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Physical and Chemical Characteristics of 'Thompson Navel' Orange Fruits Grown on Four Rootstocks in North of Iran

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Abstract: This research has been conducted to evaluate the effects of fours citrus rootstocks on physical and chemical characteristics of 'Thompson Navel' orange fruits. The rootstocks included Citrange, Citrumelo, Poncirus and Sour orange. Fruit samples were collected from uniform 15-years old trees and transferred to the laboratory. The data were extracted from measurements of chemical and physical variables of the 'Thompson Navel' orange fruits. The physical and chemical variables were fruit weight, fruit volume, fruit density, fruit length and diameter, rind thickness and pulp weight. The chemical variables consisted of pH, electrical conductivity (EC), total soluble solids (TSS), titrable acidity (TA), reducing sugars and vitamin C. Data were analyzed statistically (ANOVA) using analysis of variance in a completely randomized design. In this study, it was quite obvious that the physical and chemical properties of 'Thompson Navel' orange fruits can be affected by the rootstock. Sour orange can be considered as suitable rootstock for 'Thompson Navel' orange for most of fruit qualitative attributes under the north of Iran condition. Although Citrumelo, Citrange and Poncirus had good effects on fruit quality to some extend, Citrumelo appeared to be the most promising rootstocks in replacing the tristeza-susceptible Sour orange for 'Thompson Navel' orange in this area. Further results are discussed on the paper.

Key words: Thompson Navel · Orange · Citrus · Rootstock · Fruit quality

INTRODUCTION

Citrus rank the first in the world with respect to production among fruits. They are grown commercially in more than 50 countries around the world [1]. Sweet orange (*Citrus sinensis*) belongs to the *Rutaceae* family [2]. 'Navel' orange fruit is important group of fresh sweet orange cultivars due to its excellent quality [1]. 'Thampson navel' orange is the most widely grown Navel cultivar in Mazandaran province of Iran, where it is one of the important citrus producers area [3].

Several factors such as rootstock, nutrition and irrigation regimes, cultivation design and etc. may affect the promotion of quality and quantity of fruits [4]. The rootstock may influence several aspects of citrus growth and development, including yield, fruit quality and tolerance to stress caused by biotic and abiotic factors [5-7]Also element absorption system and root and top growth model can be affected by rootstock [9-11].

All citrus cultivars in Iran are mainly budded on Sour orange rootstock which is known for its resistance to gummosis and high tolerance to the climate condition of this area [3]. However, owing to this fact that Sour orange is susceptible to viral disease such as 'Tristeza', several rootstocks have been introduced and tested for their adaptability to avoid the risk of future incidence in citrus orchards [12].

The alternative rootstocks for Sour orange are Poncirus, Citrange and Citrumelo in Iran [3]. Rootstocks have had an important role in the development of the citrus industry in the world. The effect of rootstocks on citrus fruit production and fruit quality has been intensively studied in many citrus producing areas [13, 14].

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The objective of this study was to evaluate physical and chemical characteristics such as fruit size, rind thickness, juice content, total soluble solids (TSS), titratable acids, vitamin C, reducing sugars of 'Thampson Novel' sweet orange grafted on Sour Orange, Poncirus, Citrange and Citrumelo rootstocks in the Research and Development Orchard of Fajr-e-Sari Institute of Iran.

MATERIALS AND METHODS

Plant Material: This study was conducted in Research and Development Orchard of Fajr-e-Sari Institute in Mazandaran province of Iran.

Sweet orange trees c.v. 'Thampson Novel' (*Citrus sinensis*) grafted on four rootstocks: Sour orange, Poncirus, Citrange and Citrumelo. Fruit samples harvested from uniform 15-years old trees with four replications in November, 2008. Each replication contained ten fruits from main geographical orientations of the tree top. These trees were planted with the space of 7×4 m and had been received similar cultural practices such as irrigation, fertilization, pest and weed management.

Physical Properties: The rind and pulp were separated manually after fruit fresh weight and volume measurement also fruit length, diameter and density determination.

Fruit fresh weight was determined by weighting the fruits in the air on a precision digital balance (Mettler AJ50) with an accuracy of 0.0001 g. Fruit volume was determined by water displacement method and the weight density of the fruit was obtained by calculated the ratio of weight to volume. Then rind thickness was measured by a digital caliper with 0.01 mm accuracy and oven-dried to constant weight to calculate its moisture content. Then the fruit juice was extracted from the samples and analyzed for major chemical compositions.

Chemical Analysis: For pH and electrical conductivity (EC, $ds.m^{-1}$) determinations, the samples were homogenized and measured with a pH meter (Labtron, Iran) and conductivimeter (ABB-100), respectively. Total soluble solids (TSS) (° Brix) in the fruit juice were determined with a digital refractometer (ATAGO RX-5000) at 20°C, calibrated using distilled water. Titrable acidity (TA) was estimated by juice titration with 0.1 N NaOH to the titration end point of pH 8.3, monitored with a pH meter (Labtron) and expressed as citric acid content ($mg.100ml^{-1}$). Reducing sugars were determined according to the method of Lane and Eyon as described by Ranganna [15] and expressed as mg sugar per ml.

Vitamin C was determined by employing the Jacob and Sotoudeh's method [16] and expressed as mg per 100 ml.

Statistical Analysis: The experimental design was a completely randomized design. Data were analyzed statistically (ANOVA) using analysis of variance and differences among the means were determined for significance at $P<0.05$ using Duncan's multiple range test.

RESULTS AND DISCUSSION

Physical Properties: Based on data shown in Tables 1 and 2, it is evident that rootstocks investigated in this research had significant effects on fruit physical properties.

Fruit weight ranged from 235.94 to 314.66 g and fruit volume from 27.85 to 43.39 cm^3. It was observed that, on average, the highest and lowest weight of 'Thampson Navel' fruits attained on Citrumelo (314.66 g) and Sour Orange (235.94 g) rootstocks, respectively. The highest and lowest fruit volume resulted in fruits collected from Citrange (43.39 cm^3) and Poncirus (27.85 cm^3)

'Thampson Navel' fruits from trees on Citrange and Citrumelo showed significant difference for fruit density with other two investigated rootstocks. Similarly, average fruit density ranged from 78.70 to 86.07 $g.cm^{-3}$ for Sour orange and Citrumelo rootstocks, respectively.

Data showed that the highest fruit length and diameter were produced by 'Thampson Navel' trees budded on Citrange and Citrumelo rootstocks and the lowest were observed on Sour orange and Poncirus rootstocks.

Regarding the fruit rind thickness, Sour orange (6.03 mm) and Citrange (6.02 mm) rootstocks showed significantly the highest rind thickness and followed by Citrumelo (5.22 mm) and Poncirus (4.85 mm) rootstocks with no significant difference.

Pulp weight of the fruit was found to be the maximum for Citrange rootstock (225.17 g) and minimum for Sour orange rootstock (165.55 g).

Table 1: Analysis of variance of physical characteristics of the fruits

SOV	df	Fruit Weight	Fruit Volume	Fruit Density	Fruit Length	Fruit Diameter	Rind Thickness	Pulp weight
Rootstock	3	48735**	1738**	478**	476**	478**	10.03**	150.06**
Error		53.18	13.39	14.65	6.03	5.71	0.9	2.75

** means $p<0.01$

Table 2: Physical characteristics of the 'Thampson Novel' fruits on four rootstocks

Rootstocks	Fruit Weight(g)	Fruit Volume(cm^3)	Fruit Density($g.cm^{-3}$)	Fruit Length(mm)	Fruit Diameter(mm)	Rind Thickness(mm)	Pulp Weight(g)
Sour Orange	235.94d	30.93a	78.70b	78.30c	78.61b	6.03a	165.55d
Poncirus	253.39c	27.85c	79.36b	79.31c	79.30b	4.85c	189.65c
Citrange	312.68b	43.39a	85.93a	86.32a	85.91a	6.02a	225.17a
Citrumelo	314.66a	41.89a	86.07a	85.11b	86.07a	5.22b	234.87b

The means followed by similar letters in each column are not significantly differed at 5% level

Table 3: Chemical characteristics of the 'Thampson Novel' fruits on four rootstocks

Rootstock	pH	EC($ds.m^{-1}$)	TSS(°B)	Titrable acids(%)	Reducing sugars(g/100ml)	Vitamin C(mg/100ml)
Sour Orange	3.70a	3.00b	11.19a	1.20a	4.53a	27.44a
Poncirus	3.38c	3.21a	11.15a	1.06b	4.39b	28.76a
Citrange	3.50b	3.24a	10.06b	0.93c	3.82c	27.00a
Citrumelo	3.81a	3.19a	9.95b	0.76c	3.83c	25.27b

The means followed by similar letters in each column are not significantly differed at 5% level

The obtained data by Salunke *et al.* [4]. Yonemoto *et al.* [17], Al-Jaleel *et al.* [18] and Filho *et al.* [7] revealed that the main fruit physical aspects i.e. fruit weight, volume, length, diameter etc. were affected by rootstocks. Tuzcu *et al.* [19] reported that 'Washington Navel' orange trees budded on Carrizo citrange produced the highest fruit yield in comparison with other studied rootstocks. Regarding the rind thickness, Fallahi *et al.* [20] and Al-Jaleel [21] stated that fruit peel thickness was "affected by rootstocks". Also similar researches have been done and confirmed this reports in some previous studies.

All these results indicate the inconsistency in fruit properties differences as affected by rootstocks, which could be attributed to differences in climatic conditions and soil characteristics [22]. Differences among rootstocks could be attributed to the differential ability of the rootstocks to absorb water and nutrients and to the physical differences among the root systems [23]. These differences can further affect fruit quality, growth and health of the scion cultivar.

Chemichal Properties: Influence of different rootstocks on some chemical 'Thampson Navel' fruit properties is shown in Tables 3.

The pH ranged from 3.38 to 3.81 and there was a significant difference between both Citrumelo and Sour orange with other rootstocks. Regarding the EC, no significant difference was observed between Poncirus, Citrange and Citrumelo; while a significant difference was observed between Sour orange and mentioned rootstocks.

Results revealed that juice TSS of 'Thampson Navel' fruits from trees on Sour orange (11.19%) and Poncirus (11.15%) yielded the highest TSS percentages with no significant difference to each other; meanwhile the lowest values recorded with Citrange (10.06%) and Citrumelo (9.95%).

Titrable acidity in the juice of fruit from trees on Sour orange (1.20%) was found to be the maximum; while minimum for juice of fruit from trees on Citrumelo (0.76%). Reducing sugars of fruit juice ranged from 3.82 g/100ml in fruits grafted on Citrange to 4.53 g/100ml in juice of Sour Orange g/100ml grafted one.

As the results showed, juice of fruit from trees on Citrumelo had the lowest significant vitamin C (25.27 mg/100ml) comparing with fruit juice of other studied rootstocks; while fruit juice of trees on Poncirus had the highest amount (28.76 mg/100ml) of vitamin C.

The favor and palatability of citrus fruit is a function of relative levels of TSS, acids and the other chemical attributes of fruit [2].

Ramin and Alirezanezhads' [24] results indicated that the yield and fruit quality of grapefruit were strongly influenced by the used rootstocks. Also they stated that the rootstock type affected the fruit juice amount and soluble solid content. Concerning TSS in our research, the fruits from trees budded on Sour orange had the highest TSS as compared with those on the other rootstocks.

Regarding the effect of rootstock on chemical attributes, Ali [25] on 'Fremont' tangerine stated that the lowest percentage of juice acidity was found on Carrizo citrange. Bassal, [26] reported that fruits of 'Clemenules' mandarin on 'Swingle' Citrumelo and Cleopatra mandarin rootstocks had higher acidity than those on Sour orange.

Findings of Al-Obeed *et al.* [13] concerning the effect of various rootstocks on the ascorbic acid content of fruit juice of grapefruit and lime trees revealed that the consider parameter was not greatly affected. These findings are in concordance with our results which showed no significant difference between three of tested rootstocks.

CONCLUSION

Rootstocks can affect the success of any commercial citrus culture. Therefore, their its use is considered essential in citrus culture because of their strong influence on future successful growth. In this study, it was quite obvious that the physical and chemical properties of 'Thompson Navel' orange fruits can be affected by the proper selection of rootstock. Sour orange can be considered as suitable rootstocks for 'Thampson Navel' orange for most of fruit qualitative attributes under the North of Iran conditions. Since Sour orange rootstock is susceptible to viral disease such as 'Tristeza'. Several rootstocks need to be introduced and tested for their adaptability to avoid the risk of future incidence in citrus orchards.

Although Citrumelo, Citrange and Poncirus had good effects on fruit quality to some extend, Citrumelo appeared to be the most promising rootstocks in replacing the tristeza-susceptible Sour orange for 'Thampson Navel' orange in North of Iran.

This fact should not be ignored that ultimate quantitative and qualitative attributes a citrus fruit achieves is the result of many complex factors including nutrition and irrigation programs, rainfall distribution, pruning, fruit load, the rootstock/scion combination and etc.

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