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JUJUBE, NUTRITIOUS FRUIT ON CHINESE TRADITIONAL DIET

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Abstract

Jujube (Ziziphus jujuba), the deciduous tree species belonging to the Rhamnus family, Ziziphus genus, is priced for its sweet and nutritious fruit. Jujube is an important fruit tree in China and the largest dried fruit tree species. Origin from China, the jujube has a cultivation and utilization history of more than 7000 years. Despite act as a common fruit on Chinese diet, jujube also play very important role as herb in Chinese traditional medicine. Furthermore, jujube also act as a culture symbol in traditional Chinese culture with rich meanings. This paper gives a brief review on Chinese jujube cultivation and utilization, and give prospect of the jujube industry.

Key words*: jujube, cultivation, nutrition, production.*

INTRODUCTION

Jujube (*Ziziphus jujub*a), also called Zao in Mandarin Chinese, or Chinese date, red date, is the most important *Ziziphus* species for fruit in the Rhamnaceae family (Gao, Wu, & Wang, 2013). It is a medium-sized tree, that grows up to 7 – 10 meters high and has shiny deciduous foliage. The stone fruit varies in size depending on the cultivar, and has thin, dark red skin surrounding sweet, white flesh. The nutritious jujube fruit is rich for sugar, vitamin, and mineral contents.

Jujube is one of the oldest cultivated fruit trees in the world (M. Liu et al., 2020). It originated in the middle and lower reaches of the Yellow River, in northern China. The cultivated jujube is domesticated from wild jujube (*Ziziphus jujuba* var. *spinosa*), also called sour jujube. History of jujube cultivation and utilization in China could be traced back to more than 7000 years ago. Jujube was introduced to Chinese neighbour countries such as Japan and Korea 2000 years ago. Now days, jujube has spread to more than 40 countries, including the United States, Australia, and European countries such as Romania, Italy, and Spain (Crawford, Shan, & McCarthy, 2011; Stănică, 2019; Yao, 2013).

For its delicious and nutritious fruit, easy management, low cultivation cost and high economic benefits, ecological friendly characteristics as well, jujube meet the need of consumers, growers, marketers, governments and society. Thus, the jujube is considered a super fruit for the future (M. Liu et al., 2020).

This paper presents a brief review on Chinese jujube cultivation and utilization, and give prospect of the jujube industry.

JUJUBE CULTIVATION IN THE WORLD

Jujube cultivation in China

Comparative analysis on chloroplast genomes of 326 jujube, including 133 cultivated, and 193 wild jujube genotypes revealed that initial domestication and cultivation of jujube took place within the middle and lower reaches of the Yellow River. The divergence time of cultivated jujube and wild jujube is 1.82 million years ago (Yang et al., 2024). A large-scale genome resequencing analysis of 672 accessions including 359 cultivated, 291 wild and 22 semi-wild jujube also revealed that wild jujube originated from the lower reaches of Yellow River, and domesticated at the Shanxi-Shannxi Gorge (Y. Li et al., 2024). A carbonized jujube

kernel found in the Peiligang, a Neolithic age historical site, in Xinzheng city, Henan province, China, revealed that jujube utilization and cultivation history could be traced back to 7000 years ago (M. Liu et al., 2020). Morphology analysis on jujube stones and AMS (Accelerator Mass Spectrometry) ^{14}C dating on millet seeds in other three Neolithic sites in Northern China suggest that jujube was cultivated as early as 6 200 years ago (K. Li et al., 2024).

Despite for its long cultivation history, jujube is the most planted dry fruits in China. According to the China Forestry and Grassland Statistical Yearbook 2021, the total yield of dry jujube is 4 404 820 tons, ranked the 1st in all the dry fruits (National Forestry and Grassland Administration, 2022).

The traditional jujube cultivation areas are middle and lower reaches of the Yellow River, which is the Henan, Hebei, Shanxi, Shannxi and Shandong provinces. In the new century, jujube cultivation in China developed rapidly and changed a lot, the cultivation area greatly increased, and the main production area has transferred to Xinjiang, northwest of China. In the year 2005, the total dry jujube yield in these 5 provinces is 2 330 336 tons, more 90% of the total yield (2 463 087 tons) in China. In the year 2020, the total yield in China has increased to 4 404 820 tons, almost doubled than 2005, and the production in Xinjiang has increased to 2 465 811 tons, 55.98% of the total production of whole country. Of the top five provinces, the production in Shanxi and Shannxi still increased, while the Henan, Hebei and Shandong provinces decreased.

The main reason of jujube cultivation area shift is economic factors. In the new century, China has experienced rapid economic development. The urbanizing in east provinces is very fast, while the huge population require sufficient crop field to stabilize food supply. With the expanding of cities, jujube orchards in the suburbs are the first replaced by buildings and shrink quickly. At the same time, the rapid increase in land and labor prices has reduced the profits of jujube cultivation. Meanwhile, in the west province Xinjiang, which has a land area of 1 664 897 km^2, almost four times of California, the land price is very cheap, and the environment are very suitable for high quality jujube production (Xiao, Na, & Rong, 2021).

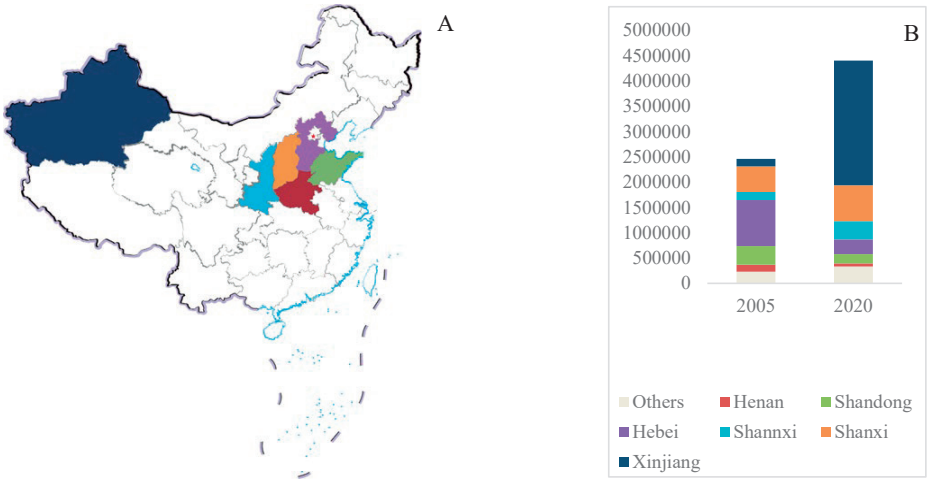

Figure 1. Jujube production in China. A. the main jujube cultivation provinces in China, B. jujube dry fruit yield in China, year 2005 and 2020

China has abundant jujube germplasm resources. According to The Chinese Fruit Tree Records: Jujube, there are more than 700 jujube cultivars recorded in China. The National Jujube Repository, constructed by Pomology Institute of Shanxi Academy of Agricultural Science, in Taigu, Shanxi province has preserved ~1000 jujube genotypes (D. Li, Niu, & Tian, 2013).

The most two cultivated dry jujube cultivars in China are 'Huizao' and 'Junzao'. In Chinese, 'Hui' means grey, illustrating the greyish ripen fruit colour and the dark green tree vigour. 'Jun'

means the best horse, implying this is the best jujube cultivar. The origin of 'Huizao' is Xinzheng, Henan province, while 'Junzao' is from Jiaocheng, Shanxi province. These two cultivars were introduced to Xinjiang in 1990s and performance well.

The most cultivated fresh jujube cultivar in China is 'Dongzao'. In Chinese 'Dong' means winter. Since the fruit ripen time of this cultivar is early October, early winter in Northern China. This cultivar is from Zhanhua, Shandong province, and Huanghua, Hebei province. Both are coastal areas of the Bohai Sea. This cultivar was introduced to many jujube cultivation areas and performance well. The first jujube whole genome sequence is from the 'Dongzao' cultivar (M.-J. Liu et al., 2014).

Jujube cultivation in other Countries

Besides China, Korea, Japan and Iran have the longest jujube cultivation history. The introduction of jujube to Korea and Japan are believed to be more than 2000 years (M. Liu et al., 2020). In Iran, records on palace roof and columns of ruins of Persepolis indicates utilization and cultivation of jujube in Iran could be traced back to 2 600 years ago. In 2021, the jujube cultivation area in Iran is ~5,000 ha, with a production of 7,500 ton. About 33 genotypes can be identified. Two of them, 'Siojan' and 'Majan' were registered as cultivars (Ghouth, 2021).

According to Historia Naturalis, written by Gaius Plinius Secundus (AD 23-79), jujube was introduced to Italy by Octavian Augustus, a Counsellor of the Roman Emperor. Then it spread to other Mediterranean countries. (STĂNICĂ, 2019).

In northern Italy, a small town Arqua Petraca, jujube tree is cultivated almost every garden. Local people use jujube fruits for liquor, jam, snacks, and celebrate jujube festival in first week of October. Researchers introduced and tested jujube cultivars suitable to be grown in Italy and get promising results. Two fresh-eating, without thorns cultivars, 'Dongzao' and 'Meimizao', with big tasty fruit are proposed for intensive planting (Cossio & Bassi, 2011).

In Romania, most ancient jujube populations exist in semi-spontaneous status in Dobrogea area, located between the Danube River and the Black Sea. This site is close to the antique Greek, Roman and Byzantine colonist ruins. Implies jujube may be introduced from the Mediterranean basin (Stănică, 2019). The University of Agronomic Science and Veterinary Medicine of Bucharest (USAMV) had carried out complex jujube research and extension for more than twenty years. The China-Romania Joint Jujube Key Research Laboratory has been established with the collaboration of USAMV with Chinese Hebei Agricultural University. Study on jujube germplasm collection, introduction, elevation and food production development have been performed systematically.

Jujube was first brought to the United States in 1837 by Robert Chisholm, and plant in Beaufort, North Carolina. In 1876, G. P. Rixford introduce jujube from southern France to Sonoma Valley, California. In 1908, the USDA Agricultural Explorer Frank N. Meyer imported first group of jujube cultivars from China to the U.S., and planted them at the USDA Plant Introduction Station at Chico, CA. Now days, jujube are widely planted across the U.S., primarily as a dooryard fruit tree. Few small-hectarage commercial planting primarily serve ethnic niche market in California. The New Mexico State University carry out complex jujube research and extension programs (Yao, 2013). A recent study on genetic diversity of jujube cultivars in the United States with single nucleotide polymorphism (SNP) markers identified 23 synonymous cultivar groups (Sapkota et al., 2024).

In Australia, the jujube was introduced from the US by Gidgegannup grower Jim Dawson in 1994 (Crawford et al., 2011). Jujube are mainly grown in the Perth Hills, the northern Rangelands, the South West and Great Southern regions of Western Australia. The counter-seasonal production to the northern hemisphere provides an opportunity for Australia jujube for the increasing demand of target markets including China, Singapore, and Malaysia, especially during the lunar new year festivals.

Despite for some genotypes introduced abroad China long time ago, the most cultivated jujube cultivars in the foreign countries outside China is Li, Lang, Sugarcane, Honey jar, and so on.

JUJUBE FRUIT UTILIZATION

Jujube is a multi-purpose plant. The jujube tree produces strong wood, yield honey, in addition to delicious fruit. The present research paper is an in-depth review in the utilization of jujube fruit.

Use as food

When directly consumed as fruit, the jujube can be eaten both fresh or dried (dehydrated). Basically, the jujube varieties could be divided as fresh or dry. Most of the dry jujube varieties (cultivars) could be eat directly as fresh jujube when they are fully ripened and not dehydrated, perhaps not so crisp as those fresh varieties (cultivars). For the fresh varieties, when they are dehydrated, there won't be any dry materials left (Qu et al., 1993).

The fresh jujube fruits have high sugar content, vitamins, edible cellulose, minerals, cyclic adenosine monophosphate, and cyclic guanosine monophosphate. Fresh jujubes are known for their high vitamin C content, mostly ranging from 300-600 milligrams per 100 grams and even higher, surpassing kiwifruit, which is known for its high vitamin C (Gao et al., 2013). Most western people think the taste of fresh jujube is similar to apple when they first try it.

Traditionally the jujube fruit will be picked after fully ripen and dried by air, sun or heat. Now days in Xinjiang, since the dry climate, the fruits are dehydrated on the tree before pick. The skin of dry jujube is fully red, that's the name 'red jujube' comes.

The dry jujube, or red jujube, could be eat directly, but for most times, jujube will be cooked together with other foods. In China, rice and wheat flour are people's stable foods, and red jujube are usually used as adjuncts for them. In the past times, only on big days such as festivals, weddings or funerals, people could eat jujube. Now days, jujube has become common food on the diet.

The most usual use is to boil them with rice and beans as soup dish. According to Chinese lunar calendar, on the eighth day of the last month, housewives will clean the kitchen, use all kinds of grains, nut, and fruits in the cabinet to cook Laba Congee, one kind of special soup. From then on, the kitchen will be prepared to celebrate the spring festival, the most important festival in China and east Asia countries. Jujube is the necessary component of Laba Congee, which means jujube is also a daily fruit in the kitchen.

Other than the spring festival, another two most important festival on Chinese lunar calendar is the Dragon Boat Festival, on fifth day of the fifth month, and the Mid-Autumn Festival, on the fifteenth day of the eighth month. On the Dragon Boat Festival, people will eat Zongzi, cooked rice in bamboo leaves. On the Mid-Autumn Festival, mooncake is necessary for celebration. Jujube is also an important component in zongzi or mooncake.

Another traditional food in feast banquets is Babaofan, type of steamed rice, with jujube, and other six kinds of beans or nuts. The name Babaofan implies 'eight treasures rice' in Chinese.

Mantou, type of white coloured steamed bread by yeasty wheat flour, is the daily food in northern China. On festival days, jujube will be decorated on top of Mantou for good looking.

Smashed together with beans, then make vegetarian fillings of Baozi, type of Chinese buns, is another common way people use red jujube.

The jujube fruits could also be processed as preserved fruits, jams, candies, vinegar, liquors, beverages, and so on. Since dehydrated, the red jujube could be stored under normal temperature for long times.

Use as tradition medicine

Jujube has been commonly consumed in traditional Chinese medicine for thousands of years. The classic ancient Chinese medical text Huangdi Neijing (475 – 221 BC), recorded jujube as one of extremely valuable fruits. In Shennong Bencao Jing (300 BC – 200 AD), jujube was regarded as one of the top-grade medicinal herbs, that could extend one's life expectancy by nourishing blood, increasing sleep quality and improving digestive system. Many other medical books reported use of jujube as herb in tradition Chinese medicine (Shahrajabian, Khoshkharam, Zandi, Sun, & Cheng, 2019).

In China, people also believe the concept 'You are what you eat'. Since the jujube skin colour is red, same colour with blood, people believe it is good for blood, especially for women. Clinical practice and pharmacological research have confirmed that jujube has potential hemato-poietic functions, effective to blood deficiency

treatment. Flavonoid, polysaccharide and triterpenoid within red jujube could serve as the potential active ingredients accounting for the aforementioned health benefits.

Other than blood deficiency, jujube also has other health benefits such as anti-inflammatory, anti-cancer, gastrointestinal protective, anti-oxidant, anti-insomnia, neuroprotective, and so on (Table 1).

In many classic traditional Chinese medicine prescriptions, jujube is an important component and play essential role (Chen et al., 2017).

Table 1. Pharmacological Properties of Jujube Fruit

No.	pharmacological property	Subject	Observation	References
1	Anticancer activity	MCF-7 and SKBR3 breast cancer cells	ZE1, ZE2, and ZE4 exerted significant antiproliferative effects on estrogen receptor MCF-7 (IC50 values of 14.42, 7.64, 1.69 μg/mL) and SKBR3 (IC50 values of14.06, 6.21, 3.70 μg/mL)	(Plastina et al., 2012)
		melanoma cells	50% inhibitory concentration of DPP at 3.99 mg/mL after 24 h of treatment, decreased significantly to 3.36 mg/mL after 48 h	(Hung, Hsu, Chang, & Chen, 2012)
		Colitis-associated colon carcinogenesis in AOM/DSS-treated	Dietary jujube increased colon length and suppressed the activation ofNF-κB/IL-6/ JAK1/STAT3 signaling pathway.	(Periasamy, Wu, Chien, Liu, & Liu, 2020)
2	Anti-inflammatory activity	male ICR mice (20−22 g);	inhibitory effects on the inflammatory cells activated by Euphorbia kansui and prostratin, a phorbol ester isolated from Euphorbia fischeriana fraction F to be the most active part	(Yu et al., 2012)
		Wistar albino rats (180−240 g)	significantly attenuated the effect of carrageenan in rat paw and extended to 2 and 3 h at 100, 200, and 400 mg/kg; inhibited granuloma formation at 200 and 400 mg/kg; markedly decreased serum nitrite/nitrate at 200 and 400 mg/kg	(Goyal, Sharma, & Singh, 2011)
3	Antiobesity activity	mouse embryo 3T3-L1 cells	CHCl3-F efficiently suppresses adipogenesis in 3T3-L1 preadipocytes	(Kubota et al., 2009)
4	Immunostimulating activity	3-month-old Kunming mice (males and females,20 ± 2g)	CZSP dramatically increased thymus and spleen indices, and peritoneal macrophages CZSP, ZSP3, ZSP3c, ZSP4, and ZSP4b induced the proliferation of spleen lymphocyte	(J. Li, Shan, Liu, Fan, & Ai, 2011)
5	Antioxidant activity	DPPH, superoxide anion, hydroxyl radical-scavenging activity, and reducing power	ZSP3c and ZSP4b containing more uronic acid had the stronger free radical scavenging activities	(J. Li, Liu, Fan, Ai, & Shan, 2011)
		DNA damage protective activity, DPPH, FRAP, reducing power, inhibition of lipid peroxidation, bleaching ability of β-carotene in linoleic acid system,	jujube fruits from Ningxia, Gansu, and Shaanbei grown in the semiarid regions ofloess plateaus showed fairly higher antioxidant activities	(Sun, Liang, Shan, Viernstein, & Unger, 2011)
		Fruit flies	Jujube fruit powder supplementation increased flies' ability to resist starvation stress and ROS stress.	(Ghimire & Kim, 2017)
6	Hepatoprotective activity	Kunming male mice (18-22 g)	reduced activities of CCl4-elevated ALT, AST, and LDH in serum, and hepatic MDAlevel at 400 mg/kg; better profile of HI, normal GSH-Px, and SOD activities in liver	(D. Wang et al., 2012)
		male ICR mice (25-28 g)	decreased ALT and AST, attenuated histopathology of hepatic injury, and ameliorated the oxidative stress in hepatic tissue at 200 mg/kg	(Shen et al., 2009)
7	Gastrointestinal protective activity	32 rabbits	reduced intestine MDA level and increased antioxidant enzyme activities in rabbits with ischemia/reperfusion (I/R) of the small intestine	(B. Wang, 2011)
8	Anti-hyperglycemic activity	Mice fed 60% high-fat and 10% fructose diet	Dried jujube and chokeberry reduced the HFFD mice body weight, attenuated blood glucose and triglyceride concentrations.	(Jeong & Kim, 2019)
		Rat L6 myotube	These polycyclic triterpenoids induced glucose uptake in a glucose transporter-4-dependent manner, and finally promoted glucose uptake in rat L6 myotubes.	(Kawabata et al., 2017)

One important concept in traditional Chinese medicine is 'to treat disease before they occur'. To keep health by dietary supplementation is one way to achieve this concept.

Jujube has both functions as food or as medicine, it can prevent and treat disease by strengthening peoples' body through daily diet.

CONCLUSION AND FUTURE DIRECTION

Jujubes are considered the "super fruit" of the future. Jujube fruit is a dietary supplement with high contents of bioactive compounds such as dietary fibers, mineral, and natural antioxidant

compounds. Nevertheless, fresh jujube has a short shelf-life. Thus, converting fresh jujube to processed products is the best way for preserving it for a long-time.

Based on available studies, jujube pro-ducts can possess good antioxidant, antiobesity, and antitumor activity. As a result, these products can be consumed as functional food.

As a perennial tree species, the jujube cultivation could last many years once it is established. The tolerance to drought, salt, and deficient soil, compose the adaptability to many environmental conditions, especially in arid and semi-arid areas where other crop species could not achieve satisfactory yield. The jujube could provide significant nutrition source and solution of food supply in these areas. Especially under the context of climate change and global warming.

Deep processing could increase the economic benefits and market of jujube. The nutritional and pharmacological benefits of jujube have been recognized by more and more people. For the jujube industry, the current issue is to develop more deep processed products, and fill the 'culture gap' to make more people accept jujube. Jujube fruit is suitable for processing, could be easily processed to many kinds of food products. Yet to expand the jujube industry, we need to develop more jujube products, especially leisure foods such as snacks, chips, pops, strips, and so on. These products better meet the consumption needs of the young generation. Therefore, the comprehensive and multi-level development of deep processed red dates and health products with specific functions, in order to effectively utilize red dates and fully play their role in food and medical health, is a serious challenge. Deep processing of red dates will gradually showcase their obvious product advantages and broad market prospects, accelerating the healthy development of the red date industry.

There are some cultural influences accompany with jujube consumption habits. For example, the Chinese name of jujube, Zao, is the same pronounce with the character 'early'. This good meaning drives Chinese people to plant jujube trees in yards, eat jujube on daily diets, to encourage people more diligent and achieve success early. This custom is quite common in East Asia countries. In traditional Chinese culture, newlyweds are given the blessing of having a precious son at an early age. Therefore, on the day of marriage, people will place jujube, peanuts, longans, and lotus seeds on the new couple's bed, which is the best blessing.

In western countries, there are also some cultural phenomena in jujube consumption. In Arqua Petraca, small town with jujube cultivation in Italy, a local beloved jujube liquor, *brodo di giuggiole,* or jujube broth, give birth to an idiom, *andare in brodo di giuggiole* (to go in jujube broth), meaning to live in a state of bliss.

Yet these cultural influences are not too familiar with the world, especially between the east and western people. It is necessary to fill up these cultural gaps, make jujube familiar to more people, and became components on more diets.

Another obstacle barrier in jujube production development that needs to be overcome is the cultivar assay and selection. Jujube has abundant germplasms, yet the characteristics of each genotype need to be determined by systematic assay. Furthermore, the most adaptable and suitable cultivar for different region with different climate and soil conditions need to be selected. In general, good taste, high and stable yield, and thorn-less cultivar is most well-come in the market. Resistance to pests and diseases are also factors need to be considered.

Fast and simple propagation techniques for cloned seedlings are also need to be developed. Especially propagate seedlings close to the new cultivation areas, to avoid long-distance transport of the seedlings. Local seedlings have stronger adaptability and less risk of disease and pest transmission, more suitable for jujube cultivation development.

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