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EVALUATION OF SOME NUTRITIONAL PROPERTIES OF CHINESE JUJUBE (*ZIZIPHUS JUJUBA* MILL.) FRUITS ORGANICALY PRODUCED IN BUCHAREST AREA

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Abstract

Chinese jujube is one of the most commonly used fruit in Chinese herbal medicine, being considered by the researchers and nutritionists a super fruit in terms of nutrition. In Romania, more than 20 genotypes were introduced from China, in the Experimental Field of the Faculty of Horticulture within the UASVM Bucharest. This study aims to present several biochemical characteristics of ten Chinese jujube genotypes. Fresh fruits were harvested at the beginning of September until October. After morphological measurements, fruits were stored at 2-3˚C and 90-95% relative humidity. For analysis hydro alcoholic extracts using 1:10 ratio was used. The extracts were subjected to spectrophotometric analysis. Using Folin - Ciocâlteu method, the total phenolic content of the extracts was determined. The flavonoid content was identified using an adapted method based on rutin equivalent. The free radical scavenging activity of the extracts was determined using 2,2 diphenyl-1-picrylhydrazyl radical. The obtained results confirm the data presented by the researches on the similar genotypes and can be an important aspect in promoting the cultivation and consumption of these fruits in more regions of our country.

Key words: *Chinese jujube, flavonoid content, free radical scavenging activity, phenolic content, spectrophotometry.*

INTRODUCTION

Chinese jujube (*Ziziphus jujube* Mill.) is one of the most commonly used fruit in Chinese herbal medicine, being considered by the researchers and nutritionists a super fruit in terms of nutrition. The fruits represent a good source of minerals (phosphorus, potassium, calcium and manganese) and antioxidant compounds, having antiproliferative, antitumoral, anti-inflammatory properties and protective effect against myocardial injury. Jujube, with numerous pharmacological properties, can be consider a very important source of nutraceuticals (Cheng et al., 2012; Wang et al., 2016; Wojdylo et al., 2019; Song et al., 2019; Chen et al., 2019; Shahrajabian et al., 2019). Chinese jujube's fruits are used from fresh or dehydrated until processed in the form of syrups, marmalades, sweets, flour, cider, etc. The food value of Chinese jujube is high especially due to the high content of soluble dry matter exceeding the value of 30%, as the total carbohydrate content is 27%. The fruit's acidity varies between 0.3 and 1.0%. It has a very high content of ascorbic acid (vitamin C) depending on the variety, with values of 330-880 mg/100 g fresh weight. The content of vitamin P exceeds 1000 mg/100 g fresh weight. Chinese jujube (*Ziziphus jujuba* Mill., sin. *Ziziphus sativa* Gaertn.) is part of the *Rhamnaceae* family (Ciocârlan, 2000). Originally from China, it has been cultivated since the earliest times and expanded to Asia Minor, Europe and America. As the name mentions, Chinese jujube is the national fruit in China (Liu et al., 2014), the high valuable production being obtained in Gobi Desert. Knowing their value, China cultivated these fruit plants since more than 4300 years. Today, there are more than 20 million farmers producing jujube, 2 million ha cultivated, 6.24 mil. tons produced/year, income 100 billion RMB (about 12.85 billion euro). This crop had an essential role in the program to eradicate poverty in northern China's mountain areas. There is a particular interest in Europe towards diversifying fresh and processed fruits offer, including the introduction of new species with high nutraceutical value. In the same time, many agricultural areas in Europe are faced with very serious problems of desertification, water shortages and saltiness, pressure of diseases or pests to traditional fruit species. In this context, the introduction of Chinese jujube crop, characterized by a very high resistance to drought and high to salty soils, as well as a high capacity to capitalize on poor soils and a high tolerance to diseases and pests (Chireceanu et al., 2013; Mardare et al., 2016; Ciceoi et al., 2017), can be a life-saving solution.

In our country, jujube trees can be found on the right bank of Danube in Ostrov area, Constanța County, without knowing their origin. The locals call the "olive tree of Dobrogea" and the existence of abundantly producing fruit trees, perfectly adapted to the local conditions, is known (Stănică, 2009; 2016). In Jurilovca, Doloşman Cape, near the ruins of the Argamum Greek colony, another population of wild Chinese jujube (*Ziziphus acido-jujuba*) (Wang et al., 2019), which grows as bush tree, was identified (Stănică and Vasile, 2008).

In Romania, more than 20 genotypes were introduced from China, in the Experimental Field of the Faculty of Horticulture from UASVM Bucharest. Researches started in 1996, following a cooperation project between the USAMV of Bucharest and Shanxi Academy of Agricultural and Forestry Sciences and Taigu Fruit Research Institute, when few genotypes of jujube have been introduced in Romania, at the Faculty of Horticulture. The collection was completed in May-June 1998, when few other varieties were grafted on a Romanian rootstock. Other new varieties were introduced after 2016, within the scientific cooperation between Hebei Agricultural University from Baoding and USAMV of Bucharest. In January 2018, was inaugurated the China-Romania Joint Jujube Key Research Laboratory with the same partner (Stănică, 2019).

In the Faculty of Horticulture collection, the genotypes recorded a fruit weight between 5.89 g (R3P10 selection) to 28.57 g (Cheng Tuo Zao). Most of the analyzed genotypes had the soluble solid content higher than 30% Brix. Fruit content in minerals varied between 0.16% and 3.38% with an average of 1.78%. The ascorbic acid content varied between 110.0 mg/100 g fw and 1020.0 mg/100 g fw (R1P11 selection) with an average of 306.1 mg/100 g fw. Fruit acidity, expressed as malic acid, varied from 0.16% to 0.82% with an average of 0.36% (Stănică, 2000; Stănică and Vasile, 2008; Dicianu et al., 2017).

The polyphenol content changes during fruit ripening. Thus, the highest content of polyphenols is found in the fruit at the beginning of its formation and decreases with its maturation, all this time playing the role of protection against pathogens and pests (Shi et al., 2018; Wang et al., 2016).

This study aims to present several biochemical characteristics of the fruits of Chinese jujube from Faculty of Horticulture collection, like total polyphenol, respectively flavonoid content and antioxidant capacity, in order to complete the fruit germplasm biochemical description.

MATERIALS AND METHODS

Ten genotypes from Experimental Field of the Faculty of Horticulture of USAMV of Bucharest were studied: R1P2, R1P7, R1P10 (Hu Ping Zao*), R2P7, R3P2, R3P3 (crack resistant), R3P4 (Hu Ping Zao*), R3P6, R3P10 (Taigu) and Dong Zao (Figure 1). Two clones of Hu Ping Zao (R2P8 and R3P4) and one genotype R3P8 were analyzed in dehydrated form (*clones of different origins) verifying whether or not this method of preservation influences the quality parameters of the fruit.

Fresh fruits were harvested at the beginning of September until October, 2017. After morphological measurements, fruits were stored at 2-3°C and 90-95% relative humidity. Part of them were dehydrated using an Excalibur dehydrator for 20 hours at 45°C.

The physio-chemical analyses were performed in the Researcher Centre for Study of Food Quality and Agricultural Products, USAMV of Bucharest.

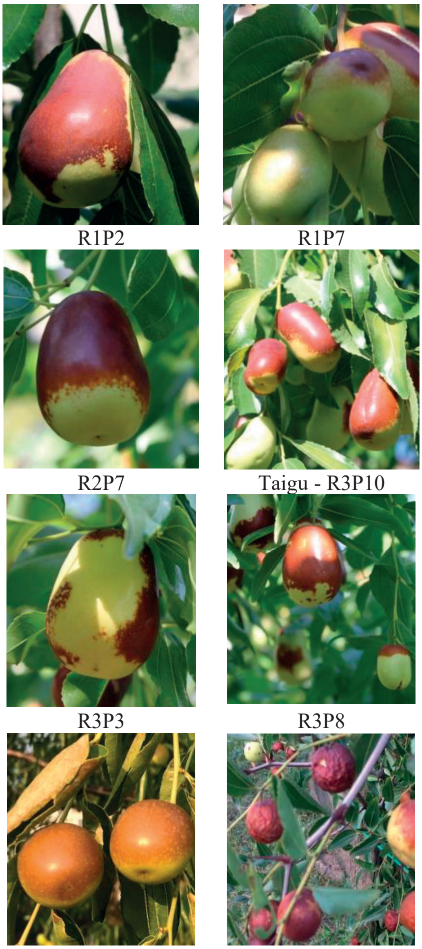
Sample Extraction

The jujube fruits (1g) were extracted with 10 mL of ethanolic solution 50%, 30 minutes in ultrasound water bath. The samples were filtrate and after that analyzed.

Determination of polyphenols, flavonoids and antioxidant activity

Total polyphenol content (TPC) was determined spectrophotometrically with the Folin - Ciocalteu method after Skupień (2006), Khanizadeh et al. (2008), Delian et al. (2011), Mureşan et al. (2014) and Bezdadea Cătuneanu et al. (2017), with some modifications. The results expressed as mg gallic acid equivalent (GAE)/g of fresh weight (mg GAE/g FW).

Total flavonoids content (TFC) was determined spectrophotometrically using a method adapted after Zilić et al. (2011) and Shen et al. (2016). The results were expressed as mg rutin equivalent/g of fresh weight.



Dong Zao

Figure 1. Chinese jujube genotypes

Free radical was determined using DPPH scavenging activity method, after Khanizadeh et al. (2008), Mureşan et al. (2014), Tudor et al. (2015) and Drogoudi et al. (2016). The absorbance of the samples was measured at 515 nm using ethanol as blank. The results were expressed as rate of inhibition and calculated using the formula: $I\% = [(A_0 - A_s)/A_0)] \times 100$, where A_0 was the absorbance of control (DPPH solution), and A_s was the absorbance of the test sample at 30 min.

RESULTS AND DISCUSSIONS

The obtained results showed that genotype influenced the composition of bioactive compounds, similar with Cosmulescu et al. (2018). Of the 10 fresh fruit samples selected, the highest total flavonoid content had the genotype R3P2 (2.03 mg RE/g FW), and the lowest flavonoid content has the R1P2 genotype (0.68 mg RE/g FW).

Flavonoid content of jujube fruits compared with other fruits is equal and higher that jackfruit pulp extracts with 1.20 mg of RE/g FW, found by Basu et al. (2016).

These results are lower than those obtained by Chen et al. (2018) studying *Ziziphus jujuba* cv. Dazao, *Ziziphus jujuba* cv. Junzao, and *Ziziphus jujuba* cv. Huizao cultivars.

On the other hand, the content in biologically active compounds such as polyphenols, flavonoids and antiradical activity, even antioxidant, are strongly influenced by the nature of the extraction solvent. In this regard, it has been shown that ethyl acetate and chloroform are extraction solvents of these compounds from jujube, but it seems strongly influence antioxidant activity (Al-Saeedi et al., 2016). Also, in this sense, the extraction method and ratio are extremely important. Thus, extraction methods as ultra-high-pressure extraction (UHPE) can obtain higher concentrations of total flavonoids and stronger DPPH radical-scavenging activity (Zhang et al., 2019).

In dehydrated fruits the highest total flavonoid content had the genotype R2P8 (1.77 mg RE/g FW) and the lowest genotype of Hu Ping Zao* - R3P4 (1.71 mg RE/g FW) (Figure 2).

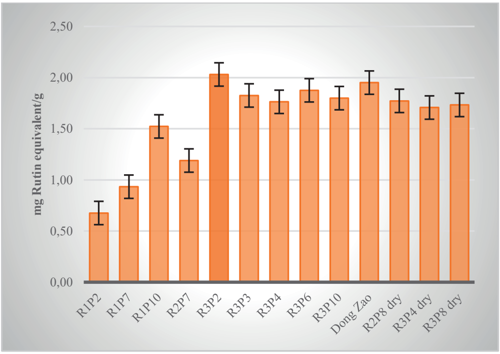


Figure 2. Total flavonoid content in Chinese jujube genotypes

Total flavonoid content in Hu Ping Zao* - R3P4 genotype was higher in the dehydrated samples compared with the fresh ones. The results are similar to those found by Najjaa et al. (2020) (172.07 ± 24.84 mg catechin equivalents (CE)/100 g powder).
Non-significant differences were between fresh samples of Hu Ping Zao clones.
The highest amount of total polyphenols content was found in the R1P2 genotype (1.13 mg GAE/g FW) and the smallest quantity in the Hu Ping Zao* - R1P10 genotype (0.82 mg GAE/g FW). The total content of polyphenol in the dehydrated fruits in the largest quantity was found in the Hu Ping Zao* - R3P4 genotype (1.00 mg GAE/g FW) and the lowest amount in the R3P8 genotype (0.78 mg GAE/g FW) (Figure 3).
These results are lower than those obtained by Koley et al. (2016) studying *Ziziphus jujuba* cultivars: Chuhara, Mundia, Thornless, Jogia, Gola, Kaithali, Umran, Seb, ZG-3, Sonaur-5, Rashmi and Elaichi.
Chinese jujube fruits TPC content it is comparable to those reported for highbush blueberry pulp cultivars that varied between 0.476-2.770 mg/g results obtained by Ribera et al. (2010) and to Perez-Jimenez et al. (2010) for apple 1.35 mg/g, peach 0.59 mg/g, redcurrant 0.43 mg/g.
Similar with flavonoid content, in the dehydrated fruits total polyphenolic content was higher than in fresh ones. Significant differences were between TPC in fresh samples of Hu Ping Zao clones and in dry ones also.

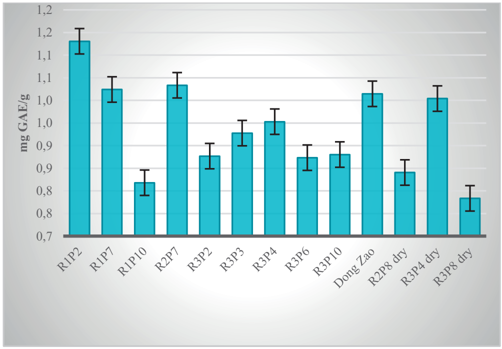


Figure 3. Total polyphenol content in Chinese jujube genotypes

The highest inhibition capacity (I% inhibition) had the Dong Zao genotype and the lowest inhibition capacity had the Taigu - R3P10 genotype (Figure 4). The results from this study were similar with Azizi et al. (2016) who found inhibition capacities between 70.69% and 93.93% inhibition in jujube accessions. Kamiloglu et al. (2009) presented a series of Turkish jujube genotypes with inhibition capacities for dried fruits between 82% and 99%. Dong Zao extract showed the highest inhibition activity among all the cultivars, similar with Xue et al. (2009), justified by the its highest TPC.
No significant differences were noticed between antioxidant capacity values Hu Ping Zao clones.

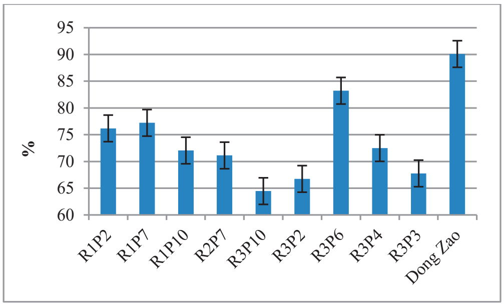


Figure 4. Antioxidant capacity of Chinese jujube genotypes

CONCLUSIONS

Analysis of the biochemical composition of Chinese jujube fruits highlighted the richness of flavonoids, polyphenols and antioxidant capacity.

Among the genotypes studied, Dong Zao cultivated in Bucharest area, known as the best quality fruit for fresh consumption, recorded significant higher values for biochemical parameters than most of the analyzed genotypes.

Regarding the storage of biologically active compounds, this study has shown that the method of preservation by drying can be an effective method of maintaining the nutritional properties of these fruits by giving the consumer the opportunity to consume them in the off-season.

REFERENCES

Al-Saeedi, A., H., Al- Ghafri, M. T. H., Hossain, M. A. (2016) Comparative evaluation of total phenols, flavonoids content and antioxidant potential of leaf and fruit extracts of Omani *Ziziphus jujube*. *Pacific Science Review A: Natural Science and Engineering*, 18, 78-83.

Azizi, A., Pirbodaghi, M. (2016). Regional variations of antioxidant capacity and phenolic properties in the Iranian jujube collection *Journal of Herbal Drugs*, 6 (4), 199-209.

Basu, P., Maier, C. (2016). In vitro antioxidant activities and polyphenol contents of seven commercially available fruits. *Pharmacogn Res*, 8, 258-264.

Bezdadea Cătuneanu, I., Bădulescu, L., Dobrin, A., Stan, A., Hoza, D. (2017). The influence of storage in controlled atmosphere on quality indicators of three blueberries varieties. *Scientific Papers. Series B, Horticulture,* LXI, 91-100.

Chen, K., Fan, D., Fu, B., Zhou, J., Li, H. (2019). Comparison of physical and chemical composition of three Chinese jujube (*Ziziphus jujuba* Mill.) cultivars cultivated in four districts of Xinjiang region in China. *Food Science and Technology*, 39(4), 912-921.

Cheng, D., Zhu, C., Cao, J., Jiang, W. (2012). The protective effects of polyphenols from jujube peel (*Ziziphus jujube* Mill.) on isoproterenol-induced myocardial ischemia and aluminum-induced oxidative damage in rats. *Food Chem Toxicol*, 50(5), 1302-1308.

Chen, K., Fan, D., Fu, B., Zhou, J., Li, H. (2018). Comparison of physical and chemical composition of three Chinese jujube (*Ziziphus jujuba* Mill.) cultivars cultivated in four districts of Xinjiang region in China. *Food Science and Technology*, 39(4), 912-921.

Chireceanu, C., Stănică, F., Chiriloaie, A. (2013). The Presence of the Mediterranean fruit fly *Ceratitis capitata* Wied., (*Diptera: Tephritidae*) in Romania. *Romanian Journal of Plant Protection*, VI, 92-97.

Ciceoi, R., Dobrin, I., Mardare, E. Ș., Dicianu, E. D., Stănică, F. (2017). Emerging pests of *Ziziphus jujuba* crop in Romania. *USAMV Bucharest Scientific Papers, Series Horticulture*, LXI, 143-154.

Ciocârlan, V. (2000). *Flora ilustrată a României (Illustrated Flora of Romania)*. *Pterydophyta et Spermatophyta*. Bucharest, RO: Ceres Publishing House.

Cosmulescu, S., Trandafir, I., Nour, V., Achim, G., Botu, M., Iordănescu, O. (2018). Variation of bioactive compounds and antioxidant activity of jujube (*Ziziphus jujuba*) fruits at different stages of ripening. *Notulae Botanicae Horticulturae Agrobotanicae*, 46(1), 134-137.

Delian, E., Petre, V., Burzo, I., Bădulescu, L., Hoza, D. (2011). Total phenols and nutrients composition aspects of some apple cultivars and new studied breeding creations lines grown in Voineşti area – Romania. *Romanian Biotechnological Letters*, 16, 6722-6729.

Dicianu, E. D., Ivan, E. Ș., Jerca, I. O., Ciceoi, R., Stănică, F. (2017). Morphometric and phytopathological analysis of Romanian jujube fruits during the storage period. *Scientific Papers Iași, Horticulture Series*, 60(1/2), 1-6.

Drogoudi, P., Pantelidis, G., Goulas, V., Manganaris, G., Ziogas, V., Manganaris, A. (2016). The appraisal of qualitative parameters and antioxidant contents during postharvest peach fruit ripening underlines the genotype significance. *Postharvest Biology and Technology*, 115, 142-150.

Kamiloglu, O., Ercisli, S., Engül, M., Toplu, C., Serce, S. (2009). Total phenolics and antioxidant activity of jujube (*Zizyphus jujube* Mill.) genotypes selected from Turkey. *African Journal of Biotechnology*, 8, 303-307.

Khanizadeh, S., Tsao, R., Rekika, D., Yang, R., Charles, M., Rupasinghe, V. (2008). Polyphenol composition and total antioxidant capacity of selected apple genotypes for processing. *Journal of Food Composition and Analysis*, 21, 396-401.

Koley, T. K., Charanjit, K., Shweta, N., Shweta, W., Seema, J. S. (2016). Antioxidant activity and phenolic content in genotypes of Indian jujube (*Zizyphus mauritiana* Lamk.). *Arabian Journal of Chemistry*, 9: S1044-S1052.

Liu, M., Zhao, J., Cai, Q., Liu, G., Wang, J., Zhao, Z., et al. (2014). The complex jujube genome provide insights into fruit tree biology. *Nature Communications,* 5:5315.

Mardare, E. Ș., Ciceoi, R., Jerca, I. O., Stănică, F. (2016). First results on phytosanitary status of Chinese jujube in Romania. *Journal of Horticulture, Forestry and Biotechnology*, 20(4), 1-4.

Mureşan, E., Muste, S., Borşa, A., Vlaic, R., Mureşan, V. (2014). Evalution of physical-chemical indexes, sugars, pigments and phenolic compounds of fruits from three apple varieties at the end of storage period. *Bulletin UASVM Food Science and Technology,* 71(1), 45-50.

Najjaa, H., Ben Arfa, A., Elfalleh, W., Zouari, N., Neffati, M. (2020) Jujube (*Zizyphus lotus* L.): Benefits and its effects on functional and sensory properties of sponge cake. *PLoS ONE* 15(2), e0227996.

Perez-Jimenez, J., Neveu, V., Vos, F., Scalbert, A. (2010). Identification of the 100 richest dietary

sources of polyphenols: an application of the Phenol-Explorer database. *European Journal of Clinical Nutrition*, 64, S112–S120.
Ribera, A. E, Reyes-Diaz, M., Alberdi, M., Zuñiga, G. E, Mora, M. L. (2015). Antioxidant compounds in skin and pulp of fruits change among genotypes and maturity stages in highbush blueberry (*Vaccinium corymbosum* L.) grown in southern Chile. *Journal of soil science and plant nutrition*, 10(4), 509-536.
Shahrajabian, M. H., Khoshkharam, M., Zandi, P., Sun, W., Cheng, Q. (2019). Jujube, a super-fruit in traditional Chinese medicine, heading for modern pharmacological science. *Journal of Medicinal Plants Studies*. 7, 173-178.
Song, L., Zheng, J., Zhang, L., Yan, S., Huang, W., He, J., Liu, P. (2019). Phytochemical profiling and fingerprint analysis of Chinese jujube (*Ziziphus jujuba* Mill.) leaves of 66 cultivars from Xinjiang Province. *Molecules*, 24(24), 4528.
Shen, Y., Zhang, H., Cheng, L., Wang, L., Qian, H., Qi, X. (2016). In vitro and in vivo antioxidant activity of polyphenols extracted from black highland barley. *Food Chemistry*, 194, 1003-1012.
Shi, Q., Zhang, Z., Su, J., Zhou, J., Li, X. (2018). Comparative analysis of pigments, phenolics, and antioxidant activity of chinese jujube (*Ziziphus jujuba* Mill.) during fruit development. *Molecules*. 23(8): 1917.
Skupień, K. (2006). Chemical composition of selected cultivars of highbush blueberry fruit (*Vaccinium corymbosum* L.). *Folia Horticulturae*, 18(2), 47-56.
Stănică, F. (2019). Twenty years of jujube (*Ziziphus Jujuba* mill.) research in Romania. *USAMV Bucharest Scientific Papers, Series Horticulture*, LXIII (2), 17-23.
Stănică, F. (2016). Chinese Date (Jujube) - a New Promising Fruit Plant for Romania. In Ye X., Jiang Y., Liu D., (Eds), *Chinese Dates a traditional functional food*. (pp. 387) CRC Press. Taylor & Francis Group.
Stănică, F. (2009), Characterization of two Romanian local biotypes of *Ziziphus jujuba*. *Acta Horticulturae*, 840, 259-262.
Stănică, F., Vasile S. A. (2008). Chinese date – a new promising fruit plant for Romania southern areas. *Acta Horticulturae*, 769, 265-269.
Stănică, F. (2000). Preliminary results regarding the behaviour of some Chinese date varieties (*Ziziphus jujuba* Mill.) in Bucuresti area. *Scientific Papers Series B*, XLIII, 203-206.
Tudor, V., Manole, C. G., Teodorescu, R., Asănică A., Barbulescu, I. D. (2015). Analysis of some phenolic compounds and free radical scavenging activity of strawberry fruits during storage period. *Agriculture and Agricultural Science Procedia*, 6, 157-164.
Wang, B., Huang, Q., Venkitasamy, C., Chai, H., Gao, H., Cheng, N., Cao, W., Xingang, L., Pan, Z. (2016). Changes in phenolic compounds and their antioxidant capacities in jujube (*Ziziphus jujuba* Miller) during three edible maturity stages. *LWT - Food Science and Technology*, 66, 56-62.
Wang, L., Luo, Z., Liu, Z., Zhao, J., Deng, W., Wei H., Liu P., Liu M. (2019). Genome size variation within species of Chinese jujube (*Ziziphus jujuba* Mill.) and its wild ancestors sour jujube (*Z. acidojujuba* Cheng et Liu). *Forests*, 10, 1-16.
Wojdyło, A., Lech, K., Nowicka, P., Hernandez, F., Figiel, A., Carbonell-Barrachina, A. A. (2019). Influence of different drying techniques on phenolic compounds, antioxidant capacity and colour of *Ziziphus jujube* Mill. fruits. *Molecules*, 24, 2361, 1-15.
Žilić, S., Šukalović, V. H. T., Dodig, D., Maksimović, V., Maksimović, M., Basić Z. (2011). Antioxidant activity of small grain cereals caused by phenolics and lipid soluble antioxidants. *Journal of Cereal Science,* 54, 417-424.
Xue, Z., Feng, W., Cao, J., Cao, D., Jiang, W. (2009). Antioxidant activity and total phenolic contents in peel and pulp of Chinese jujube (*Ziziphus jujuba* Mill.) fruits. *Journal of Food Biochemistry*, 33(5), 613-629.
Zhang, L., Pengzhan, L., Linlin, Li, Huang, Y., Yunfeng, P., Xujie, H., Song, L. (2019). Identification and antioxidant activity of flavonoids extracted from Xinjiang Jujube (*Ziziphus jujube* Mill.) leaves with ultra-high pressure extraction technology. *Molecules*. 24(1), 122.