ORIGINAL SCIENTIFIC PAPER

Morphological, pomological and nutritional traits of jujube (*Zizyphus jujuba* Mill.)

Melekber Sulusoglu[1,2], Aysun Cavusoglu[1,2], Nur Dede[3], Hülya Unver[4]

[1]*Kocaeli University, Arslanbey Agricultural Vocational School, TR-41285, Kocaeli/Turkey.*
[2]*Kocaeli University, Graduate School of Natural and Applied Sciences, Department of Horticulture, TR-41380, Kocaeli/Turkey (meleksl@kocaeli.edu.tr)*
[3] *Kocaeli University, Food and Agriculture Vocational School, TR-41285, Kocaeli/Turkey.*
[4]*Ankara University, Kalecik Vocational School,TR-06870, Ankara/Turkey*

Abstract

Jujube (*Zizyphus jujuba* Mill.) is admired for its high nutritional value and one of the important alternative fruit that need to improve the cultivation. The morphological, pomological and nutritional traits of 10 types of jujube were studied in the present study. According to results obtained, fruit number per bearing shoots was between 0.80 and 1.70 that trees with small fruit were more productive. Fruit weight was changed from 2.79 to 5.61 g and flesh/stone ratios was found between 10.48 to 16.26. Total soluble solids, total sugar content and titratable acid values were ranged from 21.37% to 28.13%, 1.61% to 2.26% and 0.33% to 0.54%, respectively. Our result showed that Kocaeli climate has appropriate natural conditions for jujube cultivation and need to support integrated and small private gardens.

Key Words: *Zizyphus jujuba* Mill., productivity, morphology, pomology, nutritional composition

Introduction

The genus *Zizyphus* belonging to the family *Rhamnaceae*, which consist of about 135 species, distributed in the temperate and tropical parts of the world, mostly in Asia and America (Ara et al., 2008). Trees are medium-sized tree, growing 7-10 meters high. The tree has shiny deciduous foliage and produces a fruit with a thin, dark red skin and sweet, white flesh surrounding a stone. Fruits are eaten fresh, dried or processed. The fruit is very nutritious with potassium, phosphorus, calcium and manganese and also is rich source of vitamin C and vitamin B complex and anti-oxidant content of fresh fruits is higher than most of fruits (Li et al., 2007, Zhang et al., 2010). Jujube fruit contains many medicinal properties (Plastina et al., 2010, Yu et al., 2012).

The jujube trees adapt the drought conditions and produce sufficient yield under severe drought conditions. Jujube appears to have no serious disease, insect or nematode pests. Jujube fruits consumed as fresh fruit in the markets of Turkey with a high prices according to quality and size of fruits. As a result of marketable value and good conditions to grow, jujube has become a popular fruit in the recent years that new orchard established and tree number was increased. Despite the increasing cultivation, there have been very limited studies related to selection and cultivation of this fruit in Turkey (Ecevit et al., 2008) and we could not found any research on jujube cultivation and quality of cultivated fruits in our location. To improve the cultivation of jujube fruit, fruit size and fruit quality have to be investigated in order to the increased commercial potential of this fruit. For this aim, in the present study some physical, pomological and nutritional properties of jujube types were investigated.

Material and methods

The study was carried out in Kocaeli city between 2008 and 2009 for two growing seasons. The city of Kocaeli is located on north-western part of Turkey, at the latitude of 40º42' N and 30º01' E and 76 m above sea level. The material of the study consisted of jujube fruit of selected trees growing in home gardens and commercial orchards (Picture 1a). Each tree was considered as a type and investigated by considering leaf, fruit and stone characteristics and 9 types of them (except type 9) were investigated for fruit nutritional values.

Fruit, stone and leaf characteristics

Shoot samples picked up randomly from each type. Length of bearing seasonal shoots, fruit number on cluster was determined and tree productivity was rated by observably from very high to very less (high, moderate and less). The fruit and stone characteristics of types, such as fruit and stone weight, width, length, flesh/stone ratios were determined. Leaf width and length was also determined for all the types. Color reading of fruit was employed with a chromameter (Minolta CR-300, Minolta, Osaka, Japan), the color of fruit was objectively measured at three points and we used h° and L values together with c, a and b values. Fruit samples were hand-picked at commercial maturity (at the end of the September, in crisp mature stage) and all fruit analyses were made in fresh fruit flesh. Total soluble solids (TSS) were measured by hand held Brix refractometer, at 20 ºC. Titratable acidity (TA) was measured by neutralization of fruit juice to pH 8.1 with 0.1 N NaOH and total acidity given as a percentage of malic acid and pH value was determined directly using pH meter. In addition, dry matter was determined after the sample dried at 105 ºC and total ash was determined after the sample was burned at 550 ºC and measured as a percent value (%). Total sugar amount of fruits were measured following the Lane-Eynon method as a g100 g^{-1} (AOAC, 1990).

Experimental design and statistical analysis

All measurement was made on randomly selected samples. Three replicates were performed, each containing 10 samples (shoot, fruit, stone and leaf). Nutritional analysis of fruits was made with three replicates and three parallel in each replicate for all types. Data were subjected to ANOVA using Minitab Software (MINITAB Inc.). Data was transformed by arcsine square for percentage means. The means were separated by Duncan's Multiple Range Test ($P<0.05$).

Results and Discussion

Average data of the two years were used for evaluation of 10 types. Wide variation was observed in most of the evaluated attributes and all of them were statistically different from each other. Leaf length and width was changed according to types (between 3.46 cm and 4.71 cm for length; between 1.57 cm and 2.14 cm for width, respectively) and the largest leaves was measured in type 6 (Table 1). According to our observations, types 1, 2, 3 and 10 was productive trees (1.17, 1.57, 1.40 and 1.70 fruit numbers per bearing shoot in respectively), their fruits were small but flesh/stone ratios were in a preferable limits for jujube (14.83, 12.58 and 14.33 respectively). Flesh/stone ratio was very important for marketable value and the highest amount was determined in type 4 and type 7 (16.26 for both of them). The present results are in agreement with finding of other researchers (Ecevit et al., 2008). Fruit per bearing shoot is an index commonly used to evaluate productivity of jujube trees, and only 8.5% of cultivars could set more than one fruit per bearing shoot (Gao et.al., 2009; Liu et al., 2009). Fruit per bearing shoot was ranged from 0.80 to 1.70 that these

results support our findings. We found great variation in fruit weight among the types; Type 7 had the largest fruit (Picture 1 b) but the productivity of type 7 tree was very less. The smallest fruited type was type 9 and it was a moderate productive tree (Table 2).

Picture 1a. Jujube Trees

Picture 1b. Jujube Fruits

Table 1. Characteristics of Leaf and Stone of Jujube Types

Types	Leaf length (cm)	Leaf width (cm)	Leaf stalk length (mm)	Stone weight (mm)	Stone width (mm)	Stone length (mm)
T1	3.89bcd	1.79bcd	4.96bc	0.30bc	7.22abcd	15.09a
T2	4.08bc	1.75bcd	4.87bc	0.34abc	7.39abc	14.58a
T3	4.28ab	1.76bcd	5.27abc	0.32abc	7.29abcd	14.88a
T4	4.26ab	1.98abc	5.10abc	0.29c	6.93d	14.35a
T5	3.97bcd	1.77bcd	4.93bc	0.38a	7.59a	14.57a
T6	4.71a	2.14a	5.63ab	0.38a	7.57ab	15.65a
T7	4.69a	1.90abc	6.07a	0.33abc	7.10cd	15.23a
T8	4.37ab	2.07ab	5.10abc	0.36a	7.61a	14.80a
T9	3.46d	1.57d	3.85d	0.20d	5.89e	13.01b
T10	3.55cd	1.66cd	4.30cd	0.35ab	7.14bcd	15.31a

Values in the same column with different lower-case letters are significantly different at P<0.05.

Table 2. Characteristics of Fruit and Productivity of Jujube Types

Type	Tree Productivity	Bearing shoot length (cm)	Fruit number/ bearing shoot	Fruit stalk length (mm)	Fruit weight (g)	Fruit width (mm)	Fruit length (mm)	Flesh/stone ratio
T1	High	18.61b	1.17abcd	1.92cd	4.66bcd	19.67bc	24.07bc	14.83ab
T2	High	21.07b	1.57ab	2.55bc	4.59cd	19.69bc	23.88bc	12.58b
T3	High	20.20b	1.40abc	2.50bcd	4.97abcd	20.53ab	24.92abc	14.33ab
T4	Less	19.56b	0.87cd	2.69ab	5.06abcd	20.44ab	23.84bc	16.26a
T5	Less	20.14b	0.90cd	2.74ab	4.30d	18.98c	23.68c	10.48c
T6	Moderate	21.35b	1.20abcd	2.46bcd	5.35abc	20.47ab	26.74a	12.99b
T7	Less	26.13a	0.80d	2.25bcd	5.61a	21.47a	26.08a	16.26a
T8	Modarete	20.84b	0.83cd	1.84d	5.04abcd	20.24abc	25.00abc	12.88b
T9	Moderate	18.52b	1.00bcd	2.27bcd	2.79e	16.68d	20.49d	13.22b
T10	High	18.89b	1.70a	3.26a	5.38ab	20.57ab	25.74ab	14.46ab

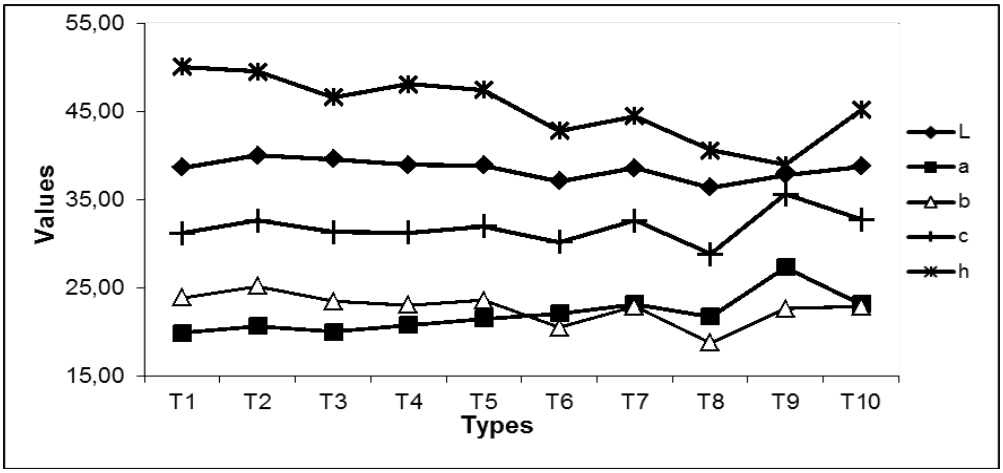
Values in the same column with different lower-case letters are significantly different at P<0.05.

Jujube fruit weight might be influenced by several factors, such as cultivar genotype, also depends on crop load. The cultivars with small fruits had relative higher fruit set and our results support this too. It was shown that jujube cultivars with smaller fruit had higher ascorbic acid and total soluble solids than the ones larger fruit (Sivakov et al., 1988, Gao et al., 2003, Chen et al., 2006) and more suitable for drying that important for industrial uses. The moisture of jujube fruit ranged from 69.55% to 75.33% which was in accordance with the results of other studies (Gao et al., 2012). TA and TSS of jujube types ranged between 0.33% to 0.54% and 21.37% to 28.13% respectively in our study (Table 3) that some values higher than the previous reports about jujubes (Ecevit et al., 2007, Gao et al., 2012). During the fruit ripening, the moisture content and TA decreased, but showed an increase in TSS and total sugar content (Gao et. al., 2012). Skin color of jujube fruit changed from green to white and dark red during its ripening and fruits contain high amounts of sugar.
The fruit skin color of jujube types were given in Graphs 1. The h value of types changed from 38.96 (type 9) to 50.12 (type 1), while c values varied from 28.78 (type 8) to 35.61 (type 9). According to skin color values, our jujube types included from reddish brown to purple brown fruits. For investigated fruits a, b and L values were changed between 19.90 (type1) and 27.32 (type 9); 18.73 (type 8) and 25.16 (type 2); 36.38 (type 8) and 40.00 (type 2), respectively.

Table 3. Nutritional Properties of Jujube Types

Type	TA (%)	TSS (%)	pH	Dry matter (%)	Ash (%)	Moisture (%)	Total sugar ($g100g^{-1}$)
T1	0.38bc	22.78de	4.55c	26.25f	1.08b	73.75b	2.15b
T2	0.39b	23.39d	4.65b	26.76ef	1.17ab	73.24bc	1.64e
T3	0.33d	21.37e	4.70a	24.67g	1.12b	75.33a	1.65e
T4	0.41b	24.22cd	4.52c	28.28cd	1.25ab	71.72d	1.61e
T5	0.35cd	26.84ab	4.56c	29.52b	1.36a	70.48e	1.90c
T6	0.54a	23.67d	4.74a	26.31f	1.74cd	73.69b	2.26a
T7	0.34cd	28.13a	4.54c	30.45a	0.69d	69.55f	2.23a
T8	0.42b	25.53bc	4.37d	28.56c	0.76cd	71.44d	1.72d
T10	0.43b	24.24cd	4.56c	27.58de	0.85c	72.42cd	1.73d

TSS: Total Solible solids (%); TA: Titratable acid (%);
Values in the same column with different lower-case letters are significantly different at $P<0.05$.



Graphs 1. a, b, c, L and h Color Values of Fruit Types

Fruit samples were collected in semi-red mature stage in our studies and sugar content might be increase with the ripening. Sugar amount was determined from 1.61 to 2.26 $g100g^{-1}$ in

fresh fruit in our types (Table 3). We thought that sugar value was affected with the genotype and ecological condition of fruit. Dry matter and ash content of investigated types was found between 24.67% and 30.45% and 0.69% and 1.36% respectively.

Conclusion

On the basis of two year's results, it may be concluded that the study location has a potential for jujube cultivation. It will need to study the cultural application to improve the fruit quality and determine the true harvest time and quality to increase the marketable value for the next step.

References

AOAC. (1990). Official methods of analysis. 15.th ed. Association of official analytical chemists. Arlington, VA, U.S.A.

Ara H., Hassan Md.A., Khanam M. (2008). Taxonomic study of the genus *Ziziphus* Mill. (*Rhamnaceae*) of Bengladesh. Bengladesh J.Plant Taxon. 15(1):47-61.

Chen,Y.Q., Zhong, X. H., Gan, L. F. (2006). The performance of Liuxiangzao‟ jujube cultivar and its cultural techniques. South China Fruits. 1:49-50.

Ecevit, F.M., Şan, B., Dilmaç-Ünal, T., Hallaç-Türk, F., Yıldırım, A.N., Polat, M., Yıldırım, F. (2008). Selection of superior ber (*Ziziphus jujube* L.) genotypes in Çivril region. Tarım Bilimleri Dergisi, Ankara Üniversitesi Ziraat Fakültesi. 14(1):51-56.

Gao, L., Zhou, G.F., Shen, G.N. (2003). New jujube varieties and their cultural techniques. China Fruits. 2:38-40.

Gao, W.H., Li, X.G., Wang, C.Z. (2009). Variation in morphology of jujube 'Muzao' (*Ziziphus jujube* Mill.) in the losses plateau of China. Proc.1st Int'l Jujube Sym. Acta Hort.840, Mengjun L. (ed.), 197-202.

Gao, Q., Wu, G., Yu, J., Wang, M., Ma, Y., Li, C. (2012). Textural characteristic, antioxidant activity, sugar, organic acid, and phenolic profiles of 10 promising jujube (*Ziziphus jujube* Mill.) selections. J.of Food Science. 77(11):1218-1225.

Li, J., Fan, L., Ding, S., Ding, X. (2007). Nutritional composition of five cultivars of Chinese jujube. Food.Chem. 103:454-460.

Liu, P., Liu, M.J., Wang, J.R., Yan, C. (2009). Investigation on the characteristics of fruiting and seed development in Chinese jujube (*Ziziphus jujuba* Mill.). Proc.1st Int'l Jujube Sym. Acta Hort.840, Mengjun L. (ed), 209-214.

Plastina, P., Bonofiglio, D., Vizza, D., Fazio, A., Rovito, D., Giordano, C., Barone, I., Catalano, S., Gabriele, B. (2010). Identification of bioactive constituents of *Ziziphus jujube* fruit extracts exerting antiproliferative and apoptotic effects in human breast cancer cells. J.Ethnopharmacol. 140(2):325-332.

Sivakov, L., Georgiev, D., Ristevski, B., Mitreski, Z. (1988). Pomological and technological characteristics of Chinese jujube (*Ziziphus jujube*) in Macedonia. Jugoslovensko Vocarstvo. 22(4):325-332.

Yu, L., Jiang, BP., Luo, D., Shen, XC., Guo, S., Duan, JA., Tang, YP. (2012). Bioactive components in the fruits of *Ziziphus jujube* Mill. against the inflamatory irritant action of *Eubhorbia* Plants. Phytomedicine. 19:239-244.

Zhang, H., Jiang, L., Ye, S., Ye, Y., Ren, F. (2010). Systematic evaluation of antioxidant capacities of the ethalonic extract of different tissues of jujube (*Ziziphus jujube* Mill.) from China. Food Chem Toxicol. 48:1461-1465.