoots are often used, sometimes the whole plants are used such as *R. xanthocarpus* Bureau et Franch. The pharmacological effects of most Chinese traditional medicines from bramble are to invigorate kidney, relieve nocturnal emission, astringe, stop bleeding, anti-inflammatory and anti-bacterial due to their rich tannin content. According to our knowledge from local people and the records in ancient and recent classical medical works [4~10], more than 45 species and 4 varieties of *Rubus* plants were used as Chinese traditional medicines against more than 40 diseases such as frequent micturition, enuresis, emission, impotence, soreness of the loin, scrofula, epistaxis, hemoptysis, metrorrhagia, hepatitis, carbuncle, blurring of vision and so on. Some of them have been produced as prepared medicines including injections. These species and varieties are *R. chingii* Hu, *R. palmatus* Thunb., *R. idaeopsis* Focke, *R. coreanus* Miq., *R. corchorifolius* L., *R. parvifolius* L., *R. multibracteatus* Lévl. et Vant., *R. parkeri* Hance, *R. corchinchinensis* Tratt., *R. tephrodes* Hance, *R. sieboldii* Blume, *R. xanthocarpus* Bureau. et Franch., *R. irenaeus* Focke, *R. pinfaensis* Lévl. et Vant., *R. innominatus* S. Moore var. *kuntzeanus* (Hemsl.) Bailey, *R. amphidasys* Focke, *R. innominatus* S. Moore, *R. mallodes*

Focke, *R. peltatus* Maxim., *R. pungens* Camb., *R. amabilis* Focke, *R. delavayi* Franch., *R. rosaefolius* Smith, *R. ellipticus* Smith, *R. ellipticus* Smith var. *obcordatus* (Franch.) Focke, *R. buergeri* Miq., *R. lambertianus* Ser., *R. lambertianus* Ser. var. *glaber* Hemsl., *R. phoenicollasius* Maxim, *R. eucalyptus* Focke, *R. sumatranus* Miq., *R. hirsutus* Thunb., *R. pirifolius* Smith, *R. ichangensis* Hemsl., *R. alceaefolius* Poir., *R. setchuenensis* Bureau et Franch., *R. reflexus* Ker., *R. pectinellus* Maxim, *R. trianthus* Focke, *R. hastifolius* Léveil et Vant., *R. crataegifolius* Bge., *R. doyonensis* Hand.-Mazz., *R. feddei* Léveil et Vant., *R. idaeus* L., *R. leuanthus* Hance, *R. blinii* Léveil and *R. pungens* Camb. var. *oldhamii* (Miq.) Maxim. In our recent research [6, 11~15], some wild germplasms have been found extremely rich in SOD (superoxide dismutase), vitamin E and mineral elements Se, Zn and Fe in their fruits and leaves, which have close bearing on tomor, senescence and immunity diseases. Some species have been considered to be effective for esophageal cancer, a common disease in China. So it is significant to research, develop and utilize Chinese medical bramble with modern medical and pharmaceutical techniques.

2 Promising Chinese Rubus taxa for horticulture

With rich reserves and wide variability, the Chinese brambles provide an abundant source of previously untapped germplasm for breeders. Studies on wild *Rubus* germplasms in China have being carried out since 1989 in Nanjing Botanical Garden. Some achievements have been obtained by the authors and others. Based on the field investigations, collections, introductions and evaluations of wild species carried out in the past 10 years [3, 4, 11~26], twenty-seven species or types have been identified to be excellent germplasm resources for raspberry and blackberry selection and breeding because of their advantages such as resistance to pests and diseases, tolerance to low and high temperatures, adaptability, good plant habit and fruit quality (Table 1).

The fruits of most *Rubus* species in China are edible. The determination of nutrients showed that the contents of protein, amino-acids, organic-acids and mineral elements in the fruits are very rich and particularly the contents of V_E and SOD are remarkably higher than those of others cultivated fruits and wild fruits [6, 12~16, 18, 19, 22~27]. These species have high value to be utilized directly as small fruits. The wild fruits of *R. xanthocarpus* Bureau et Franch., *R. corchorifolius* L., *R. coreanus* Miq., *R. chingii* Hu, *R. hirsutus* Thunb., *R. crataegifolius* Bge., *R. biflorus* Buch.-Ham. ex Smith and *R. ellipticus* Smith var. *obcordatus* (Franch.) Focke are excellent for fresh fruits or processing because of their big size, good flavor and high quality.

Economic traits of wild Chinese brambles varied greatly [28, 29]. They are valuable germplasm resources for breeding of raspberry and blackberry. Some Chinese species have also been used in breeding programs in Europe and North America [30]. A great majority of fruits for mordern breeding projects can be found in the wild Chinese *Rubus*. *R. cockburnianus* Hemsl., *R. flosculosus* Focke, *R. tephrodes* Hance and *R. coreanus* Miq. have potentiality for breeding towards productivity. *R. xanthocarpus* Bureau et Franch., *R. corchorifolius* L., *R. coreanus* Miq., *R. chingii* Hu, *R. hirsutus* Thunb., *R. crataegifolius* Bge. and *R. biflorus* Buch.-Ham. ex Smith may be good for breeding towards fruit quality. *R. corchorifolius* L., *R. chingii* Hu, *R. ellipticus* Smith var. *obcordatus* (Franch.) Focke and *R. lineatus* Reinw. are erect and thorn-free or thornless. *R. coreanus* Miq., *R. biflorus* Buch.-Ham. ex Smith and *R. Parvifolius* L. are good in resistance and adaptation.

It is deserved to be mentioned that some excellent wild brambles could be directly utilized for cultivation. *R. parvifolius* L., *R. corchorifolius* L., *R. coreanus* Miq., *R. ellipticus* Smith var. *obcordatus*

Table 1 Rubus **plants with potential breeding capabilities in China**

Taxa	Potential breeding capability
R. flosculosus Focke	Vigor, productivity, resistance to pests and diseases, firm fruit
R. cockburnianus Hemsl.	Vigor, very high yield via high fruit numbers per lateral, late-ripening, winter hardiness
R. idaeus L.	Large fruit with good flavor, winter hardiness
R. idaeus L. var. *glabratus* Yüet Lu	Large fruit with good flavor, winter hardiness, spine-free
R. ellipticus Smith var. *obcordatus* (Franch.) Focke	Vigor, erect habit, productivity, good quality primocane fruit, low chilling requirement and adaptation to high temperature
R. biflorus Buch.-Ham. ex Smith	Vigor, self-supporting canes, good quality fruit with large size, resistance to pests and diseases
R. amabilis Focke	Erect habit, very large size fruit, winter hardiness, resistance to pests and diseases, beautiful flower for ornament
R. lutescens Franch.	Perennial herb, large fruit with good flavor, winter hardiness, premocane-fruiting
R. lutescens Franch. var. *fruticesus* X. G. Sun	Undersized shrub, large fruit with good flavor, winter hardiness, premocane-fruiting
R. coreanus Miq.	Vigor, resistance to pests and diseases, good adaptation
R. xanthocarpus Bureau. et Franch.	Perennial herb, very good flavor fruit with large size, easy propagation
R. sumatranus Miq.	Large fruit and small seed, good flavor, adaptation to high temperature, productivity, premocane-fruiting
R. hirsutus Thunb.	Large fruit and small seed, good flavor, aroma, productivity, early ripening, premocane-fruiting
R. rosaefolius Smith	Large fruit and small seed, good flavor, productivity, early ripening, premocane-fruiting
R. peltatus Maxim.	Very large fruit and small seed, good fruit color, beautiful flower for ornament
R. corchorifolius L.	Large, firm and early ripening fruit with excellent flavor, aroma and good color, vigor, erect habit, nearly spine-free, resistance to pests and diseases, good adaptation
R. crataegifolus Bge.	Large fruit, good flavor and color, erection, winter hardiness
R. chingii Hu.	Large, firm and early ripening fruit, excellent flavor and small seeds, vigor, erection, nearly spine-free, resistance to pests and diseases
R. lineatus Reinw.	Erect habit, thorn-free, vigor, winter hardiness, premocane-fruiting, good quality fruit
R. tephrodes Hance	Vigor, very high yield via high fruit number per lateral, late ripening fruit with rich red pigment
R. lambertianus Ser.	Late-ripening, productivity, good adaptation, firm fruit with rich and stable pigment
R. setchuenensis Bureau. et Franch.	Spine-free
R. pentagonus Wall. ex Focke var. *modestus* (Focke) Yüet Lu	Spine-free, erect habit, large and good quality fruit
R. arcticus L.	Herbaceous, winter hardiness, good fruit flavor
R. saxatilis L.	Herbaceous, winter hardiness, good fruit flavor
R. chamaemorus L.	Herbaceous, winter hardiness
R. parvifolius L.	Very good adaptation, low chilling requirement, resistance to drought, high temperature, pests and diseases

(Franch.) Focke, *R. lineatus* Reinw. and *R. hirsutus* Thunb. can be turned into domestic fruits from wild plants after being fostered and improved on their growing places because they have rich reserves and are widely distributed over different zones with a very high density. *R. xanthocarpus* Bureau. et Franch. and *R. hirsutus* Thunb. can be directly introduced, domesticated and cultivated because of large fruit, good flavour, stunted brush, early fruit-bearing, easy propagation and rough cultivation.

3 Pigment in bramble fruit

The development of food additives is showing a tendency to use natural and edible pigments instead of artificial ones. The fruits of bramble vary their colors with different species[31]. The aim of this research on *Rubus* pigment is to find a good natural pigment source for food industrial uses. The pigments were extracted from the fruits of *R. tephrodes* Hance, *R. lambertianus* Ser., *R. hirsutus* Thunb. and cultivated blackberry with alcohol and water. On these pigment extracts (concretes), the solubility, pH reaction, spectrum characters, thermal stability, oxidation, reduction and metal cations resistance and chemical components were investigated. It is indicated that the pigments in *Rubus* fruit would rather be extracted with alcohol than with water. *R. tephrodes* Hance and *R. lambertianus* Ser. are considered as good natural resources of edible additive for juices, wines and jelly products because the pigments extracted from their fruits show good color and stability. The main chemical components of pigments in *Rubus* fruit are anthocyanidins including cyanidin, pelargonidin, delphinidin and their glycosides (Table 2). It has been shown that cyanidin, delphinidin and their glycosides are the main pigments in purple red-purple black colored fruits, whereas cyanidin, pelargonidin and their glycosides are the main pigments in orange red-bright red colored fruits. Some flavonoides additionally exist in bramble fruits.

Table 2　Pigments in the fruits of 4 Rubus species

Species	*R. tephrodes* Hance	*R. lambertianus* Ser.	*R. hirsutus* Thunb	Blackberry (*Rubus* cv.)
Fruit color	purple red-black	orange red-red	red	purple black
Pigment color	purple red	orange red	red	purple red
Chemical component	Cy, Dp, Cy-3-Glu, Dp-3-Rut, Dp-3-Glu Cy-3-Gal	Cy, Pg, Cy-3-Rut, Cy-3, 5-GG, Pg-3-Rut, Pg-3-GG, Pg-3-Glu	Cy, Pg, Cy-3-Glu, Cy-3, 5-GG, Pg-3-Glu, Pg-3-GG	Cy, Dp, Cy-3-Glu, Cy-3, 5-GG, Cy-3-Gal, Cy-3-Rut, Cy-3-GG, Dp-3-Rut, Dp-3, 5-GG
Stability	good	good	average	average
Evaluation	good additive	good additive		

4 Flavor in bramble fruit

The flavor is an important trait to evaluate fruit quality of raspberries and blackberries. Better flavor is one of the modern breeding objectives. *Rubus* fruits are not found to be good flavoring materials, however, the studies on its volatile components may be helpful for resistance breeding against diseases and pests, and improvement of fruit quality[32, 33]. In our collection, the fruits of *R. hirsutus* Thunb., *R. corchorifolius* L. and *R. chingii* Hu and so on show their peculiar flavor both in smell and taste. In order to identify flavorous components in bramble fruit, the fresh fruits of several species were treated by ether, and the abstracts gathered were examined by GC-MC. 83, 21, 29 and 51 flavorous components have been identified respectively from the fruits of *R. hirsutus* Thunb., *R. chingii* Hu, *R. lambertianus* Ser. and cultivated blackberry, of which, methoxy, sec-ethyl acetate, ethyl acetate, ethyl forate, α-pinene, β-pinene, camphene, junipene, limonene, p-cymene, linalool and terpinol are regarded as the key flavorous components resulting in the peculiar smell and taste in bramble fruits (Table 3). *R. hirsutus* Thunb., *R. corchorifolius* L. and R. chingii Hu are the excellent germplasm for selection and breeding of raspberry and blackberry towards fruit flavor.

Table 3 The key flavorous constituents and relative contents in the fruits of Rubus **species**

Key flavor compounds	*R. hirsutus* Thunb.	*R. chingii* Hu	*R. lambertianus* Ser.	Blackberry (*Rubus* cv.)
ethyl forate	2.02	3.10	4.32	
ethyl acetate	4.72	5.38	18.71	
methoxy sec-ethyl acetate	55.02	2.76	17.34	
acetic methyl acetate			1.67	
benzoic acid ethyl ester	0.30			
hexyl forate	0.33			
phenylacetaldehyde		0.67	0.23	
camphene	11.54	13.22		10.14
α-pinene	22.08	28.24		36.20
β-pinene	23.35	24.10		11.30
limonene	9.02	9.80		6.20
junipene	6.25	4.24		4.20
β-myrcene	4.86	3.14		4.30
p-cymene	1.21	0.89		
m-cymene				2.33
phellandrene	3.50	1.57		2.11
caryophyllene				0.96
tinalool and oxide	0.52	0.20	0.21	0.18
terpineol	2.02	0.30	0.33	0.05
citronellol			0.36	0.05

5 Other uses

There are some good ground cover plants (e.g. *R. calycinoides* Hayata) and ornamental plants (e.g. *R. amabilis* Focke) in the genus *Rubus*. It is also believed that some species are valuable in soil protection and environment beautification.

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表2 蒿属牡蒿组6植物的核型公式

Table 2 The karyotype formular of six Sect. *Latilobus* species of *Artemisia*

分类群 Scientific name	核型公式 Karyotype formular	不对称类型 Type of asymmetry
南牡蒿 *A. eriopoda* Bge. var. *eriopoda*	K(2*n*) = 2*x* = 18 = 12m(2SAT) + 4sm + 2st	2A
海滨牡蒿 *A. littoricola* Kitam.	K(2*n*) = 2*x* = 18 = 14m + 2sm + 2st	2A
东北牡蒿 *A. manshurica* (Kom.) Kom.	K(2*n*) = 4*x* = 36 = 30m + 6sm	2A
牡 蒿 *A. japonica* Thunb.	K(2*n*) = 4*x* = 36 = 28m + 8sm	2A
沙 蒿 *A. desertorum* Spreng.	K(2*n*) = 2*x* = 18 = 14m + 2sm + 2st	2A
长总苞沙蒿 *A. desertorum* Spreng. var. *longiflora* G. Y. Zhang	K(2*n*) = 2*x* = 18 = 14m + 2sm + 2st	2A

体。据此推断本组的起源中心为中国东北或以南地区，在向东、北两个方向扩展过程中，受气候及地理环境的综合作用产生了多倍体现象。

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