Annales Universitatis Paedagogicae Cracoviensis
Studia Naturae, 5: 194–219, 2020, ISSN 2543-8832
DOI: 10.24917/25438832.5.13

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Chinese jujube (*Ziziphus jujuba* Mill.) – a promising fruit from Traditional Chinese Medicine

With an understanding of traditional Chinese medicine (TCM) comes a unique knowledge of Chinese herbs and fruits, as both typical ethnic foods and traditional health-promoting foods. Additionally, the exploration of Asian food culture provides historical information related to traditional Chinese medicine and the use of Chinese herbs and fruits in dietary applications (e.g. Khoshkharam et al., 2020; Shahrajabian et al., 2019 a,b, 2020 a,b; Sun et al., 2019 a,b, 2020).

The Chinese jujube (*Ziziphus jujuba* Mill. or *Z. jujuba*), which originated in China, has a history that spans more than 4,000 years and is recognised as the most important fruit species belonging to the Rhamnaceae Juss. family (Mardare et al., 2016), especially in Asia. It was first described scientifically by Carolus Linnaeus as *Rhamnus ziziphus* L., in "*Species Plantarum*" in 1753. Later in 1768, Philip Miller concluded it was sufficiently distinct from *Rhamnus* genus to merit separation into a new *Ziziphus* genus. Miller named it *Z. jujuba*, using Linnaeus's species as a name for the genus (Bean, 1988).

Chinese jujube and the similar Indian jujube (*Z. mauritiana* Lamk.) are largely used in traditional Asian medicine as super fruits (Krishna et al., 2016) – Fig. 1. Indian jujube (also belonging to family Rhamnaceae L.) is a tropical/subtropical fruit native to the northern hemisphere (Pareek, 2013). For example, Li et al. (2018) discovered that the Chinese jujube originates from sour jujube (*Z. acidojujuba* Mill.) and is an economically very important genus (Zhang et al., 2015). They also concluded that most jujube cultivars have a certain correlation with their origin, and there are obvious gene exchanges between sour jujube, Chinese and Indian jujube cultivars. Its pulp is eaten mostly fresh but may be dried or processed into confectionary recipes in bread, cakes, compotes and candy (Krška, Mishra, 2008; Mishra, Krška, 2017).

Fig. 1. Chinese jujube's dry fruit – drupe (*Ziziphus jujuba* Mill.) (Photo. M.H. Shahrajabian)

Wang and Hu (2016) reported that jujube is an important fruit in China and has attracted significant interest because of its common consumption as food, a food additive, as a flavouring and in TCM (Mahajan, Chopda, 2009). In China, a wine made from jujubes, called "*hong zao jiu*" is also produced. In a Chinese book on herbal medicine, Huangdi Neijing (475-221 BC), jujube was described as one of the five most valuable fruits in China. In Shennong Bencao Jing (300 BC-200 AD), an earlier book recording medicinal herbs, jujube was considered to be one of the superior herbal medicine that prolonged life-span by nourishing blood, improving quality of sleep, and regulating the digestive system (Chen et al., 2017). According to Gupta (2004), jujube, along with date palms and grapes, started to be domesticated on the Indian subcontinent around the year 9,000 BC, together with wheat and barley, which were cultivated from the very beginning of agriculture.

The aim of this article was to review the most important information about the Chinese jujube's (*1*) botanical characteristics, (*2*) cultivation in China and around the world, (*3*) variety of cultivars, (*4*) crop pests and (*5*) importance in traditional cuisine and Chinese medicine.

Jujube classification and species characteristic

Ziziphus jujuba, commonly known as jujube, red date and Chinese date, is a species that has many scientific names. These names are used as synonyms – a list of synonyms and a detailed botanical description (flower, fruits and trunk, branches, culture and other characteristics) of this species can be found in the appendix (Tab. 1, points 1–2 – Appendix 1). As a species found on five continents, it is characterised by a very large variety of cultivars (Tab. 1, points 3–7 – Appendix 1), which proves it is a plant that has been used by humans for centuries. Similarly, *Z. mauritiana* is characterised by a very diverse local (customary) nomenclature, which proves that it is a plant commonly known for cultivation in various regions, especially in Asia (Tab. 2, points 1–2 – Appendix 1).

From an economic point of view, fruits are the most important raw material derived from species of the *Ziziphus* genus. There are three phases of fruit maturation of the Chinese jujube, which are based on colour, flesh firmness and composition, such as starch, sugar, acid and water. The phases are 1) white mature: the fruit is near full size and shape – the skin of the fruit is thin and changes from green to greenish white in colour, and the flesh becomes white and loose with less juice and sugar and more starch; 2) crisp mature: the fruit skin is half to fully red in colour, becomes thicker, harder and easily separated from the flesh which becomes crisp, juicy and sweet, containing more sugar and acid; and 3) fully mature: sugar content of the flesh increases rapidly and water content begins to decrease, while the flesh near the stone and fruit stalk becomes yellow and soft and the skin changes to a dark red and the fruit becomes wrinkled. These three stages of ripening determine the specific use and properties of the fruits of not only Chinese jujube but all species of this genus.

Jujubes adapt to a wide range of elevation, from 0 to 2,000 m, between latitude 18°14′ to 45° and longitude 76° to 124° and in soil pH 5.5 to 8.5. Jujubes may tolerate –30°C in the winter and 49°C in the summer (Miri, 2018). Eight major phenological stages have been observed for Chinese jujube: bud growth; leaf formation; leaf growth; shoot growth; formation of inflorescence; flowering; fruit formation, growth and development; fruit maturation and winter dormancy (Sapkota et al., 2020).

Jujube trees adapt to drought conditions and produce sufficient yield under severe conditions (Sülüşoğlu et al., 2014). The tree can survive with an annual rainfall of only 200 mm but, for better fruit set and fruit quality, more precipitation or supplemental irrigation is needed. Shahin et al. (2011) found that increasing water stress significantly reduced rate of stem length, number of leaves per plant, leaf area and fresh and dry weight of different plant organs. They also concluded that the Date genotype of the Chinese jujube had the highest statistically significant performance in increasing vegetative growth compared with other genotypes, when under water stress. Additionally,

this species is autogamic, so only one tree is needed for fruit-set. Additionally, jujubes are also tolerant of high salinity, alkalinity and root exposure from erosion or roots being deeply covered by blowing sand, but Chinese jujube should not be planted in the shade of other trees (Yao, 2013).

Jujube, as a nutritious fruit, is important especially for people in low-income groups because of its relatively inexpensive cost for value, compared to other available fruits. It is also a relatively less perishable fruit and its cultivation by large-scale famers can be economically beneficial and help to maintain national economic levels (Islam et al., 2016).

Jujube cultivation in China

Chinese jujube is considered an ideal economic crop for arid and semiarid areas of the temperate zone where common fruit trees do not grow well (Liu, 2010). Chinese jujube has become a leading fruit tree in the northern part of China with a total production of 4,250,000 t in 2009 with a planting area of 1,500,000 ha (Ping et al., 2012). China produces and exports more jujube than any other country in the world, and it has been estimated that more than 90 percent of the world's products made from jujube are provided by China (Zhang et al., 2012). According to the Xinjiang Statistical Yearbook 2015, there was a total planting area of 483,628 ha and yearly production of more than 2.5 million t (Chen et al., 2017).

In China, the jujube tree is popular as a woody species that reduces soil erosion while producing an economic crop in response to the government policy of changing from small grain production to conservation forestry on the Loess Plateau (Wu et al., 2013). The Henan province used to be one of the most important jujube production regions in China (Wang, Hu, 2016) – Fig. 2.

The planting area for jujube in Shanxi province exceeds 100 acres, which are mostly planted in the mountains where dry farming is the primary mode of cultivation due the severe scarcity of water for irrigation (Chen et al., 2014). Guo et al. (2017) found that wild jujube (*Ziziphus acidojujuba* Mill.) is highly tolerant to alkaline, saline and drought stress. Liu et al. (2016) also recommended that, in order to fully utilise the limited arable land and achieve fast economical returns, jujube/wheat intercropping be employed in Xinjiang Uygur Autonomous Region in China by planting wheat between the lines of jujube tree when jujube trees are young. Because of its positive ecological, economic and social benefits, the jujube/wheat intercropping system became one of the most widely applied agro-forestry systems in Xinjiang, northwest China.

Jujube production has developed at a rapid and significant pace over the past 39 years in China. Its annual production has increased more than 15 times from 1980 to 2015 from 376,000 t to over 6,000,000 t, on a fresh weight basis. Ninety percent of

Fig. 2. The major cultivation areas of jujube (*Ziziphus jujuba* Mill.) in China (Chen et al. 2017 – changed)

this production is concentrated in six Northern provinces, namely Hebei, Xinjiang, Shandong, Shanxi, Shaanxi and Henan (Fig. 2). Moreover, the current total growing area in China is approximately 2 million hectares. Xinjiang provinces in western China have seen a massive increase in production in the last 10 years with both the introduction of new cultivars and favourable growing conditions for producing premium quality fruit (Lin et al., 2013). The 10 leading cultivars of Chinese jujube in China and other imported cultivars are shown in the appendix (Tab. 1, points 3–4 – Appendix 1).

Jujube cultivation in different parts of the world

China is undoubtedly one of the largest producers of *Ziziphus jujuba* in the world (Chen et al., 2017; Višnjevec et al., 2019; Shahrajabian et al., 2019c). Over 40% of this plant's crop is grown in China (Fig. 3). However, other countries have shown a growing interest in producing this species, such as Egypt, Iran, Saudi Arabia, Algeria and Iraq, primarily due to the health-promoting properties of the fruit and ease of growth (Tab. 1, point 5 – Appendix 1).

In Lebanon, Jordan and other Middle Eastern countries, the fruit is eaten as snacks or alongside a dessert after a meal. In Persian cuisine, the dried drupes are known as Annab, while in Azerbaijan, it is commonly eaten as a snack and known as Innab. The

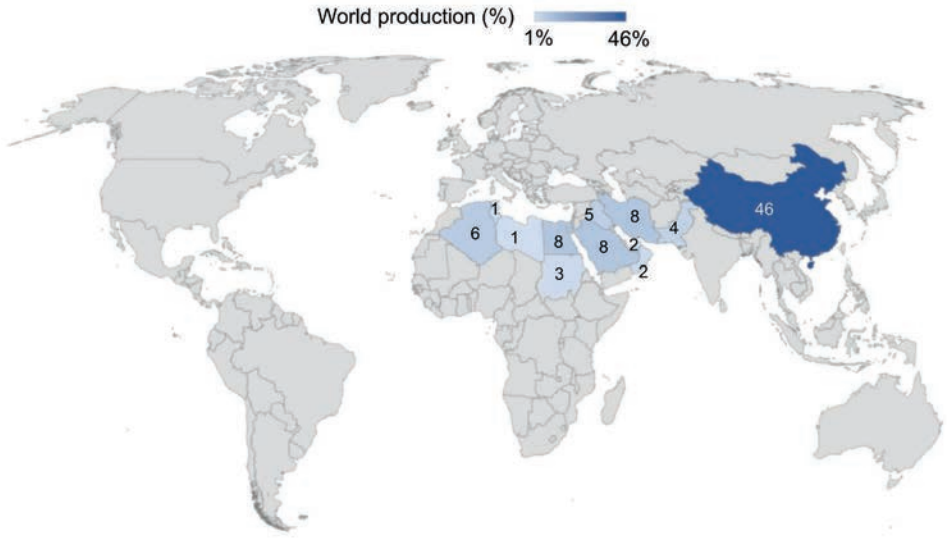

Fig. 3. World production of jujube (*Ziziphus jujuba* Mill.); additionally about 6% other countries together – Azerbaijan, USA, Korea, Australia and others (data source: Johnstone, 2017)

Turks use a similar name, hunnap. *Z. jujuba* grows in northern Pakistan and is known as Innab, commonly used in the Tibb Unani system of medicine. In India, the fruits are dried in the sun and the hard nuts are removed, then it is pounded with tamarind, red chilies, salt and jiggery. In both China and Korea, a sweetened tea syrup containing jujube fruits is available in glass jars, and canned jujube tea or jujube tea in the form of teabags is also available. Jujube has been introduced worldwide because of its high nutritional and economic values (Gao et al., 2013; Zhang, Li, 2018).

Ghazaeian (2015) concluded that climate is very important for the qualitative and quantitative characteristics of jujube. A demand for fresh jujubes continues to outweigh supply on the local markets (Johnstone, Shan, 2016). Western Australia is close to South-East Asia, thus its counter-seasonal production versus the northern hemisphere may provide an opportunity to market Australian grown fresh Chinese jujube for the increasing off-season demand in these countries. The jujube industry in Western Australia has an exciting future, as it grows well in many areas of the country. There are also many cultivars, which confirms the significant interest of local growers (Tab. 1, point 6 – Appendix 1)

Ciocarlan (2000) reported that the Chinese jujube could be found in a semi-spontaneous status in the Dobrogea region, which is located between the Danube and the Black sea in Romania; there are several places where the Chinese jujube exists in naturalised populations. In Romania, the tree was brought "via the Silk road" 2,000 years ago (Stănică, Vasile, 2008; Stănică, 2009). It is cultivated in Europe, but its primari-

ly researches have been conducted in Romania, Italy and Macedonia (Cossio, Bassi, 2013; Johnstone, 2014; Markovski, Velkoska-Markovska, 2015; Višnjevec et al., 2019).

In North America, jujubes were found to be cultivated mainly in the southwest, southern and south-eastern states – from North and South Carolina to Florida and from Georgia to California, as well as in Pennsylvania (Yao et al., 2015). The plantation of jujube is becoming increasingly popular in this part of the world, as evidenced by its numerous cultivars (Tab. 1, point 7 – Appendix 1).

Jujube pests and other problems with fruit production

Balikai et al. (2013) described almost 130 pest species that were recorded on *Ziziphus* crops in India and specified that 177 species of insect (some of them are listed in table 3) and non-insect were recorded to be jujube pests around the world. In India, in an IPM governmental meeting in 2015, 10 pests were cited as pests of national significance: fruit flies *Carpomyia vesuviana* Costa (Diptera: Tephritidae), fruit borers *Meridarchis scyrodes* Meyr (Lepidoptera: Carposinidae), green slug caterpillars *Thosea* sp. (Lepidoptera: Limacodidae), grey caterpillars *Thiacidas postica* Walker (Lepidoptera: Noctuidae), mites *Larvacarus transitans* Ewing (Tetranychoidea: Tenuipalpidae), ber beetles *Adoretus pallens* Banchard (Coleoptera: Scarabaeoidae), grape mealybugs *Maconellicoccus hirsutus* Green (Hemiptera: Pseudococcidae), ber mealybugs *Perissopneumon tamarindus* Green (Hemiptera: Pseudococcidae), thrips *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) and termites *Odontotermes obesus* Rambur (Isoptera: Termatidae).

Tab. 3. Taxonomical position and nature of various insects observed on ecosystems with jujube (Nizamani et al., 2015)

No.	Common name	Technical name	Family	Order
Major Pests				
1.	Jujube Lead roller	*Ancylis sativa* Liu	Tortricidae	Lepidoptera
2.	Jujube Hairy caterpillar	*Euproctis fraternal* Moore	Lymentriidae	Lepidoptera
3.	Jujube beetle	*Adretus pallens* Blanchard	Scarabaeidae	Coleoptera
Minor Pests				
4.	Cutworm	*Agrotis biconica* Kollar	Notuidae	Lepidoptera
5.	Thrip	*Scirtothrips dorsalis* Hood	Rambutanae	Thysanoptera
6.	Jujube looper	*Achaea janata* Linn.	Notuidae	Lepidoptera
7.	Jassid	*Amrasca biguttula biguttula* Ishida	Cicadilidae	
8.	Aphid	*Aphis gossipie* Glover	Aphididae	Hemiptera
9.	Jujube Gray weevil	*Myllocerus discolor* Boheman	Curculionidae	Coleoptera

Sporadic Pest				
10.	Dusky cotton bug	*Oxycareous hyalinipennis* Costa	Lygaediae	Hemiptera
11.	Green Grasshopper	*Dichromorpha viridis* Scudder	Acrididae	Orthoptera
12.	Jujube Butter fly	*Tarucus balkanicus* Freyer	Lycaenidae	Lepidoptera
13.	Moth	*Orgyia postica* Wlk	Lymantriidae	Lepidoptera

In Europe, the following jujube pests were noted: *Carpomyia vesuviana*, *C. incomplete* Becker, *Bactrocera zonata* Saunders, *Ceratitis capitata* Wiedemann and *Hispa* sp., *Grammadera clara* Brunner von Wattenwyl (Balikai et al., 2013). In Romania, the most significant pests of *Z. jujuba* are *Carpomya vesuviana* and *C. incomplete* – dipterous that lay their eggs in July under the fruit epiderma, and *Carposina sasakii* Mats. – a Lepidopterous which, in China, destroys 15–20% of fruits; with other minor pests being *Ceratitis capitata*, *Cydia molesta* Busck and *Polycrosis botrana* Schuffermuller (Stănică, 1997). In field experiments, while monitoring pest incidence, several species were identified that may become a threat: *Halymorpha halys* Stal (Heteroptera: Pentatomidae), *Metcalfa pruinosa* Say (Homoptera: Flatidae), *Ceratitis capitata* and *Nezara viridula* L. (Heteroptera: Pentatomidae); in the same experiment scientists reported other potential polyphagous pests, like weevils, fruit borers and moths that insignificantly damaged the fruits (Ciceoi et al., 2017).

Hua et al. (2015) found that jujube fruit cracking has become a major concern in jujube production and it can affect fruit quality and yield and crop productivity, resulting in significant economic loss. Zeraatgar et al. (2018) concluded that salicylic acid and calcium nitrate play an important role in maintaining and extending post-harvest quality of fresh jujube fruit. These substances could cause at least a 10-day delay in the reduction of some the fruit's beneficial attributes. Disease and cracking resistant cultivars are shown in table 1, point 8 – Appendix 1.

Jujube nutritional composition and chemical constituents

Kader et al. (1982) stated that, relative to most other fresh fruits, Chinese jujubes are lower in water content and titratable acidity and higher in total sugars (mostly reducing sugars) and phenolics. The major minerals in jujube are phosphorus, potassium, calcium and manganese. In addition, there are also high amounts of sodium, zinc, copper and iron. Chinese jujubes are very rich in ascorbic acid (vitamin C) content which increase with maturation to 559 mg/100 g fresh weight. This was also confirmed in other studies (e.g. Pareek, 2013). The fruits are nutritious, being high in flavonoids and vitamins B_1 and B_2, thus it can be considered a so-called functional food – having nutritional as well as medicinal uses (Huang et al., 2008).

Rahman et al. (2018) noted that 51.99–71.75% of the Chinese jujube is edible, with the edible part containing 82.35–89.63% carbohydrates, 4.43–6.01% protein, 0.48–0.63% lipids, 2.80–4.80% polysaccharides, 45.64–88.97 mg/100 g ascorbic acid, 132.16–196.58 mg/100 g phenolics and 101.17–132.04 mg/100 g flavonoids in its dry matter. The jujube fruit is rich in mineral content and fibre, a good source of food for direct consumption and it may be a useful food additive when dried (Hendek Ertop, Atasoy, 2018; Višnjevec et al., 2019). Jujube fruit, especially in dried and powder form, can be valorised as a fortifying and hydrocolloid ingredient, due to its high carbohydrate content.

However, the content of different substances may vary depending on the breeding cultivar. Li et al. (2007) provided the proximate composition of five cultivars of Chinese jujube ('Jinsixiaozao', 'Yazao', 'Jianzao', 'Junzao', 'Sanbianhong'). In their experiment, total phenols, minerals and vitamins were determined for the fruits of these cultivars; significant variation was found for content of water (17.38–22.52%), carbohydrate (80.86–85.63%), proteins (4.75%–6.86%), lipids (0.37–1.02%), soluble fibre (0.57–2.79%), insoluble fibre (5.24–7.18%), reducing sugar (57.61–77.93%) and ash (2.26–3.01%). Glucose and fructose were identified as major soluble sugars in all five cultivars, while rhamnose, sorbitol and sucrose were also present in lower amounts. Chen et al. (2018) reported the 'Junzao' cultivar contained relatively low levels of total dietary fibre, protein, total sugar and total titratable acids. The 'Huizao' cultivar possessed an intermediate level sugar-to-acid ratio and intermediate levels of ascorbic acid. The 'Dazao' cultivar showed high levels of total dietary fibre, protein, sugar and total acids. In their experiment, principal components analysis indicated that the parameters that differentiated these jujube cultivars appeared to be the total dietary fibre, protein, total sugar, fructose, glucose, sucrose and total titratable acids.

Chen et al. (2017) noted that jujube exerts neuroprotective activity, including protecting neuronal cells against neurotoxin stress, stimulating neuronal differentiation, increasing expression of neurotrophic factors and promoting memory and learning. Flavonoid, cyclic adenosine monophosphate (cAMP) and jujuboside may potentially be the bioactive ingredients accounting for the aforesaid biological activities. These findings imply that jujube is a potential candidate for use in the development of health supplements for prevention and/or treatment of neurological diseases. Seven chemical markers found in jujube, including kaempferol *3-O*-rutinoside, quercetin *3-O*-rutinoside, (-)-catechin, (-)-epicatechin, swertish, spinosin and cAMP, have also been associated with neuroprotection (Fig. 4 – Appendix 2). The structures of the triterpenic acids, nucleosides and nucleobases, as well as saccharides, in jujube fruits are presented in figure 5 – Appendix 2. The appendix also contains a list of all of the most important chemical ingredients contained in jujube fruit (Tab. 1, point 9 – Appendix 1).

Traditional medicinal uses and potential health benefits of jujube

Jujube (*Zisiphus jujuba*) has been used as a TCM plant for many years for its various and numerous health benefits, including anti-inflammatory (Yu et al., 2012), anti-cancer (Plastina et al., 2012), gastro-intestinal protective (Huang et al., 2008), anti-oxidant (Cheng et al., 2012), anti-insomnia and neuro-protective (Yoo et al., 2010) properties. Jujube fruits and seeds are still used in Chinese and Korean traditional medicine and are believed to alleviate stress, according to the modern medicine industry (Mill Goetz, 2009). Among other things, jujube causes a decrease in the blood levels of glucose and lipids and causes a significant decline in triglyceride, LDL and cholesterol levels (Hemmati et al., 2015). Tahergorabi et al. (2015) reported that different parts of the jujube have been used for curing different kinds of illness such as diabetes, diarrhoea, skin infections, liver complaints, urinary disorders, obesity, fever, pharyngitis, bronchitis, anaemia, cancer, insomnia and, of course, for blood purification and tonification of the gastro-intestinal tract.

The jujube leaf, which is the main by-product of the jujube, has been used in TCM for thousands of year, to improve sleep, to nourish the heart and soothe the nerves and to reduce haemorrhaging and diarrhoea (Zhang et al., 2014; Damiano et al., 2017). Modern studies found that the jujube leaves were rich in bioactive components and have various physiological and pharmacological functions (Mahajan, Chopda, 2009; Damiano et al., 2017). The aqueous ethanol extract of the jujube leaf is used as an energetic constituent for hepatosis and wound healing in animal trials (Hovanet et al., 2016; Bai et al., 2017). Jujube-leaf green tea extracts can inhibit human hepatocellular carcinoma cells by activating AMP-activated protein kinase (AMPK) (Huang et al., 2009; Liu et al., 2017); additionally, an unidentified β-D-glucosidase inhibitor has been found in jujube leaf extract (Jo et al., 2016).

Based on Iranian traditional medicine, local healers have used powders made of the stem bark and leaves of jujube to cure wounds on different parts of the body, including oral wounds such as aphthous (Hamedi et al., 2016). Roots and bark of jujube have been used to treat dysentery; the bark has been reported to cure boils and found helpful for the treatment of diarrhoea (Mahajan, Chopda, 2009) and jujube seeds were used to cure eye diseases and help with leucorrhoea. Currently, fruits of jujube are widely used in Iranian folk medicine as an antitussive, laxative agent and blood pressure reducer (Hamedi et al., 2016). In Persian traditional medicine, jujube fruit is also used in combination with other herbal medicines to treat colds, flu and coughing.

Jujube fruit contains flavonoids, vitamins, amino acids, organic acids, polysaccharides, and microelements (Li et al., 2007, 2016), which have been found useful in spleen diseases and supporting body systems (Shen et al., 2009). Hamedi et al. (2016) found that the fruit of the jujube is digestible; is tonic; works like an aphrodisiac; is

laxative; removes biliousness, burning sensations, thirst and vomiting and is also used in curing tuberculosis and blood diseases.

Beavo and Brunton (2002) found that jujube fruits contain a certain amount of cAMP, which has a positive effect on the heart muscle, nutritional myocardium and diastolic blood vessels, as well as having anti-arrhythmia and anti-platelet aggregation effects. Recent phytochemical research on jujube fruits has revealed anti-cancer, anti-inflammatory, anti-obesity, immuno-stimulating, anti-oxidant, hepato-protective and gastro-intestinal protective properties, as well as inhibition of foam cell formation in macrophages (Abedini et al., 2016; Keerthi et al., 2016; Rajopadhye, Upadhye, 2016; Alhassan et al., 2019).

Cosmulescu et al. (2017) mentioned that jujube fruits are rich in bioactive compounds (flavonoids, carotenoids and anthocyanin) and can complement a healthy human diet. Shi et al. (2018) concluded that changes in jujube fruit colour are associated with changes in antioxidant activity. Flavonoids and polysaccharides could contribute to the antioxidative effect of jujube (Choi et al., 2011).

Hoshyar et al. (2015) indicated that, among other things, *Z. jujuba* ameliorates the adverse effects of NMU carcinogenesis and could be useful, for example, in treating mammary tumours in humans. Taechakulwanijya et al. (2013) found that jujube seed extracts were not toxic to control Vero cell lines but induced cell death in Jurkat leukemia T cell lines, making them promising candidates for more elaborate studies of their anticancer mechanisms. The triterpene acids from jujube are considered active ingredients, having anti-inflammatory and anti-cancer properties (Tahergorabi et al., 2015).

Betulinic acid and jujuboside B might be the active components underlying beneficial effects on the cardiovascular system (Seo et al., 2013). Vafaei and Abdollahzadeh (2015) reported that jujube fruit extract could accelerate burn wound healing. Jujube polysaccharides are thought to be the primary active ingredient contributing to jujube's immune-modulating and hemato-poietic functions (Zhao et al., 2008). The jujube polysaccharides, composed of glucose (23%), xylose (31.3%), mannose (12.9%) and fructose (21.6%), possess antioxidant effects that may have contributed to observed positive effects (Wang, 2011). Gao et al. (2013) mentioned that jujube polysaccharides are reported to be useful in ameliorating intestinal oxidative injury resulting from ischemia and reperfusion. Additionally, it was found that taking a combination of jujube fruit and low doses of routine pharmaceutical drugs can improve and cure ulcerative colitis disease (Gheibi et al., 2018).

Generally, the vitamin and mineral content of jujube fruit helps to support cardiovascular health and enhance metabolism. The most important pharmacological properties of jujube are anti-diabetic effects, hypnotic-sedative and anxiolytic effects, neuroprotective activity, inhibition of sweetness, anti-cancer activity, antimicrobial

activity, anti-ulcer activity, anti-inflammatory and anti-spastic effects, anti-allergic activity, permeability-enhancing activity, cognitive activity, anti-fertility/contraceptive properties, hypotensive and anti-nephritic effects, cardiovascular activity, immunostimulant effects, anti-oxidant effects and wound healing activity (Anbarasi, Brindha, 2013; Pareek, 2013).

Additionally, Varghese and Patil (2005) revealed that jujube leaves exert an insecticide effect against *Helicoverpa armigera* Hübner and *Triboliun confusum* Jacquelin du Val. It has been shown that jujube leaf insecticide activity occurs through inhibition of digestive and mitochondrial enzymes which lead to retarded larval growth.

Conclusion

Jujube or Chinese dactyl (*Zizyphus jujuba*) is a popular cultivated plant in many parts of the world, especially in China and Iran. Its fruit is an edible oval drupe, which has a wide range of applications, especially in food and medicine. Jujube trees have the ability to adapt to various biotic and abiotic stresses such as salinity and drought. Chinese jujube is grown in temperate regions, while the similar Indian jujube (*Z. mauritiana*) is cultivated in hot arid regions of India. China is still the largest producer of jujube fruit in the world, although recently there has been a notable increase in interest in jujube fruit production in other parts of the world. Jujube fruit contains 23 types of amino acids that are not found in most other kinds of fruits. It also contains vitamin C, riboflavin and thiamine. The major components of the jujube fruit are used, in combination with other medicinal plants and fruits, in TCM. The jujube leaf, which is the main by-product, has also been used in TCM for thousands of years. Jujube has numerous important pharmacological activities and is considered a valuable source of nutraceuticals. It is a plant with great healing potential in diseases of civilisation, including various types of cancer, and is an important source of nutrients, easily available in the poorer regions of the world.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Appendix 1

Tab. 1. Detailed characteristics of Chinese jujube (*Ziziphus jujuba* Mill.)

1) Scientific classification and synonyms (Liu, 2010)

Kingdom: Plantae; Unranked: Angiosperms; Unranked: Eudicots; Unranked: Rosids; Order: Rosales; Family: Rhamnaceae; Genus: *Ziziphus*; Species: *Z. jujuba* Mill.

Synonyms: *Paliurus mairei* H. Lev;
Rhamnus jujuba L., *R. soporifera* Lour., *R. zizyphus* L.
Ziziphus jujuba (L.) Lam., *Z. jujube* (L.) Gaertn, *Z. mairei* (H. Lev.) Browicz & Lauener, *Z. nitida* Roxb., *Z. orthacantha* DC., *Z. poiretii* G.Don nom. illeg., *Z. rotundata* DC., *Z. sativa* Gaertn., *Z. soporifera* (Lour.) Stokes, *Z. spinosa* (Bunge) Hu ex F.H. Chen, *Z. tomentosa* Poir., *Z. trinervia* Roth nom illeg., *Z. vulgaris* var. *inermis* Bunge, *Z. vulgaris var. spinosa* Bunge, *Z. zizyphus* (L.) H. Karst., *Z. zizyphus* (L.) Meikle., *Z. jujubum* St.-Lag.

2) Description of all plant: flower, fruit and trunk branches, culture and other characteristics (Liu, 2010; Markovski, Velkoska-Markovska, 2015; Ivanišová et al., 2017)

Height: 457 to 1070 cm; Spread: 305 to 915 cm; Crown uniformity: irregular outline or silhouette; Crown shape: oval, round; Crown density: open; Growth rate: medium; Texture: fine.
Foliage – Leaf arrangement: alternate; Leaf type: simple; Leaf margin: crenate, serrulate; Leaf shape: lanceolate, ovate; Leaf venation: bowed; Leaf type and persistence: deciduous; Leaf blade length: 5 to 10.5 cm, less than 5.5 cm; Leaf colour: green; Fall colour: yellow; Fall characteristic: showy.
Flower – Colour: yellow; Flower characteristics: inconspicuous and not showy; spring flower.
Fruit – Shape: oval, round; Length: 2.5 to 12.5 cm; Fruit covering: fleshy; Colour: black, red; Fruit characteristics: it attracts squirrels and other mammals; fruit, twigs, or foliar cause significant litter, showy.
Trunk and branches – Grow mostly upright and will not droop, not particularly showy, should be grown with a single leader, thorns are present on the trunk or branches.
Breakage: resistant; Current year twig colour: brown; Current year twig thickness: medium.
Other characteristics – Roots: Surface roots are usually not a problem.
Culture – Light requirement: tree grows in part shade/part sun; and also grows in full sun; Soil tolerances: clay, loam, sand, slightly alkaline, acidic, well-drained; Drought tolerance: high.

3) The 10 leading cultivars in China (Liu, 2010)

Cultivar name	Use	Main producing area
'Dongzao'	fresh	Hebei, Shandong
'Linyilizao'	fresh	Shanxi
'Pozao'	dry	Hebei
'Changhongzao'	dry	Shandong
'Yuanlingzao'	dry	Shandong, Hebei
'Muzao'	dry	Shanxi, Shannxi
'Bianhesuan'	dry	Henan
'Jinsxiaozao'	dry, fresh	Hebei, Shandong
'Huizao'	multipurpose	Henan, Xinjiang
'Zanhuangdazao'	multipurpose	Hebei, Northwest

4) Potential jujube cultivars for importation from China (Liu, 2010)

Cultivar name	Province	Overview
'Baodeyouzao' (Oil jujube)	Shanxi, Shaanxi, Yellow River	• High yielding, Early maturing, • Average fruit weight 11.6g, 3.5 × 2.1cm, • Deep red skin, dense, juicy flesh with sweet and sour flavour, • Low fruit cracking, low fruit drop;

'Dongzao' (Winter jujube, winter date, lubei)	Shandon, Hebei	• Large tree, high yield, late fruiting, • Large fruit (11.5g ave, max 35g, 2.7-3.4cm × 2.6 × 3.4cm), • Thin peel, flesh crisp, white, juicy, sweet and rich, • High yield and large, late fruit;
'Guantanzao'	Shanxi	• Medium sized tree, weak vigour, productive and stable yield, mid-late maturity, • Med-large fruit, oblong shaped, (3.5 × 2.5cm), ave fruit weight 10g (max 12g), • Thick peel, sweet flesh, less juice, • Low fruit cracking, high edible rate and dry quality, adaptability to drought and disease;
'Huizao' (Ash date, Zinzhuang)	Xinzheng City, Henan province	• Medium sized tree, oval shaped fruit (3.2 × 2.3cm), average fruit weight 12.3g, max 13.3g, • Crisp, sweet and juicy fruit, • Fruit is susceptible to cracking/splitting. Suitable for dried fresh and processed or candied dates;
'Jinsixiaozao'	Hebei	• Small fruit, average weight of 5g, skin is bright red, flesh is white, dense and crisp texture, medium juiciness, sweet and slightly sour, • Mid-late maturing fruit, • Good for storage and transportation, good quality for fresh or dried;
'Kongfusucuizao'	Qufu, Shandong	• Tree is talk and strong, • Fruit is long oval shaped, average fruit weight 12g, max 20 g, • Crisp, juicy, sweet fruit, slightly sour, • Early maturing variety, drought tolerant and resistant to rust and anthracnose, fruit shrink disease;
'Linyilizao' (Li)	Shanxi, Yuncheng, Linyi	• Small tree, dense foliage, large fruit, diameter 4.2 × 4.0cm, average fruit weight 30g, max 40g, • The fruit is thin and ochre-red with white flesh that is crisp, juicy and sweet, • Late maturing fruit, • The fruit is big and beautiful with a high edible rate, adaptable tree;
'Ningyangliuyuexian' (June Fresh)		• Smaller tree, dense branches, no thorns, • Fruit long tube shape, average fruit weight 13.6g, • Peel medium-thick, light purple, flesh green and white. Fine quality fruit that is crisp, sweet and slightly acidic, • Resistant to cracking, good quality fresh jujube however adaptability is poor and the tree requires deep and fertile soil conditions. Early maturing;
'Zanhuangdazao' (Gold silk jujube)	Hebei, Zanhuang	• Tree is tall and upright, Fruit oblong or obovate, diameter 4.1 × 3.1cm, average fruit weight 17.3g, max 29g. Peel is thick and dark reddish brown. Flesh nearly white, dense, medium juice, sweet and sour, • Only natural triploid, fruit suitable for dry, candied and fresh. Versatile, adaptable, resistant to drought, suitable for warm climate;
'Zaocuiwang'	Hebei	• Strong tree vigour and easy to manage, early maturing, • High yield, 2-year-old grafted plants produce about 5kg, • Strong resistance to drought, waterlogging and salinity. Very lows cracking and rust;

'Zaofengzui'	Shandong	• Shorter growth period of 85d. Fruit nearly round, diameter 3.0 × 2.9 cm, average fruit weight 12.1 g, max 16.3 g, fruit size uniform, • Peel think and crisp, fleshy texture and delicate, juicy, • Wide adaptability and strong resistance to anthracnose, ulcer disease, black spot disease rate of less than 3%, rot disease rate of 6%;
'Zaoshulizao'	Hebei	• Larger oval or pear-shaped fruit, diameter 3.5 × 3.2 cm, Average fruit weight 17.8 g, max 27 g, • Peel is thin, reddish brown, flesh thick, green white or milky white, crisp, juicy, sweet, slightly sour, • High and stable yield, no cracking and good quality fruit, • Early results of plastic greenhouse cultivation show average yields of 1.7 kg in the second year, 3.9 kg in the third year and 5.0 kg in the fourth year.

5) World distribution (Liu, 2010; Johnstone, 2017)

Region	Country
Asia	Afghanistan, Armenia, Azerbaijan, Bengla, Burma, China, Cyprus, India, Iraq, Iran, Israel, Japan, Kyrgyzstan, Lebanon, Malaysia, Mongolia, Pakistan, Palestine, South Korea, Syria, Thailand, Turkey, Turkmenistan, Uzbekistan
Europe	Bulgaria, England, France, Germany, Greece, Italy, Czech, Macedonia, Portugal, Romania, Russia, Slovenia, Spain, Ukraine, Yugoslavia
Africa	Egypt, Tanzania, Tunisia
North America	Canada, USA
Oceania	Australia, New Zealand

6) Cultivars in Australia (Johnstone, 2014)

Cultivar name	Use	Characteristics
'Li'	fresh	Large, mid-season ripening
'Chico'	fresh	Fruit is round but flattened, excellent fresh fruit with a apple-like sweet-acid taste, good either fresh or dried, mid-late season ripening
'Shanxi-Li'	fresh	Very large fruit
'GA866'	fresh	Sweet fruit with a higher sugar level, large and elongated fruit
'Redlands'	fresh	Very large, sweet, round fruit and mid-season ripening
'Silverhill'	fresh	Med-large, elongated fruit, very sweet, very late season ripening, good for humid areas
'Sherwood'	fresh, dried	Fruit is very dense and excellent quality, late season
'Honeyjar'	fresh, dried	Small but very unique, sweet tasting, crunchy, juicy fruit, very thin-skinned, early ripening, considered a fresh eating jujube but also good dried
'Sihong'	fresh, dried, processed	Excellent, large, round fruit, mid-season ripening, one of the best fresh varieties, also good processed or dried
'Suimen'/'Shuimen'	fresh, dried, processed	Fruit is elongated, Fairly good fresh but better dried or processed, Mid-season ripening
'Lang'	dried, processed	pro-Large, pear-shaped fruit, Mid-late ripening, Good variety for dried fruit, very good for processing, Not suited for humid areas, The tree is very upright and virtually thorn-less
'Don-polenski'	dried	Similar to Lang with a better, crisper flavour
'Thornless'	dried	Fruit similar to Lang
'Admiral Wilkes'	dried, processed	pro-Elongated and very late ripening, Best processed or dried

7) Current cultivars in the USA (Yao, 2013)

Sources	Cultivar names
F.N. Meyer's collection	'Li', 'Lanf', 'Shui men' (Shuimen, Sui men or Sui), 'Mu/Mu shing hong', 'So', 'Yu'
Chico breeding program	'GA866', 'GI-7-62/Chico', 'GI-1183', 'Thornless'
Cultivars from across the United States	
Alabama	'Silverhil'l, 'Ed Hegard', 'Swobada'
California	'Don Polenski', 'Jin', 'Porterville', 'Redland #4', 'Sugarcane'
Georgia	'Fitzgerald', 'Leon Burk', 'Prine'
Florida	'Geant'
Kansas	'Topeka'
Kentucky	'Priest'
Louisiana	'Abbeville', 'Sherwood'
Pennsylvania	'Tsao'
Tennessee	'R3T1'
Texas	'Texas Tart'
Washington, DC	'Admiral Wilkes'
Imports after the 1990s	
R. Meyer's import	'Shanxi Li', 'Honeyjar', 'Globe', 'September Late', 'Ant Admire', 'Sihong'
J. Gilbert's import	'Qiyuexian'/'Autumn Beauty', 'Mango Dong Zho'/'Winter Delight™', 'Black Sea™', 'Coco™', etc.
NMSU Alcalde's import	'Jinsi #2', 'Jinsi #3', 'Pitless', 'Junzao', 'Teapot', etc., with total of 30 cultivars.

8) Disease resistant cultivars (Liu et al., 2013)

Fruit cracking resistant: 'Chuanlingzao', 'Chenwudongzao', 'Chahuzao', 'Mopanzao', 'Jianzao', 'Guantanzao', 'Xuezao', 'Huluchanghong', 'Hebeilongxuzao', 'Baodeyouzao';

Fruit shrink resistant: 'Chuanlingzao', 'Chengwudongzao', 'Changjixinzao', 'Suyuanling', 'Ningyangliuyuexian', 'Kongfusucuizao', 'Pingguozao'.

9) The major chemical components of jujube (Liu, 2010; Gao, et al., 2013; Chen et al., 2017; Cosmulescu et al., 2017; Shahrajabian et al., 2019c)

a) carbohydrate such as: glucose, fructose, sucrose, rhamnose, and sorbitol; b) vitamin, especially vitamin C and vitamin B complex; c) fatty acids such as: oleic, linoleic (omega-6), palmitic and palmitoleic acids; d) alkaloids, the cyclic peptide alkaloids, mauritine A, mucronine D, amphibine H, nummularine A-B, sativanine A-H, and –K, frangulanine, jubanine A-C, scutianine C-D and ziziphine A (were isolated from stem bark of jujube), the alkaloids coclaurine, isoboldine, norisoboldine, asimilobine, iusiphine and iusirine (were isolated from leaves), e) glycosides: flavonoid glycosides/spinosins, glycosides/saponins; f) terpenoids, such as colubrinic acid, alphitolic acid, *3-Ocis*-p-coumaroylalphitolic acid, *3-O*-transpcoumaroylalphitolic acid, *3-O-cis*-p-coumaroylmaslinic acid, *3-O-trans*-pcoumaroylmaslinic acid, oleanolic acid, betulonic acid, oleanonic acid, zizyberenalic acid, betulinic acid, zizyberanal acid, zizyberanone, zizyberanalic acid and ursolic acid.

Tab. 2. Selected characteristics of Indian jujube (*Ziziphus mauritiana* Lamk.) (Shahrajabian et al., 2019c)

1) Local names of Indian jujube (Morton, 1987; Ved et al., 2016)
Amharid: Kurkura; Arabic: Nabak (fruit), sidr; Bengali: Ber, boroi, kool, ber, boroi; Burmese: Zee-pen, zizidaw, eng-si; English: Dunks, jujube, Indian cherry, Indian jujube, Indian plum, geb, ber, common jujube, Chinese date, Chinese apple, bear tree, desert apple; Filipino: Manzanita; French: Jujube, jujubier, jujubier commun, le jujubier, le jujubier sauvage, liane croc-chien; German: Indischer Jujubenstrauch; Gujarati: Bordi; Hindi: Baer, badari, elladu, ber, khati, jelachi; Indonesian: Widara, dara, bidara; Khmer: Putrea; Lao: Sino-Tibetan; Malay: Bidara, jujub, epal siam; Mandinka: Tomborongo, tomboron moussana, toboro; Nepali: Bayer; Sanskrit: Kuvala, karkandhu, badara, ajapriya, madhuraphala; Somali: Geb, gub; Spanish: Yuuba, Ponsere, perita haitiana; Swahili: Mkunazi; Tamil: Elandai, yellande; Thai: Ma thong, ma tan, phutsan; Tigrigna: Geva; Trade name: Jujube; Urdu: Ber; Vietnamese: Tao nhuc, tao.
2) List and origin of 37 cultivars in India – cultivar name and state (Singh et al., 2017)
1.'BC-1' – Rajasthan, 2.'Umran' – Maharashtra, 3. 'Seb' – Rajasthan, 4. 'Illaichi' – Punjab, 5. 'Tikadi' – Rajasthan, 6. 'Gola' – Haryana, 7.'Reshmi' – Haryana, 8.'CAZRI-Gola' – Rajasthan, 9.'Banarasi Karaka' – Uttar Pradesh, 10.'Aliganj' – Uttar Pradesh, 11.'Katha' – Rajasthan, 12.'Z-G-3' – Punjab, 13.'Mundia' – Haryana, 14.'Bagwadi' – Punjab, 15.'Maharwali' – Rajasthan, 16.'Banarasi Pebandi' – Uttar Pradesh, 17.'S x K hybrid' – Rajasthan, 18.'Sanaur-5' – Haryana, 19.'Thoronless' – Punjab, 20.'Kali' – Rajasthan, 21.'Jogia' – Rajasthan, 22.'Kaithli' – Haryana, 23.'Chhuhara' – Maharashtra, 24.'Dandan' – Punjab, 25.'Gola Gurgaon' – Haryana, 26.'Chonchal' – Haryana, 27.'Popular Gols' – Haryana, 28.'Akrota' – Haryana, 29.'Laddu' – Uttar Pradesh, 30.'Thar Bhubraj' – Rajasthan, 31.'Ponda' – Haryana, 32.'Wilayati' – Punjab, 33.'Thar Sevika' – Rajasthan, 34.'Narikeli' – West Bengal, 35.'Sua' – Haryana, 36.'Vikas' – Gujarat, 37.'Babu' – Gujarat.

Appendix 2

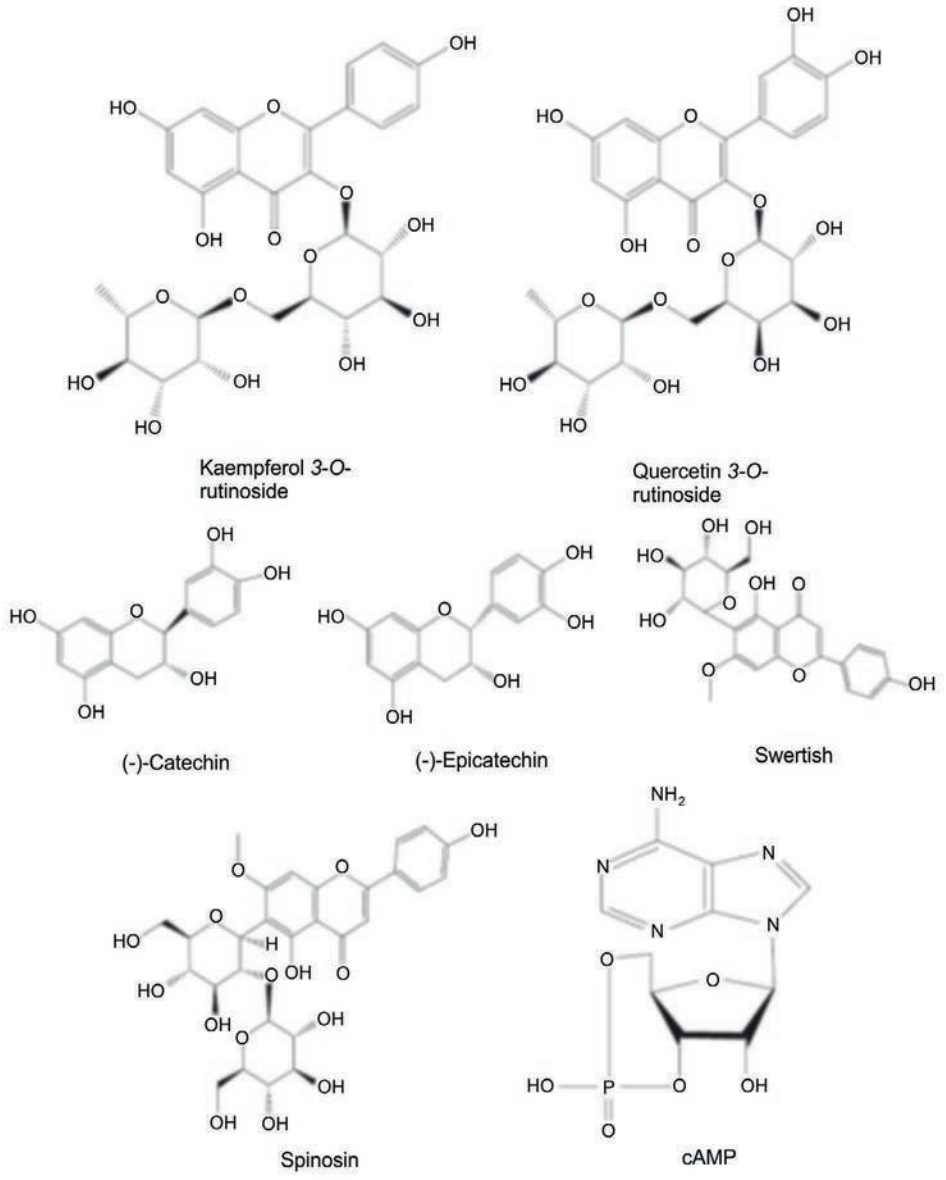

Fig. 4. Structures for chemical compounds in jujube having potential neuroprotection effect. Seven chemical markers found in jujube including kaempferol *3-O*-rutinoside, quercetin *3-O*-rutinoside, (-)-catechin, (-)-epicatechin, swertish, spinosin, and cAMP were reported to possess effect on neuroprotection (Chen et al., 2017)

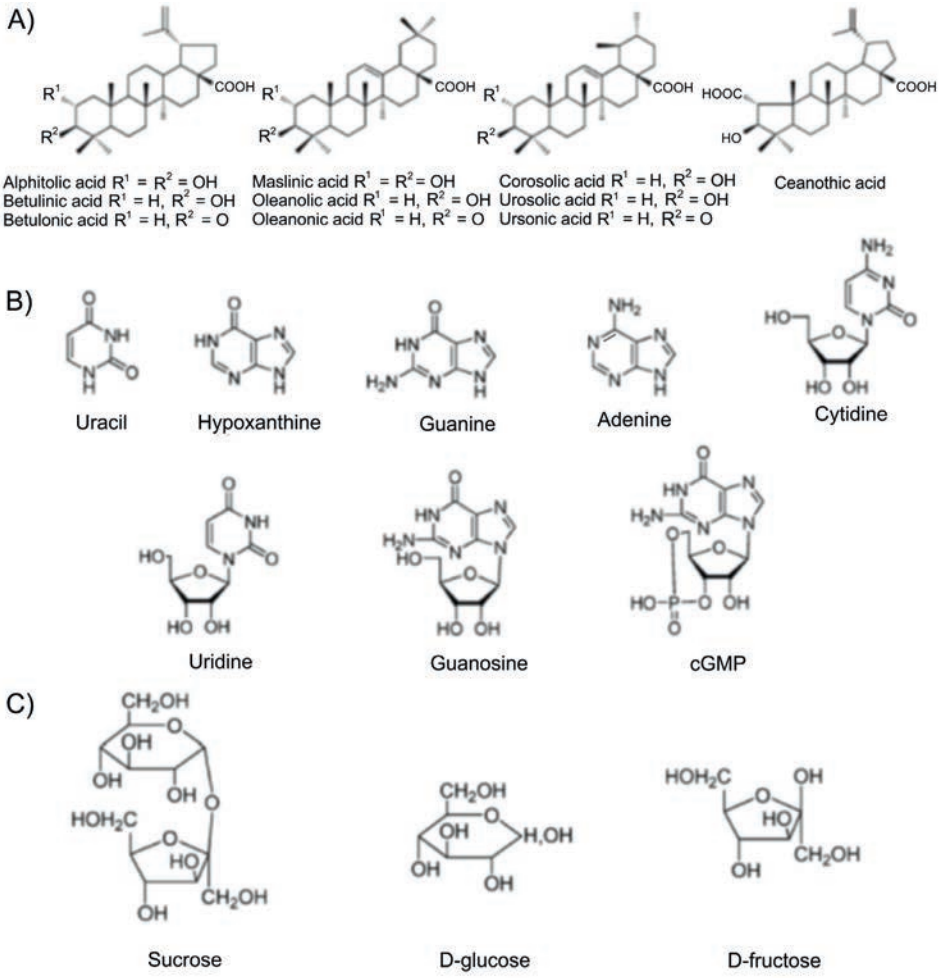

Fig. 5. Structures of triterpenic acids, nucleosides and nucleobases as well as saccharides in jujube fruits. (A) – triterpenic acids; (B) – nucleosides and nucleobases; (C) – saccharides (Guo et al., 2015)

Jujuba pospolita (*Ziziphus jujuba* Mill.) – obiecujący owoc z tradycyjnej medycyny chińskiej

Streszczenie

Głożyna pospolita, jujuba pospolita lub chiński daktyl (*Zizyphus jujuba* Mill.; Rhamnaceae L.), to popularna w wielu częściach świata roślina uprawna. Jej owocem jest jadalny, owalny pestkowiec, który ma szerokie zastosowanie w kuchni i tradycyjnej medycynie. Jujuba jest uprawiana w regionach o klimacie umiarkowanym, podczas gdy podobna do niej głożyna omszona (*Z. mauritiana* Lam.) jest uprawiana w gorących i suchych regionach Indii. Największym producentem owoców jujuby na świecie są Chiny, choć w ostatnim czasie zauważalny jest wzrost zainteresowania produkcją tego owocu w innych częściach świata. Owoc jujuby zawiera 23 rodzaje aminokwasów, których nie ma w większości innych owoców. Zawiera również witaminę C, ryboflawinę i tiaminę. Główne składniki owoców jujuby są używane w połączeniu z innymi roślinami i owocami leczniczymi w tradycyjnej medycynie chińskiej. Liść jujuby, który jest głównym produktem ubocznym, był również używany w celach leczniczych od tysięcy lat. Jujuba ma wiele ważnych właściwości farmakologicznych i można ją uznać za cenne źródło nutraceutyków. Jest rośliną o dużym potencjale leczniczym w leczeniu chorób cywilizacyjnych, takich jak nowotwory, a także ważnym źródłem składników odżywczych, łatwo dostępnych w biednych regionach świata.

Keywords: Chinese dactyl, fruit, jujube, pharmacological science, Traditional Asian Medicine

Received: [2020.07.23]

Accepted: [2020.09.14]