MORPHOMETRIC AND PHYTOPATHOLOGICAL ANALYSIS OF ROMANIAN JUJUBE FRUITS DURING THE STORAGE PERIOD

ANALIZA MORFOMETRICĂ ŞI FITOPATOLOGICĂ A FRUCTELOR DE JUJUBE DIN ROMÂNIA ÎN TIMPUL PERIOADEI DE DEPOZITARE

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Abstract. *Chinese jujubs are one of the most appreciated fruits. In Romania, jujube culture has begun to increase the interest both among producers and consumers, and the study of 15 genotypes is currently carried out at the Faculty of Horticulture in Bucharest. Our research focuses on the post-harvest behavior of jujube fruits and on morphometric and phytopathological analyzes. The fruits were stored in a controlled atmosphere. To date, jujube fruits have proven to be resistant to diseases and pests, being grown without phytosanitary treatments for 19 years. Our observations in the field in the year 2016 have demonstrated the existence of four species of mushrooms per fruit before full maturation. The pathogens identified by the fruits belong to the genus: Alternaria spp., Rhizopus spp., Fusarium spp. and Monilinia spp. The results showed an indirect correlation between the incidence of fungi and the resistance of the jujube fruit to the crack.*
Key words: morphometric caractericts, *Ziziphus jujuba*, postharvest, pathogens

Rezumat. *Jujubele chinezesc este unul dintre cele mai apreciate fructe. În România, cultura de jujube a început să crească interesul atât între producători, cât şi consumatori, iar studiul a 15 genotipuri este în prezent efectuat la Facultatea de Horticultură din Bucureşti. Cercetările noastre se concentrează pe comportamentul post-recoltă a fructelor de jujube şi pe analizele morfometrice şi fitopatologice. Fructele au fost depozitate în atmosferă controlată. Până în prezent, fructele de jujube s-au dovedit a fi rezistente la boli şi dăunători, fiind cultivate fără tratamente fitosanitare timp de 19 ani. Observaţiile noastre din teren în cursul anului 2016 au demonstrat existenţa a patru specii de ciuperci pe fructe, înainte de maturarea completă. Patogenii identificaţi pe fructe aparţin genurilor: Alternaria spp., Rhizopus spp., Fusarium spp. şi Monilinia spp. Rezultatele au arătat o corelaţie indirectă între incidenţa fungilor şi rezistenţa fructului jujube la crăpare*.
Cuvinte cheie: caracteristicile morfometrice, *Ziziphus jujuba*, post-recoltare, agenţi patogeni

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INTRODUCTION

The jujube (*Ziziphus jujuba* Mill) is cultivated and appreciated in China since 4000 years and today is more and more cultivated all over the world. After harvesting, the fruits are either eaten fresh or are dried and used as food or for pharmaceutical products, given the high number of pharmacological compounds, nutrients and amino acids (Xue *et al.,* 2009; Choi *et al.*, 2011).

Ziziphus jujuba fruit shape varies from round, oval to elliptical. The size of the fruit varies from the size of a cherry to the size of a plum and some varieties can reach the dimensions of a hen's egg (Markovski *et al*., 2015). The fruit epidermis is thin, shiny, reddish-brown to chocolate colour (Soliman *et al.,* 2013). The fruit maturity is visually established by the fruit colour. When the fruits have more than 50% dark brown pigment, they have the best taste and juiciness. At full maturity, when the fruit is fully coloured, the organoleptic properties are average, but the fruits are good for drying. (Chen *et al.*, 2015). Some other good indicators of fruit maturity are their specific weight, the total dry matter content and the sugar index (Yao, 2013).

Despite the presence of so many bioactive compounds, *Ziziphus jujuba* is very tolerant to diseases and pests so that the fruits are less chemically treated if compared with other types of fruit (Velkoska-Markovski *et al.,* 2013). The fruit quality is highly correlated with their phytosanitary condition in the moment of storage initiation and the phytosanitary measures that must be applied during the storage, in order to avoid the spread of the diseases (Chira, 2008). The jujube fruits are susceptible to losses due to fungal diseases that occur after the harvest (Tian *et al.,* 2005).

The fruit cracking is a physiological disorder related to water, which can destroy entire harvest in the less favorable years. The disorder severity depends on water management during the growing season, precipitation and varietal resistance to cracking (Yao, 2013). In China, Shandong Province was mentioned that once in 5 years, due to climate conditions, the cracked fruits were attacked by rot, causing 40% losses (Yao, 2013). The drip irrigation is the most efficient for the growth and development of jujube fruit (Yaragattikar and Itnal, 2010), but even in perfectly balanced irrigation conditions throughout the whole growing season, the most important factor that influences the cracking phenomenon is the variety (Yao, 2013).

In Romania, jujube grows semi-spontaneous, in the Dobrogea area (Stănică, 2008), being represented mainly by two biotypes, *Ostrov* and *Jurilovca*. The first one grows as a garden plant close to the border of the Danube River and the second one, found at 150 km from the Ostrov village, not far from the Black Sea, is represented by spontaneous shrubs (Stănică and Dumitraşcu, 2008). At the Faculty of Horticulture from Bucharest, has been started in 1996 a research program regarding this new fruit species, 15 genotypes being analysed, as well as different propagation techniques, using *in vitro* and classical methods (Stănică, 2002).

Considering its high tolerance to pests and diseases, few phytopathological agents had been recorded on jujube. The plants may be affected by crown gall disease, *Agrobacterium tumefaciens*, anthracnose, *Gloesporium* sp., gray mold, *Botrytis cinerea* or rust, *Phakopsora zizyphi-vulgaris*. In our country, so far, no phytosanitary problems have been recorded (Stănică, 1997). Instead, the stored fruits are susceptible to fungal diseases and quality losses, characterized by pulp softness and the decrease of the content of amino acids (Lin *et al*., 2004). After the harvest, *Ziziphus jujuba* is very sensitive to pathogenic infections which strongly limits the shelf life and continuous market supply. The infections are mainly caused by *Alternaria alternata* (Fr.) Keissl and *Monillinia fructicola* (G. Winter) and can usually lead to severe losses even if the fruits are stored at 0°C (Qin et Tian, 2004, Tian *et al.,* 2005; Yan *et al,* 2011; Wang *et al*, 2011) while the blue mold caused by *Penicillium expansum*, is one of the most important diseases of jujube fruits (Qin and Tian, 2004). All three pathogens can enter in the fruit tissues in the early stages of growth and remain hidden there during ripening, while the symptoms will only be visible after harvest and during storage (Qin and Tian 2004, Tian *et al*, 2005, Yan *et al*., 2011).

Our research shows that in the ripening period several pathogens as *Alternaria* spp, *Stemphyllium* spp, *Rhizopus* spp, *Penicillium* spp., *Fusarium* spp. and *Monilinia* spp. can be present on the fruits and threatens the jujube fruits quality during storage.

MATERIAL AND METHOD

The aim of the study was to identify the pathogens present on Chinese jujube fruit immediately after harvest. We analyzed samples from 15 *Ziziphus jujuba* genotypes grown in the south-eastern Romania, at harvest, the climatic conditions of the year 2015.

The fruits were harvested manually in perfect condition and were stored in controlled atmosphere, in the following storage conditions: temperature -2- 0°C, humidity 95%, O_2 3%-5%, CO_2 less than 2%. We have studied a number of 15 genotypes of *Ziziphus jujuba*. The morphometric parameters were determined measuring the average weight, length, diameter at the base and the upper diameter, with the calipers, rulers, the refractometer and the balance. For the phytosanitary determinations regarding the pathogen loads, we examined the fruit of all the studied genotypes. To identify the fungus was used the stereomicroscope Euromex Stereo Blue and the microscope Euromex Ox Range.

RESULTS AND DISCUSSIONS

The morphometric determinations of jujube fruits during the storage period, in 2015 are presented in table 1.

The length of the fruit had a variation between 35.39 mm (R1P6) and 47.93 mm (R1P7). The Romanian genotype had a medium length of 14.00 mm (R1P5). Regarding the fruit shape, the largest diameter at the base of the fruit had R1P7, with 30.98 mm and the smallest was at R2P5, 10.96 mm. The top diameter was

the largest for R1P3, 30.35 mm and the smallest at R1P2, 21.85 mm. The of fruit length and diameters are presented in table 1.

Table1

Morphometric determinations of jujube fruits during the storage period in 2015

Nr. Crt.	Genotype	Weight / 10 fruit	Fruit length media (mm)	Diameter base media (mm)	Diameter top media (mm)
1	R1P2	0.160	43.48	23.60	23.60
2	R1P3	0.200	43.59	25.26	30.35
3	R1P4	0.175	42.45	27.04	27.60
4	R1P6	0.105	35.39	20.07	20.13
5	R1P7	0.220	47.93	30.98	28.45
6	R1P8	0.105	40.62	27.72	26.50
7	R1P9	0.155	39.64	22.94	27.59
8	R1P10	0.140	37.50	25.90	28.30
9	R2P5	0.220	14.00	10.63	10.96
10	R2P6	0.190	38.16	26.09	27.63
11	R2P7	0.180	40.37	26.35	27.48
12	R2P8	0.140	36.56	22.14	27.40
13	R3P2	0.175	43.09	26.20	27.45
14	R3P3	0.225	45.53	26.82	27.09
15	R3P6	0.175	43.96	27.22	26.80

The data presented in table 2 shows that the pathogen species identified on *Ziziphus jujuba* fruits in the year 2015, after one month of storage in controlled conditions, belongs to the genus *Alternaria* spp., *Stemphylium* spp., *Monilinia* spp. and *Fusarium* spp. The *Alternaria* fungus was present on 10 of the 15 studied genotypes. The only genotype with no pathogen agent was R1P7.

Table2

The phytopathogenic agents found during the storage period in 2015

No. ctr.	Genotype	The phytopathogenic agent (2015)			
		***Alternaria* spp.**	***Stemphylium* spp.**	***Monilinia* spp.**	***Fusarium* spp.**
1	R1P1	+	+	-	+
2	R1P2	+	-	-	+
3	R1P3	-	-	-	+
4	R1P4	-	-	+	+
5	R1P5	+	-	-	-
6	R1P6	+	-	+	-
7	R1P10	+	-	+	-
8	R2P6	+	-	+	+
9	R2P7	-	-	+	-
10	R2P7	+	-	+	-
11	R3P1	+	-	-	+
12	R3P2	+	-	-	-
13	R3P3	+	-	+	-
14	R3P6	-	+	-	-

Following our observations in 2015 in the experimental jujube field, we identified especially on the cracked fruits, but also on the fruits presenting different lesions caused by insect feeding, four phytopathogenic agents were found on the fruits: *Alternaria spp., Monilinia* spp., *Fusarium* spp. and *Rhizopus* spp. The *Rhizopus* spp., fungus was present on all the fruits of the studied genotypes.

CONCLUSIONS

The fruit characteristics in terms of size, recorded the highest value at R1P7 genotype with 47.93 mm and the smallest value at R1P5 genotype, with 14.00 mm. The highest basal diameter of 30.98 mm was found at R1P7 genotype and the lowest was 10.96 mm at R2P5 genotype. The fruit weight ranged between 14 g at R2P8 genotype and R1P10 and 22,5 g at R3P3 genotype. In terms of phytosanitary status, we have identified the following pathogens: *Alternaria* spp, *Stemphyllium* spp, *Rhizopus* spp, *Penicillium* spp., *Fusarium* spp. and Monilinia spp. The highest pathogen incidence was determined for the *Alternaria* spp. fungus while *Stemphyllium* spp. was found only on two genotypes, R1P1 and R3P6. A good resistance to the pathogen attack showed the R1P3, R1P4, R3P2, R3P6 genotypes, where the values of the pathogens incidence is lower. The only genotype detected with no pathogen was R1P7.

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