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Studies on Collection Breeding and Application of *Curcuma* Plants Resources in China

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Abstract: The Zingiberaceae family has a rich variety of plant species, diverse forms and colors, and is an important resource for cultivating new varieties. *Curcuma* is an important genus of plants in the Zingiberaceae family, with over 50 species worldwide, mainly distributed in southeastern Asia. The application value of *Curcuma* plant resources has always been a focus of attention for domestic experts and scholars. However, so far, there has been no systematic introduction and research on the introduction, breeding, and application of turmeric plant resources. Based on the analysis of the distribution of the germplasm resources of the genus *Curcuma*, this paper reports that since the 1970s, the South China Botanical Garden of the Chinese Academy of Sciences has introduced and carried out the collection and related research of the resources of the genus *Curcuma*. A total of 28 species of *Curcuma* were collected in China, and all of them were planted in the South China Botanical Garden of the Chinese Academy of Sciences.

Keywords: *Curcuma*, Plants Resources, Collection, Breeding, Application, China

1. Introduction

Zingiberaceae is a common monocotyledonous plant species in tropical and subtropical regions, with over 1600 species belonging to 52 genera worldwide [1]. *Curcuma* plants is a perennial herb mainly produced in Southeast Asia. There are currently 14 original species and 14 introduced and cultivated species in China [2-5]. *Curcuma* plants is an important medicinal plant material and a popular precious ornamental flower in southern China during summer. It has good economic benefits and ornamental value, and has excellent development prospects [6]. However, due to the limitations of traditional ball propagation techniques, turmeric plants have problems such as low reproduction coefficient and variety degradation, greatly limiting market development [7-9]. Therefore, exploring the introduction, preservation, and breeding application of *Curcuma* plants provides technical support to meet market demand, and has practical significance for the industrial production of Curcuma plants.

2. Distribution of *Curcuma* Plant Germplasm Resources

Curcuma L. is a perennial herb of the ginger family, having fleshy, aromatic roots and very short (or absent) above-ground stems. The main producing area of Curcuma is Southeast Asia; It is also found in northern Australia. It is abundant in Taiwan, Fujian, Guangdong, Guangxi, Yunnan, Tibet and other provinces [1]. Turmeric enjoys warm and humid climate, abundant sunshine and abundant rainfall, and is born in forests, grasslands and roadside [5]; Turmeric is a tropical perennial, suitable for moist jungle margins and rich, watery soils.

3. Collection of *Curcuma* Plant Germplasm Resources

The introduction site is Guangzhou, located south of the Tropic of Cancer at an altitude of 21 meters. It has a humid climate with a subtropical monsoon and abundant rainfall throughout the year. Strong solar radiation, high temperature, hot and humid summer, warm and dry autumn and winter, generally frost free; The average temperature in January is 13.8°C, with an extreme low temperature of -2°C, the average temperature in July is 28.5°C, and the extreme high temperature is 38°C; The number of days with an annual accumulated temperature of 6400°C-6500°C and a daily average temperature of ≥ 10°C is 285-315 days. April to June is the rainy season every year, August to September is hot with many typhoons, and October to March of the following year is the dry season. The annual rainfall is 1690 mm, the rainy season is 1358.4 mm, and the evaporation is 834 mm; The dry season rainfall is 332.6 mm, and the evaporation is 634 mm. The minimum ratio of monthly rainfall to monthly evaporation can reach 1/6, with an average annual relative humidity of 80.6%. The average relative humidity from October to January of the following year is 68.6%, and the average relative humidity from February to September is 82.15%. The zonal soil is laterite soil, with locally alluvial plain sandy loam soil.

The South China Botanical Garden of the Chinese Academy of Sciences has collected germplasm resources of *Curcuma* since the 1970s. So far, 28 species of *Curcuma* have been collected from Yunnan Province, Guangxi Zhuang Autonomous Region, Guangdong Province, Guizhou Province and other places (Table 1) [1]. The collected species are planted in the endangered protection base and greenhouse of the South China Botanical Garden.

Table 1. *Curcuma Plants in China Have Been Collected.*

Number	Specific Name	Genus Name	Florescence	Reproduction	Application Prospect
1	*C. alsimatifolia* Gagnep. [10]	*Curcuma*	May-Jun.	Easy reproduction	Ornamental flower
2	*C. amarissima* Roscoe	*Curcuma*	May-Jul.	Easy cultivation Easy flowering	Medicinal plant
3	*C. aromatica* Salisb.	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Medicinal plant
4	*C. attenuate* Wall	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Medicinal plant
5	*C. aurantiaca* van Zijp.	*Curcuma*	May-Jun.	Easy reproduction	Ornamental flower
6	*C. australasica* Hook. f.	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Medicinal plant
7	*C. cordata* Wall	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Ornamental flower
8	*C. elata* Roxb. [11]	*Curcuma*	Apr.-May	Easy reproduction	Medicinal plant
9	*C. flaviflora* S. Q. Tong	*Curcuma*	May-Jul.	Easy reproduction	Medicinal plant
10	*C. gracillima* Roxb.	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Medicinal plant
11	*C. grandiflora* Bold. [11]	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Medicinal plant
12	*C. gulinqingensis* N. H. Xia & J Chen	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Medicinal plant
13	*C. kwangsiensis* S. G. Lee	*Curcuma*	Feb.-Apr.	Easy reproduction	Ornamental flower
14	*C. kwangsiensis var. nalinensis*	*Curcuma*	May-Jun.	Easy reproduction	Medicinal plant
15	*C. inodora* Blatt	*Curcuma*	May-Jun.	Easy reproduction	Medicinal plant
16	*C. longa* L.	*Curcuma*	Apr.-May	Easy cultivation Easy flowering	Medicinal plant
17	*C. nankunshanensis* N. Liu	*Curcuma*	Mar.-Apr.	Easy reproduction Easy cultivation	Medicinal plant
18	*C. phaeocaulis* Valeton	*Curcuma*	Jun.-Jul.	Easy cultivation Easy flowering	Medicinal plant
19	*C. roscoeana* Wall.	*Curcuma*	May-Jun.	Easy reproduction	Medicinal plant
20	*C. rubrobracteata* kornick., M. Sabu et Prasanthk	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Medicinal plant
21	*C. ruiliensis* N. H. Xia & J Chen [11]	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Ornamental flower
22	*C. sichuanensis* X. X. Chen [10]	*Curcuma*	Apr.-May	Easy cultivation Easy flowering	Ornamental flower
23	*C. wenyujin* Y. H. Chen & C. Ling [11]	*Curcuma*	May-Jun.	Easy reproduction	Medicinal plant
24	*C. woodie* N. H. Xia & J. Chen	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Medicinal plant
25	*C. yingdeensis* N. H. Xia & J Chen [11]	*Curcuma*	May-Jun.	Easy reproduction	Ornamental flower
26	*C. yunnanensis* N. Liu & S. J. Chen	*Curcuma*	May-Jul.	Easy reproduction Easy cultivation	Medicinal plant
27	*C. zanthorrhiza* Roxburgh	*Curcuma*	May-Jun.	Easy cultivation Easy flowering	Medicinal plant
28	*Curcuma zedoaria* (Christm.) Rosc.	*Curcuma*	May-Jun.	Easy reproduction Easy cultivation	Medicinal plan

4. Breeding of *Curcuma* Plants

Curcuma plants are mostly perennial semi positive plants, growing in understory, forest edges, or sparse shrubs. They can tolerate strong light and have strong light and temperature tolerance, and can reproduce sexually and asexually [12].

4.1. Sexual Reproduction

Except for some cultivated species and hybrid species, *Curcuma* plants can usually reproduce offspring through seeds. Generally speaking, seeds of medium ripe light yellow fruits and mature yellow brown fruits have a higher germination rate. To ensure the rapid and orderly emergence of seedlings, pre germination is generally carried out before sowing. Pre germination is usually carried out by soaking and layering. In addition, the *Curcuma* plants seed coat has poor permeability and false seed coat. Therefore, before sowing, the seeds can be mixed with clean fine sand, wrapped in gauze, and rubbed in water to remove the false seed skin [12].

4.2. Asexual Reproduction

Curcuma plants can usually reproduce using rhizomes. When using rhizomes for branching and reproduction, select plants with vigorous growth and abundant tillering buds based on their natural growth potential, and cut them from the gaps in the plant rhizomes. After the incision is dry, plant the plants separately. The method of bulb propagation can also be used. After falling asleep in autumn, the bulbs and rhizomes are dug out from the mother's bulbs and divided into different new plants [12].

Cutting propagation is a common reproductive technique in *Curcuma* plants. During the operation, the leaf stem is usually cut into segmented stem segments after flowering or fruit ripening. Choose a damp place or use a shade as a cutting tool, insert the stem end into the substrate, and under general management conditions, the seedling rate can reach over 70% [12].

Curcuma plants can be industrially propagated through tissue culture techniques. Generally speaking, young roots, stems, flowers, and buds can be used as precursor plants. Among them, the corm of *C. alsimatifolia* is used as the explant, the young stem tip of *C. rubrobraceata* is used as the explant, the corm bud of *C. kwangsiensis* is used as the explant, and the tuber bud of *C. wenyujin* is used as the experimental explant material. At present, more than 20 plants of the *Curcuma* genus can be cultured through tissue culture technology, and more than 10 plants of the *Curcuma* genus can be commercially propagated on a large scale. *Curcuma* plants with mature tissue culture include *C. elata*, *C. longa*, and *C. kwangsiensis* [13-15].

5. Application of *Curcuma* Plants

The main active components of curcumin are curcumin and volatile oils (sesquiterpene, diterpene, etc.). Curcumin has a certain therapeutic effect on nasopharyngeal cancer, gastric cancer, prostate cancer, colon cancer, etc., and is listed as the third generation of cancer chemoppreventative drugs by the National Cancer Institute of the United States. Tharakan et al. [16] believe that the activation of nuclear factor NF-κB signaling pathway is closely related to the occurrence of human tumors [17], and curcumin can block the activated NF-κB signaling pathway and inhibit the proliferation of esophageal squamous cell cancer cells, so curcumin is used as an adjunct drug for esophageal cancer. Curcumin can inhibit the enzyme activity of HIV-1 and can be used in clinical trials of AIDS. Lu et al. [18] believed that elemene, a sesquiterpenoid in Zedoary, has anti-tumor effects [19], which verified the earlier suggestion proposed by Li et al. [20] that β-elemene can effectively inhibit the activity of ovarian cancer cells. Li [21] believed that the inhibitory effect of β-elemene was mainly achieved by inducing cell cycle arrest [22]. Curcumin inhibits the expression of β-catenin and p-GSK3β (Ser9) as well as downstream cyclin D and c-Myc by acting on Wnt/β-catenin signaling pathway in human lung cancer cell A549, showing its potential in the treatment of lung cancer [23]. Curcumin can also down-regulate Notch and HIF-1 mRNA levels, inhibit the expression of VEGF and nuclear factor Kb (NF-κB), and reduce tumor weight and size through the regulation of angiogenesis mediated by vascular endothelial growth factor (VEGF) signaling pathway [24]. Curcumin can inhibit cell proliferation, increase cell apoptosis and G2/M block, and is cytotoxic to non-small cell lung cancer. It can also induce reactive oxygen species (ROS) production, thereby activating DNA damage signaling pathways [25]. The literature reviewed the effects of long-term low-dose curcumin administration on non-small cell lung cancer, and the results showed that 0.25 to 0.5 $\mu mol \cdot L^{-1}$ curcumin could significantly inhibit the invasion and metastasis potential of natural and chemotherapy-resistant non-small cell lung cancer [26]. Even if anaplastic lymphoma kinase (ALK) rearranged non-small cell lung cancer cells become resistant to ALK inhibitors [27], curcumin derivatives still show good effects in inhibiting tumor cell growth and invasion [28]. In some tumor cell lines, the phosphatidylinositol kinase (PI3K)/protein kinase B (Akt) signaling pathway is associated with cell proliferation and apoptosis, but the current literature on the relationship between PI3K/Akt signaling pathway and apoptosis is inconsistent [29-30]. Studies have shown that curcumin further inhibits the activation of PI3K/Akt/mammalian target of rapamycin (mTOR) pathway by up-regulating the expression of miR-206 [31], thereby inhibiting the invasion and migration of NSCLC cells. Hmm-41, a new derivative of curcumin, activates the PI3K/Akt pathway and has the potential to inhibit migration and proliferation in human lung cancer cell line A549 [32]. The combination of curcumin and gemcitabine can improve the sensitivity of multi-drug resistant cell line A549/GEM to gemcitabine, and significantly reduce the migration and invasion ability of A549/GEM cells. The therapeutic effect of gemcitabine combined with curcumin is better than that of gemcitabine alone, and it is less toxic to animals [33]. Curcumin can also inhibit the expression of DNA methylation-related enzymes in non-small cell lung cancer cells [34], increase the cytotoxicity of crizotinib by regulating miR-142-5p and its target Ulk1, and induce tumor cell apoptosis [35].

6. Conclusion

Curcuma is mostly a traditional Chinese herbal medicine. With continuous research and development, its physiological activity has been continuously explored, and more and more attention has been paid by scientific research and medicine circles. A lot of research has been done on its resources, cultivation, chemical composition, pharmacology, biosynthesis, chemical preparations, clinical verification and other aspects. It was confirmed that curcuma contains a variety of components with strong biological activities and little side effects, and it has strong effects in anti-cancer, antibacterial and anti-inflammatory, liver protection, antioxidant, lipid reduction and so on. And cancer, viruses, etc. are worldwide problems, turmeric plants in this area of clinical trials have a good performance, the future can be in-depth exploration in these aspects, so that it in the future of anti-cancer, antiviral medicine market occupy an important position, broad prospects for development, and the healthy development of human society is of great significance.

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Conflicts of Interest

The authors declare that they have no competing interests.

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