

## ORIGIN

Jujube (*Ziziphus jujuba* Mill), also called Chinese date, red date, or Tsao, is native to China. It originated in the middle and lower reaches of the Yellow River, and has been cultivated in China for more than 4,000 years. Botanically, it is derived from its wild relative sour jujube or wild jujube (*Z. spinosa* Hu). In ancient times, people selected and cultivated sour jujubes with bigger fruit, and it gradually became the cultivated modern jujube species (*Z. jujuba*). There are still semi-cultivated sour jujubes like ‘Tiger Eye’-big round sour jujube and Yanjishan big sour jujube, which are popular in Beijing and Shandong Province, China, respectively.

Jujubes belong to the Rhamnaceae (Buckthorn) family. The jujube can be easily confused with the Indian jujube (*Z. mauritiana* Lam), which is a tropical plant of the same genus, whereas the Chinese jujube is a cold-hardy deciduous plant. Although it varies with location, jujube usually starts to leaf out in April or May, blooms in June to July, and matures in late August to October. The dried fruit of the date palm (*Phoenix dactylifera*) looks similar to that of jujube, but botanically they are not related to each other.

## HISTORY

Jujubes were first introduced to the U.S. from Europe by Robert Chisholm and planted in Beaufort, NC, in 1837. In 1876, G.P. Rixford brought jujubes from France and introduced them to California and nearby states. Most of the early imports were from seedlings. USDA Agricultural Explorer Frank N. Meyer introduced the first group of commercial cultivars to the Plant Introduction Field Station at Chico, CA, in 1908. Later, they were

distributed to other USDA stations in Texas, New Mexico, Oklahoma, Georgia, and Florida. Scientists evaluated those jujube introductions until the 1960s, and a few selections were developed at Chico, CA. Shortly after the importation, Meyer and other scientists realized the potential of jujubes in the U.S., especially in the Southwest where sunshine is plentiful, summers are hot, and the climate is arid. In 1947, L.F. Locke from the Southern Great Plains Field Station at Woodward, OK, wrote, “This jujube is little known, but is highly dependable fruit of high food value.”

In New Mexico, jujube trees can be found growing in diverse locales around the state. There are 50-year-old sour jujube and regular jujube trees (cultivars unknown) on the NMSU Las Cruces campus (Doña Ana County, elevation 4,000 ft). There are jujube trees in the South Valley area outside Albuquerque that were planted in 1928. A homeowner in Cliff, NM (Grant County, elevation 4,500 ft), has jujubes near his house, and they have been producing a prolific crop every year for the past 30 years. Other scattered trees in Las Cruces, Los Lunas (Valencia County, elevation 4,856 ft), Albuquerque (Bernalillo County, elevation 5,312 ft), Tucumcari (Quay County, elevation 4,816 ft), and Alcalde (Rio Arriba County, elevation 5,700 ft) are all growing and producing well.

## DESCRIPTION

### Tree

Jujube is a deciduous ornamental fruit tree 15 to 30 ft in height with very hard, strong wood. Branches are zigzagged with paired spines in young trees. Depending on the cultivar, tree growth habit varies from broad spreading canopies to very narrow and upright.

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## Leaves

Leaves are shiny, ovate or oval in shape, and not branched, and grow on alternating sides of branches. Leaves are 1 to 2 inches (2.5-5.5 cm) long and 0.75 to 1.5 inches (2-4 cm) wide.

## Buds and shoots

Jujube shoots are different from other fruit species. Vigorous new shoots of peach, apple, and grape can have branches in the same growing season, and the branches have structure similar to the primary shoot. Jujube has four types of shoots: primary (extension) shoot, secondary shoot (side branches), mother bearing shoot (fruiting spur), and fruit-bearing shoot (branchlet) (Figure 1). There are three kinds of buds for jujubes: main buds, secondary buds, and dormant buds.

There are two buds, one main bud and one secondary bud, at each node of both primary and secondary shoots and at the apex of mother bearing shoots. The terminal main bud of the primary shoot will keep growing each season to expand the tree canopy, and the lateral main buds (at the base of each secondary shoot) normally do not sprout and instead become dormant except with strong stimulation. The secondary buds on each node of primary and secondary shoots are early-maturing buds, which produce secondary shoots or fruit-bearing shoots.

The jujube primary shoot is always accompanied by secondary shoots (side branches), or the secondary shoots are part of the primary shoot and later diverge in function. The primary shoot elongates every year to expand the tree canopy. The secondary shoot acts as a base for the fruiting structure, does not extend in length, and withers back after two or three years. At each node of the secondary shoot is a mother bearing shoot (fruiting spur), which is a compact spur that grows approximately 0.04 inch (1 mm) and produces 2 to 5 fruit-bearing shoots each year. The fruit-bearing shoot (branchlet) is thin, flexible, deciduous, and 4 to 8 inches (10-20 cm) long; it bears flowers and fruits at its axils. The primary shoot, secondary shoot, and branchlet are zigzagged and spiny.

## Flowers and fruits

Unlike apples or peaches, jujubes do not have big, showy flowers. The flowers are fragrant, pale greenish-yellow in color, and small, with diameters rang-

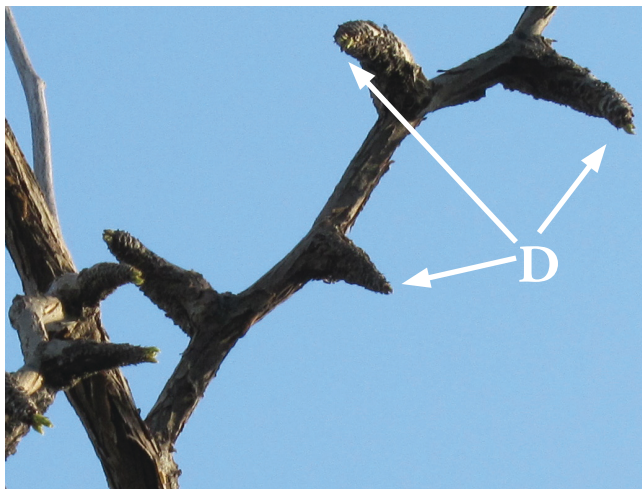
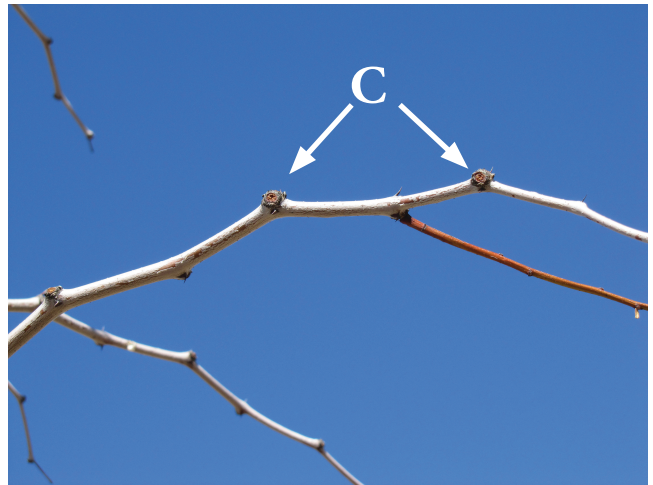
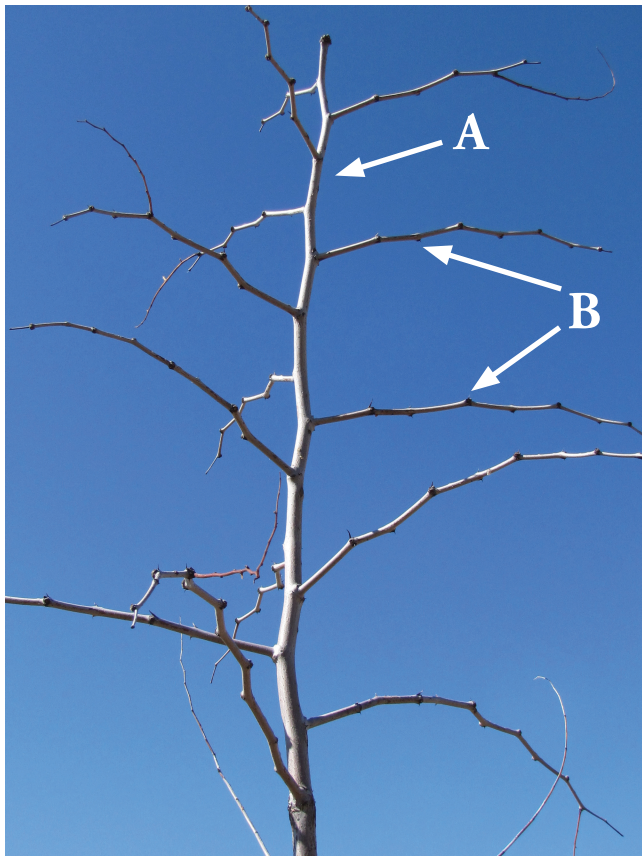
ing from 0.15 to 0.30 inch (4-8 mm) (Figure 2). Flowers can appear singly or in a cluster at each leaf axil. Jujube's flower cluster (inflorescence) is a cyme (Figure 2) with up to 13 flowers depending on the cultivar and its position on the branchlet. Jujube flower buds initiate, bloom, and develop to mature fruit within one growing season, which is unique and different from other tree fruit crops. Jujube bloom lasts for several weeks, making jujubes good nectar plants.

Jujube fruit is a drupe with one pit (stone) in the middle containing up to two seeds. Its fruit derives from its ovary and the nectar disk. Fruit size varies from thumb-size to golf ball-size depending on the cultivar. The fruit shape can be round, oblong, oval, ovate, obovate, oblate, apple-like, or abnormal shapes.

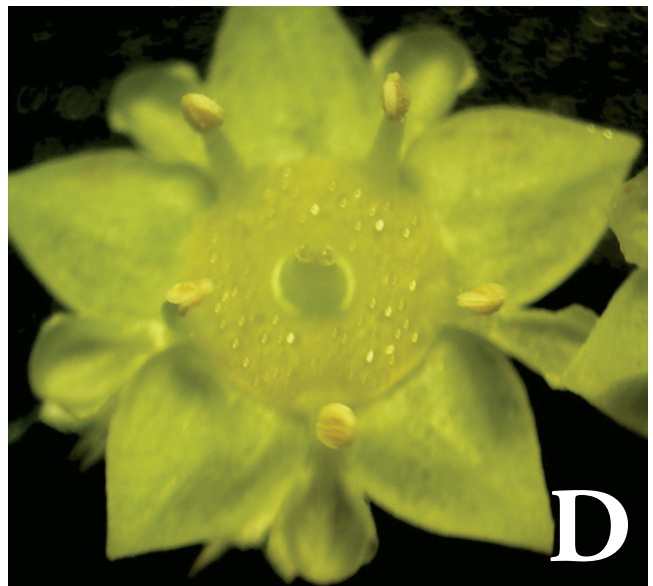
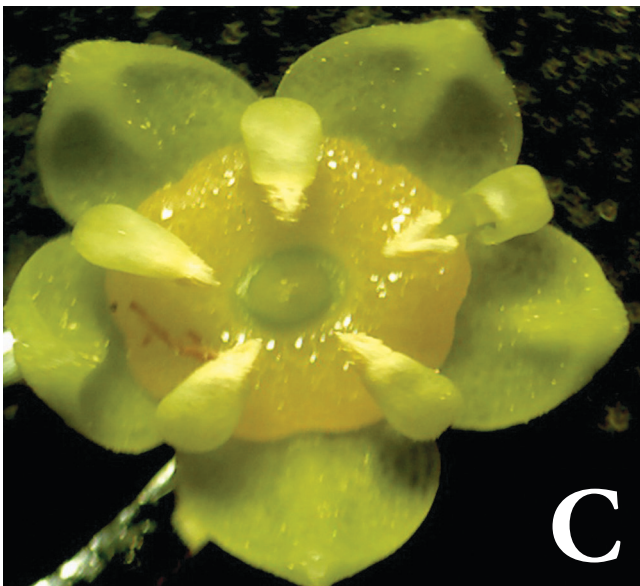
## CULTIVARS

Currently, there are 700 to 800 jujube cultivars in China, including fresh eating, drying, multipurpose (good for both drying and fresh eating), candied, and ornamental. Cultivars for drying, including multipurpose cultivars, formerly dominated and accounted for 90% of the jujube production in China. Now, with the selection and introduction of new fresh eating cultivars, plus the abundance of cold storage facilities, fresh eating cultivars are gaining popularity in China.

In the U.S., jujube cultivars are very limited. They include Frank Meyer's cultivars, cultivars recently imported from China or other jujube-growing countries, those released from the USDA Chico breeding program, and a few selections from seedlings across the country. Research from China indicated that quite a few regional dominant cultivars are self-fertile with no need for additional pollination; some cultivars can self-pollinate and set fruit, but cross pollination will improve the fruit set and fruit yield. A few cultivars are sterile without pollen, and a pollinizer cultivar and pollinating insect activity are required for these. Common pollinating insects include honeybees, houseflies, and ladybugs. As for the cultivars in the U.S., their self-compatibilities are not clear yet. For that reason, it is best to plant two or more cultivars instead of a single cultivar.



**Figure 1.** Jujube shoot structures: A. primary shoot, B. secondary shoot, C. mother bearing shoot (young fruiting spur), D. old fruiting spur, E. fruit-bearing shoot (branchlet). (Photos by Shengrui Yao).



**Figure 2.** Jujube flowers: A. a simple cyme, B. a large cyme, C. a half-opened flower, D. a fully opened flower. (Photos by Shengrui Yao).

**‘Li’:** Popular commercial cultivar imported directly from China by Frank Meyer. Large, round fruit up to 3 ounces, mid-season, fresh eating cultivar. Good quality.

**‘Lang’:** Popular commercial cultivar imported directly from China by Frank Meyer. Fruit is big and pear-shaped and good for drying. Some fruit may split if it rains at mature season.

**‘So’:** Frank Meyer’s cultivar. Beautiful ornamental tree with zigzagged branches. Medium-sized, round fruit with balanced sweet/tart flavor. Good for fresh eating and drying. Suitable for landscaping and home gardeners.

**‘Shuimen’:** Frank Meyer’s cultivar. Medium-sized, elongated fruit with big pit, good for fresh eating and drying.

**‘Sugarcane’:** Small- to medium-sized, round to elongated fruit with excellent quality. Fruit is extremely sweet and crunchy on a spiny tree. Good for fresh eating and drying. It could be the offspring of Chin zse tsao. This cultivar has low fruit set at Alcalde, NM. Pollinizing cultivars and bee activity are necessary to ensure good fruit set.

**‘GA866’:** From USDA Chico Plant Introduction Station’s jujube breeding program in California. Excellent large fruit with very high sugar content. Fruit is elongated and pointed at the far end.

**‘Sherwood’:** A seedling from Louisiana. Firm fruit with excellent quality. Trees are upright and narrow. Late-maturing cultivar. Good for long growing season areas.

**‘Honey Jar’:** A recent importation from China by Roger Meyer (no relation to Frank Meyer). Round, small fruit with excellent quality. Very sweet and crispy. Excellent for fresh eating. Tree is precocious and fruits during planting year or grafting year.

**‘Shanxi Li’:** Became popular in the late 1980s and early 1990s in China. Now one of the major fresh eating cultivars in China. Medium- to large-sized fruit with good eating quality. Mid-season maturity. Tree is precocious and productive.

**‘Sihong’:** A new importation from China by Roger Meyer. Good for fresh eating and excellent for drying. When dried, fruit has fine wrinkles on its surface. Mid-season maturity.

**‘Abberville’:** Tree is prolific and loaded with small fruit. Fruit quality is mediocre. Branchlets and fruits remain on tree for 1 to 3 weeks after defoliation, making it a good ornamental tree.

NMSU’s Alcalde Science Center imported over 30 cultivars directly from China in 2011, including famous traditional cultivars, recently selected fresh eating and drying cultivars, and several early season and ornamental cultivars. As of 2012, they are still under USDA quarantine, but the best-performing cultivars will be released to the public after several years of evaluation under New Mexico conditions.

## CULTURE

### Propagation

Most commercial jujube trees are grafted on sour jujube (*Z. spinosa*) because of its seed availability and stress tolerance. Tongue–whip grafting and bark grafting are popular methods of jujube propagation. Jujubes can also be propagated through root suckers if the mother plants are from root suckers. If the mother plants are grafted trees, the suckers are only good as rootstocks. Softwood cutting is also possible for jujubes in a moist environment.

### Precocity and tree life span

Jujube trees are very precocious. They bear flowers the same year as planting or grafting, and some cultivars can even bear some fruit. Most cultivars will produce a few fruits in the second year. After 4 to 5 years, jujubes will have a reasonable yield. A mature jujube tree can have 40 to 100 lb or more of fruit depending on tree size and culture management. Jujube trees can keep producing in commercial orchards for 50 years or more. The ‘Jujube King’ is over 1,000 years old and is still producing fruit annually in Shandong Province, China.

### Soil requirements

Jujubes can grow and set fruit well in a wide range of soil conditions, from sandy to loam to clay, and from acidic to alkaline (pH 5.0-8.5). Jujubes can survive in barren soils. Most New Mexico soils should be suitable for jujube production.

### Irrigation and fertilization

Jujube plants are quite tolerant to drought. For a premium fruit set and yield, though, jujube trees need to be irrigated in New Mexico’s arid weather conditions.

There is limited research on jujube fertilization. Trees will survive with little or no fertilizer, but for commercial production, fertilizer applications are usually necessary. Do not fertilize newly planted trees until they are well-established.

### Pruning

In general, jujube’s training and pruning are simple, but there are some basic rules to follow. “One cut stops, two cuts sprouts” is a saying unique to jujubes. Unlike apple and peach, if you give a one-year-old jujube shoot just one cut in the middle, no

bud will grow under that cut. To force a main bud to sprout below a cut, the secondary shoot must be removed below the cut. Jujubes are light-demanding (full sunshine) plants. Pruning them annually will benefit the tree and improve the fruit set and fruit quality.

### **Harvest**

As the fruit begins to mature, fruit color changes from dark green to yellow-green, known as the creamy, white mature stage. As maturation continues, brown/red spots develop at the petiole end (where the fruit joins the stem) or randomly in the middle of the fruit. The color further changes to half red/half creamy, and eventually becomes fully red/brown, known as the fully mature stage. People often compare firm jujube fruit texture to that of a crispy apple. Several days after fully red, fruit texture starts to soften and wrinkles appear on the surface.

Fruit maturity is not uniform. Fresh eating cultivars can be marketed from the white mature stage until they are fully red but still firm. Fresh fruit harvested when first ripe can be stored at 40°F (5°C) for two weeks or more without losing quality. The best time to harvest drying cultivars is when they are fully red. In New Mexico's arid climate, fruits can be harvested when they start to wrinkle or can be left hanging on the trees for a while after wrinkling. In humid areas, fruits must be harvested when they are fully red in color and dried as soon as possible to avoid yeast or mold infection. Manual harvest is preferable for fresh eating cultivars. For drying cultivars, growers in China lay tarps below trees and then shake the trees or use long poles to dislodge fruits. Mechanical harvest using trunk shakers may be applicable for production of large acreage of drying cultivars.

### **Pests, diseases, and disorders**

In China, the dominant diseases for jujube are witch's broom and fruit splitting. Witch's broom is caused by a type of phytoplasma bacteria (*Candidatus Phytoplasma ziziphi*) and can destroy an entire orchard. The worst fruit splitting, resulting from

heavy rainfall near harvest time, can ruin the entire season's crop. Peach fruit moth (*Carposina niponensis*) is the number one pest for jujubes in China.

It is easy to produce jujubes organically in New Mexico because, so far, jujubes are disease- and pest-free in the state. Fruit cracking is sometimes observed in the 'Lang' cultivar at Alcalde if it rains in early September. Most of the time in this climate, though, cracks will remain dry without developing yeast or fungal infection, and thus will not really affect fruit quality.

### **FRUIT NUTRITION AND USES**

Jujube fruit is recognized as a nutritious food and important traditional medicine in China, Korea, Japan, and Southeast Asia. Jujubes are richer in vitamin C, sugar, bioflavonoids, edible cellulose, and minerals than other fruit species. Soluble solids content ranges from 20 to 40% in fresh mature fruit. Carbohydrate content in dried jujubes can reach as high as 70 to 85%. Fresh jujube fruit contains 200 to 500 mg of vitamin C per 100 g fresh weight, while apple, pear, and peach have 1 to 8 mg/100 g fresh weight. Jujubes are also rich in cyclic adenosine monophosphate (cAMP), which is an important "second messenger" in many biological processes in the human body.

Thus far in the U.S., jujubes have been considered more of a novelty than a specialty crop, with fresh and dried production mainly for home and local markets. However, the fruit can be used in many different ways. Dried jujubes are a nutritious snack and can replace raisins and dates in baking. Recipes have been created for jujube cake, jujube butter, candied jujubes, and jujube syrup. In China and Southeast Asia, besides being eaten fresh and dried, jujubes are also processed as candied fruit, smoked fruit, juice, jam, wine, mixed beverages, powders, and tea. Dried fruits are also cooked in porridge or broth, and are further processed into a paste for moon cake filling. As jujubes become more familiar and popular in the U.S., many value-added products with jujubes will be created.

## Recipes

### Jujube Butter

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6 pints jujube pulp  
1 teaspoon nutmeg  
1/2 teaspoon cloves  
2 teaspoons cinnamon  
10 cups sugar  
1/4 pint vinegar  
1 lemon

Boil fruit until tender in sufficient water to cover. Drain, then run cooked fruit through a sieve or colander to remove the skin and seeds. Add remaining ingredients and cook slowly until thick. If you want to can the mixture, please follow safe canning procedures (see the *USDA Complete Guide to Home Canning*, available from [http://nchfp.uga.edu/publications/publications\\_usda.html](http://nchfp.uga.edu/publications/publications_usda.html)).

### Jujube Cake

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1 cup sugar  
1/2 cup butter  
2 cups dried, minced jujube  
1 cup water  
Bring these to a boil, then set aside to cool.

2 cups wheat flour  
1 teaspoon soda  
1/2 teaspoon salt

Sift these together, then add to the wet ingredient mixture and combine. Bake in your favorite cake pan at 325°F for around 20 minutes until a toothpick stuck into the center comes out clean.

### Jujube Paste

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Cook desired amount of dried jujubes in water for 10 minutes or until soft. Make sure to not overcook the fruit, which might turn sour if overcooked.

Puree in a food processor, then sweeten with sugar to taste. Work the puree into smooth paste. The paste can be used as a spread or as filling for confectious such as cookies, desserts, and steamed buns.

## CONCLUSION

Late-season startup, precocity, cropping reliability, nutritional benefits, and mild flavors make jujube an excellent edible ornamental and backyard tree. It also has great potential for commercial production in New Mexico. The large American-Asian food market and the medicinal food market are familiar with jujubes and are ready to consume them; however, it may take some time for Americans to become familiar with this exotic fruit. Growers can start with small acreage, and expand their operation to a bigger acreage with more diversified cultivars as the market grows.

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