Original Research Article

Evaluation of some Valencia cvs. performance under new reclaimed soil conditions

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ABSTRACT

Aims: The objective of this study was to evaluate the performance of three imported Valencia cultivars (*Citrus sinensis* (L.) Osb.) namely Campbell ,Olinda and Delta all were budded on Volkamer lemon (*Citrus volkameriana*) and grown in sandy soil under drip irrigation system.
Study design: One way completely randomized design was used for the experiment.
Place and Duration of Study: The experimental was carried out during two successive seasons 2014- 2015 and 2015- 2016 at a private citrus orchard in South El Tahrir, El Beheira governorate, Egypt.
Methodology: The study covers some morphological, anatomical and physiological characteristics for the three investigated cultivars. Yield, fruit quality, total indoles, total phenols, total carbohydrates and minerals concentrations were determined.
Results: Anatomical study of leaves showed that the Campbell leaves gave the higher values of most tissues measurements under study. Fruitlets structure demonstrated that, the highest values of flavedo thickness were observed in Delta followed by Campbell and at last Olinda fruitlets, the highest value of segments width was obtained by Olinda followed by Campbell then Delta. The wall thickness between segments appears the highest value in Campbell followed by Delta and Olinda, respectively. Generally, the results revealed that, Campbell produces the highest yield and best fruit quality parameters, whereas Olinda fruits gave the highest fruit juice percentage which is an extremely important parameter for its industrial processing.
Conclusion: Thus, it could be concluded that Campbell and Olinda proved as a reliable cultivars under the prevailing agro-climatic conditions of South El Tahrir district, Egypt.

Keywords: Evaluation, Campbell, Olinda, Delta, Anatomical characteristics, Fruit quality

1. INTRODUCTION

Citrus is one of the leading fruit crops under tropical and sub-tropical conditions of the world with respect to its area and production. Among different citrus species, sweet orange (*Citrus sinensis* Osbeck) is one of the prominent groups with wide range of varieties and distribution. More than 60 percent global citrus production is contributed by the sweet orange [1].

The orange tree is small, spiny tree, typically growing to 7.5m, but occasionally reaching heights up to 15m. Leaves are leathery and evergreen, and range from elliptical to oblong to oval, 6.5-15cm length and 2.5-9.5cm wide, often with narrow wings on the petioles. The fragrant white flowers, produced singly or in cluster of up to 6 are around 5cm wide, 5 petals and 20 to 25 yellow stamens. The fruit, which may be globose to oval, is typically 6.5 to 9.5 cm wide, and ripens yellow to orange. The fruit rind contains numerous small oil glands. The

fruit pulp is typically juicy and sweet, divided into 10 to 14 segments (while, there are seedless varieties) and ranges in color from yellow to orange to red [2].
Valencia orange is considered as one of the best and most popular late-maturing citrus varieties, prized for its high productivity and good juice quality. For these reasons, Valencia orange is the most widely cultivated citrus variety in the world. The most well-known clonal selections of Valencia orange are 'Cutter', 'Delta', 'Frost', 'Lue Gim Gong','Olinda', and the vigorous clone 'Campbell' [3]. Valencia oranges are known for their high- quality juice, which has a deep orange color and high sugar content. However, the fruit is medium in size with few seeds (0-6) [4].
The different ecological conditions effects on citrus productions are apparent. Thus, it is valuable to know the favorable ecological conditions for the cultivars chosen and their interactions under these parameters by ecological conditions of the growing sites. Further, factors like cultivar characteristics, rootstocks, growing conditions along with cultural practices, type of flowers, and the fruit drops can affect yield and quality performance of citrus cultivars [5]. Since environmental conditions and cultural practices are unique and vary considerably from one area to another, thus this study was carried out to determine the horticultural adaptability and performance of Campbell, Olinda and Delta cultivars under conditions of South El Tahrir, El Beheira governorate, Egypt.

2. MATERIAL AND METHODS

The present study was carried out during two successive experimental seasons 2014 - 2015 and 2015 - 2016 in a private citrus orchard in El Beheira governorate, Egypt. Three Valencia orange cultivars (*Citrus sinensis* (L.) Osb.) namely Campbell, Olinda and Delta budded on Volkamer lemon (*Citrus volkameriana*) grown on sandy soil at 4 × 6 m under drip irrigation system, were used. The total number of trees in this experiment was forty five trees (3 cultivars x 5 replicate x 3 trees in each replicate).
Following parameters were investigated:

2.1 Tree canopy

Tree canopy volume was determinate at the end of February during two experimental seasons; tree canopy volume was estimated according to the formula of Obreza [6].
Tree canopy volume (m) = H × D × 0.5238
Whereas H= tree height (m) and D = diameter of tree periphery (m).

2.2 Anatomical studies

Leaves at the first week of March and fruitlets at the first week of May were collected from the three studied cultivars (Campbell, Olinda and Delta trees) throughout the 2nd growing season of 2015/2016. Specimens were killed and fixed for 48 hours in F.A.A. (10 ml formalin, 5 ml glacial acetic acid, 50 ml ethyl alcohol 95%, and 35ml distilled water). Plant materials were washed in 50% ethyl alcohol and dehydrated in a normal butyl alcohol series before being embedded in paraffin wax (melting point 56 °C).Transverse sections, 20 μm thick, were cut using a rotary microtome, double stained with crystal violet/erythrosine, cleared in xylene and mounted in Canada balsam [7]. Examination and photomicrographs were taken at Botany Department, Faculty of Agriculture, Cairo University.

2.3 Fruit set

Total number of flowers was counted at 75% of blooming and number of fruitlets was counted at the third week of June and then fruit set percentage (%) was calculated according to the equation:
Fruit set% = (number of fruitlets/ number of flowers) ×100

2.4 Yield

At harvest time (at the first week of March under these experimental conditions) fruits of each tree were harvested and the yield was estimated as number of fruits and weight in Kg.

2.5 Fruit quality

At harvest stage, representative sample of 10 fruits was taken from each tree and the following characters were determined:

<u>2.5.1 Fruit physical properties</u>

Average fruit weight (g), average fruit size (cm^3), fruit height and diameter (cm) were measured and fruit shape index (length/diameter) was calculated, peel thickness (cm), fruit firmness (l.b/ $inches^2$) and fruit juice percent % (w/w) were measured.

<u>2.5.2 Fruit chemical properties</u>

TSS %, acidity % (as mg citric acid/100 cm^3 juice), TSS/ acid ratio and vitamin C (ascorbic acid as mg/100 ml juice) were determined according to A.O.A.C.[8].

2.6 Leaf chemical composition

Both total indoles and total phenols were determined in fresh leaves three times (March, May and July) at the two experimental seasons. Total indoles were determined according to Larsen [9]. Total phenols were determined according to Swain and Hillis [10]. Total carbohydrates in dry shoots of spring cycle were determined in September at the two experimental seasons by using 3,5-dinitrosalicylic acid method according to Miller [11]. N, P, K, Fe, Zn and Mn concentrations in dried leaves were determinate in September of the two experimental seasons. Total N% was determined by semi-micro Kjeldahl method described by Plummer [12]. Phosphorus was estimated colorimeterically by using the chlorostannous reduced molybdophosphoric blue colour method as described by King [13]. Potassium concentration was determined by using the flame photometer. Fe, Mn and Zn concentrations were determined by using atomic absorption spectrophotometer.

2.7 Statistical analysis

One way completely randomized design was used for the experiment. The data statistical analysis carried out according to Snedecor and Cochran [14]. Averages were compared using L.S.D test at 5% level.

3. RESULTS AND DISCUSSION

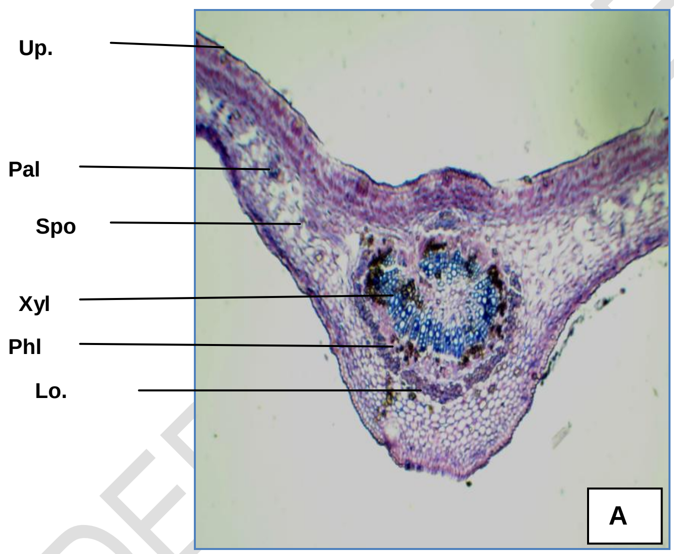
3.1 Anatomical studies

<u>3.1.1 Leaf studies</u>

Leaves are simple, leathery texture, deep green colour, ranging from elliptical to oblong to oval in shape, 5.6 cm long and 2.3 cm wide, the apex is acuminate, it have entire margin, bearing narrow wings on the petioles. Anatomically, data showed that the mesophyll in cross section of the leaf of the three cultivars is heterogeneous, consist of 2 rows of palisade and 8-9 rows of spongy tissues. The upper and lower epidermis is represented by one row of cell. Lamina thickness in Campbell is higher in values (578 µm), while Olinda (570 µm) and Delta (510 µm). This is because the thickness of palisade and spongy tissues were increased in Campbell recorded 170 and 400 µm, respectively. Whereas, in Olinda recorded 165 and 365 µm and in Delta are 150 and 300 µm, respectively. The mid vein thickness in Campbell is higher (1380 µm) followed by Olinda (1115 µm), but in Delta recorded 940 µm as a result of increasing length and width of midvein bundle recorded 690 and 1060 µm in Campbell, and 480 and 890 µm in Olinda, whereas in Delta recorded 445 and 830 µm, respectively. These results are in harmony with Sedeek *et al*. [15] on *Citrus maxima.* Microscopically measurements and microphotographs of histological characters at the leaf of three cultivars of *Citrus sinensis*, Campbell, Olinda and Delta are given in Table (1) and Figure (1).

Table (1): Anatomical characters of citrus cultivars leaf during 2nd season

Characters (µm)	Cultivars		
	Campbell	Olinda	Delta
Lamina thickness	578	570	510
Palisade thickness	170	165	150
Spongy thickness	400	365	300
Mid vein thickness	1380	1115	940
Main vascular bundle			
- Length	690	480	445
- Width	1060	890	830



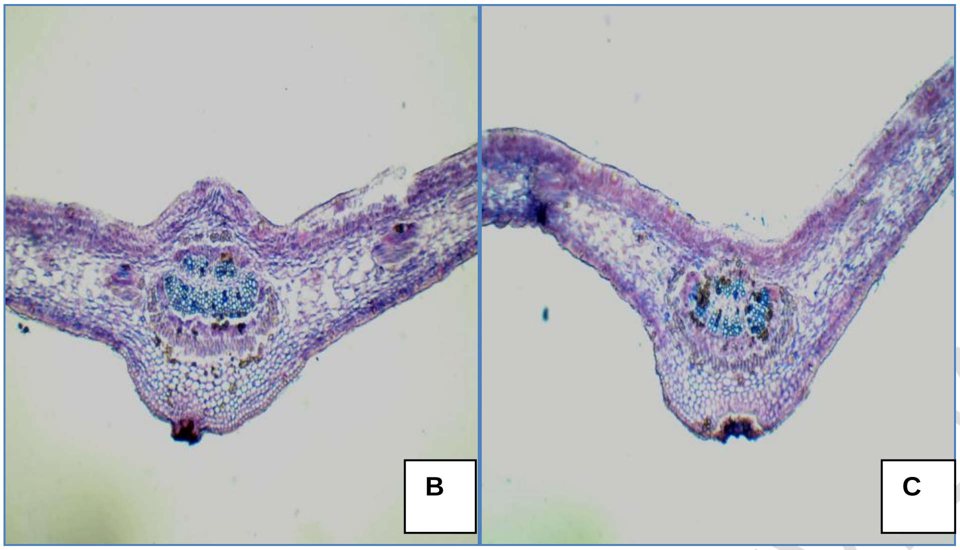


Fig. (1): **Transverse sections through the middle part of citrus leaf, (A) Campbell (B) Olinda (C) Delta (X 40): Up. Epi: upper epidermis, Pal: palisade, Spo: spongy, Xyl: xylem, Phl: phloem, Lo. Epi: lower epidermis.**

3.1.2 Fruitlets structure

A transverse section of the three studied cultivars of *Citrus sinensis* fruitlets were taken and illustrated in Table (2) and illustrated in Fig. (2). The fruitlets, globose to oval in shape, it is 7.0 to 9.5 cm wide, and ripens to orange. Concerning anatomical structure of fruitlets, results showed that it is composed of an outer flavedo layer that contains the exterior fruitlets color and oil glands (epicarp). Flavedo made of parenchymatous cells covered with cuticle and embedded oil glands. The thickness of flavedo recorded the highest values in Delta (290 µm**)** while in Campbell showed 262.5 µm and meanwhile Olinda recorded the lowest (230 µm). Under the flavedo is a white spongy albedo layer (mesocarp). Albedo formed of polygonal parenchyma cells, showing air spaces and vascular bundles. The thickness of albedo ranged from 1150 µm in Delta to 1635 µm in Olinda. The endocarp is a membranous parenchymatous cells. It is separated into 10 to 14 segments; filled with juice vesicles that are elongated and attached to the center of the fruit. Segments width showed an increase value in Olinda (477.5 µm) followed by Campbell (420 µm) then Delta recorded 400 µm. The wall thickness between segments showed the most increase value in Campbell (105 µm), while recorded 85 and 90 µm in Delta and Olinda, respectively.
Similar results were obtained by Sedeek *et al*. [15] on *Citrus maxima* (Burm.) Merrill.

Table (2): Anatomical characters of citrus cultivars fruitlets during 2nd season

Characters (µm)	Cultivars		
	Campbell	Olinda	Delta
Flavedo thickness	262.5	230	290
Albedo thickness	1340	1635	1150
Segments diameter	420	477.5	400
Wall thickness	105	90	85

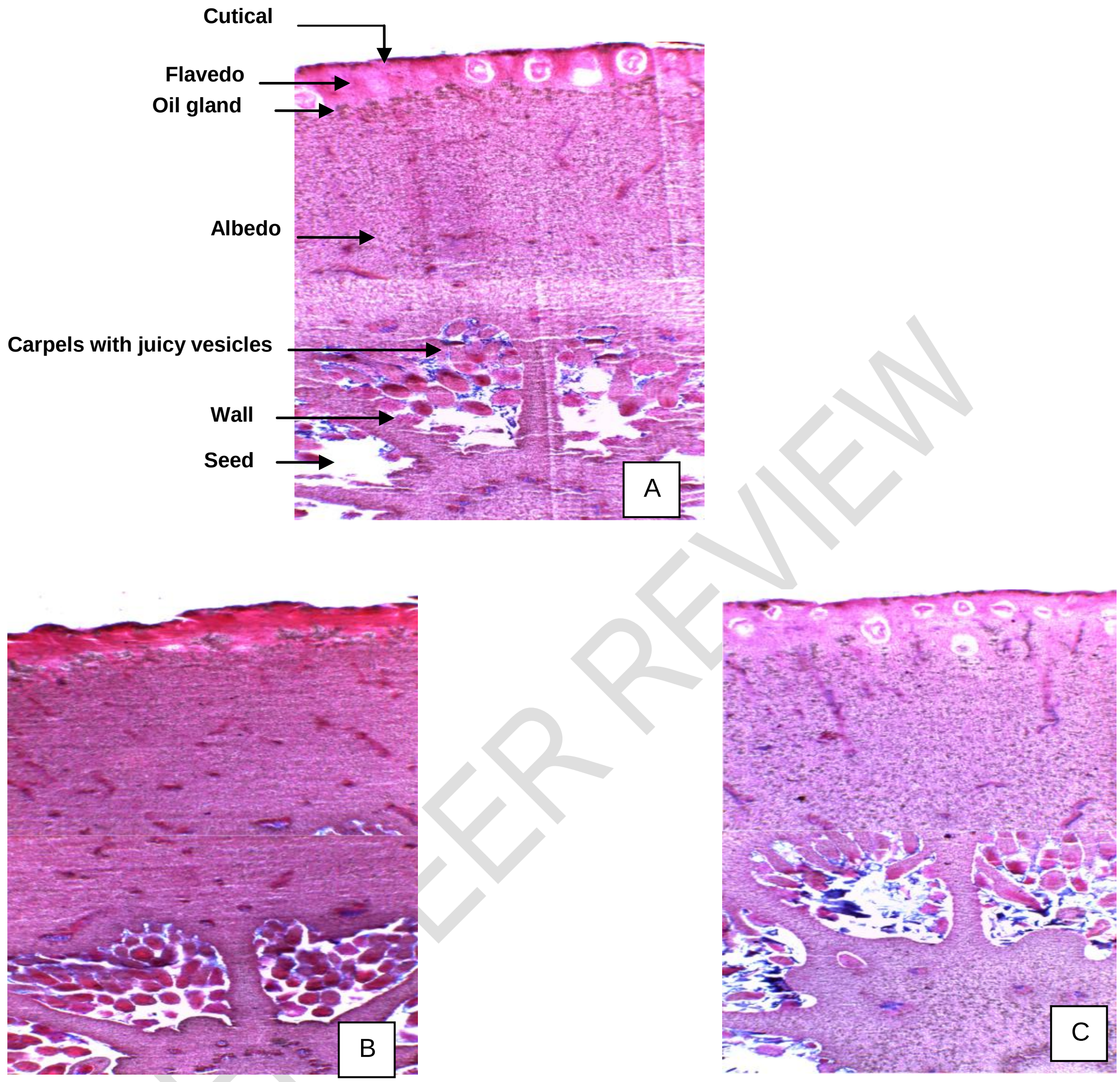


Fig. 2: Transverse sections through the fruitlets of different citrus cultivars (A), Campbell (B) Olinda (C) Delta (X 40)

3.2 Tree canopy

The data in Table (3) showed that, in the two experimental seasons the highest value of tree canopy was observed in Campbell Valencia trees as compared with the other cultivars, which, may affected by the increment palisade Campbell leaves comparing to the other cultivars (Table1). Since, the leaf vein features responsible for water, nutrient, and sugar transport, and biomechanical support; thicker veins may have greater water and sugar transport capacity [16].

Table (3): Tree canopy, fruit set, fruit number and yield of studied cultivars

Cultivars	Tree canopy (m)		Fruit set (%)		Fruit number		Yield (Kg/ tree)	
	1st	2 nd	1st	2 nd	1st	2 nd	1st	2 nd
Campbell	12.58 a	14.10 a	25.43 a	28.92 a	263.33 a	254.33 a	69.05 a	64.22 a
Olinda	10.37 b	11.58 b	18.04 b	16.86 b	205.00 b	216.67 b	60.79 a	61.93a
Delta	9.55 b	9.61 c	14.81 b	14.17 b	180.00 b	205.00 b	42.50 b	51.10b

Means in each column fallowed by the same letter did not differ at $p<0.05$ according to Duncans multiple range tests

It clear from the results that, there are positive relationship between tree canopy and fruit yield. Whereas, Campbell trees had the highest tree canopy and fruit yield as compared with other cultivars.

These results are in agreement with those were obtained with Hostler, *et al*. [17] who found that, there was a positive correlation between tree canopy and fruit yield of citrus as well as Zaman *et al*.[18] who noticed that, tree age, size and yield maps produced similar spatial patterns with the grove, as high yielding areas were associated with large tree canopies.

3.3 Fruit set

The data in Table (3) revealed that, in the two experimental seasons the highest value of fruit set was recorded by Campbell trees followed by Olinda.
Flowering induction and flower number are main factors for yield and fruit setting production in citrus crops [19]. Fruit set rather than flowering is the step that limits yield in most *Citrus* cultivars [20].

In this respect, there are correlations between accumulation of carbohydrates and flower formation, but carbohydrate levels are not the sole factor regulating citrus flowering [21]. Although the evidence is still mostly indirect, it may be concluded that the level of carbohydrates is often a major factor limiting fruit set [22]. Developing fruits serve as competitive sinks for available metabolites [23]. Also, during the period of fruit abscission, in which competition for carbohydrates is considered to be a limiting factor for fruit retention, fruit nutrition is supported by current photosynthesis and stored reserves [24].

3.4 Fruit yield

It is clear from the data presented in Tables (3) that, the Campbell trees significant higher fruit yield comparing to Olinda trees at the two experimental seasons, followed by Delta trees. This lake of significant in fruit yield between the two cultivars results from the superiority of Campbell in producing more fruits while, Olinda had more weighty fruits.

This results are in harmony with those were obtained Qureshi *et al*. [25] who found that, maximum fruit number and fruit yield were recorded by Campbell Valencia followed by Hinkely and Olinda Valencia orange.

In this respect, Campbell Valencia was found to be heavy yield as compare with Olinda Valencia, with higher juice volume but had high acidity level [25]. The highest yield was achieved when the 'Olinda Valencia' orange was grafted on Macrophylla and 'Volkamer' lemon rootstocks while those grafted on Cleopatra mandarin produced the lowest yield [26].

3.5 Fruit quality

3.5.1 Physical Properties

The data in Table (4) showed that, in the two experimental seasons, the highest values of fruit weight and fruit size were recorded in Olinda trees.

These results are in agreement with those obtained with Singh and Gill [27] who found that, Olinda recorded maximum values for fruit weight, peel weight and percent juice content.

Table (4): Fruit physical properties of studied cultivars

Cultivars	Fruit weight (g)		Fruit size (cm^3)		Fruit shape index		Fruit firmness (l.b/inches^2)		Peel thickness (cm)	
	1st	2 nd	1st	2 nd	1st	2 nd	1st	2 nd	1st	2 nd
Campbell	262.67 b	253.58b	306.67 b	289.67a	1.08 a	1.07 a	15.51 b	15.50 b	0.59 a	0.56 a
Olinda	300.33 a	286.27a	347.67 a	305.00 a	1.04 a	1.06 a	17.45 b	16.00 b	0.58 a	0.53 a
Delta	235.33 c	249.67b	269.33c	270.00 b	1.10 a	1.09 a	18.05 a	17.20 a	0.58 a	0.57 a

Means in each column fallowed by the same letter did not differ at $p<0.05$ according to Duncans multiple range tests

Fruit size is the main factor affecting the market price of Valencia fruit [3]. In general, fruit size is correlated with fruit number per tree. The fewer fruit on the tree, the larger and heavier are the fruit. Moreover, in a particular year beside fruit load, the ultimate size a citrus fruit achieves is the result of many complex factors including nutrition and irrigation programs, pruning, and the rootstock-scion combination. Large fruit size is most often preferred in the fresh fruit market and brings higher prices early in the season [28].

In this respect, citrus fruit quality may be indicated by external fruit features, such as peel colour, size, rind texture, and physical as well as biochemical characters of its internal features, like seediness, juice and vitamin C contents, total soluble solids, titratable acidity and TSS\acid ratio [29].

The data in Table (4) demonstrated that, there was no significant difference in peel thickness of the studied cultivars. It is obvious from data in Table (4) that, in the two experimental seasons the highest values of fruit firmness was observed in Delta cv. fruit. This may explained as the thickness of Delta flavedo recorded the highest values in as showed previously in its anatomical parameters (Table 2). As Sirisomboon and Lapchareonsuk [30] cleared that, the average diameter was found to correlate with the initial firmness and toughness of the flavedo. While, the highest value of fruit juice percent was recorded by Olinda cv. fruit. This may refer to the augmentation of the Olinda fruit segments diameter (Table 2). As, Segment length was positively correlated with fruit juice weight and fruit juice percentage [31].

These results are in agreement in with those obtained by Singh and Gill [27] who found that, highest juice percentage was recorded in fruits harvested from Olinda cultivar.

In this respect, the juice percentage in the fresh citrus fruit is considered to be very important factor due to the increasing demand in fruit juice consumption [32]. Highest juice percentage in citrus fruits is an ultimate customer's demand [33].

3.5. 2 Chemical Properties

The data in Table (5) demonstrated that, in the two experimental seasons, no significant variation in vitamin C of the studied cultivars. However, no constant trend could be detected on total soluble solids in fruits of the studied cultivars at the two experimental seasons, whereas the lowest value of acidity and the highest value of T.S.S/ acid ratio were observed in Campbell trees at the second season.

In this respect, in the juice industry, fruits are sold based on the amount of soluble solids content and therefore the growers are interested to maximize the productivity of soluble solids [32]. TSS is an important measure of the sugar content of fruits, as sugars constitute approximately 85% of the soluble solids in citrus fruits [33]. Also, for purposes of fresh fruit sales, external appearance is more important, therefore the internal maturity factors are deemphasized, although in most areas a minimum T.SS/acid ratio is established to maintain acceptable quality. For processing, internal quality is the overriding factor, therefore juice percentage and higher T.SS/acid ratio is emphasized [34].

Table (5): Fruit chemical properties of studied cultivars

Cultivars	Fruit juice percent (w/w)		Vitamin C (mg/100ml)		T.S.S (%)		Acidity (%)		T.S.S/ acid ratio	
	1st	2 nd	1st	2 nd	1st	2 nd	1st	2 nd	1st	2 nd
Campbell	52.88 a	51.07 b	36.96 a	37.43 a	10.50 a	10.00 a	0.852 a	0.869 b	10.50 a	11.51 a
Olinda	56.73 a	57.33 a	35.36 a	35.13 a	10.00 a	10.67 a	0.855 a	1.010 a	10.00 a	10.60ab
Delta	43.89 b	44.91c	40.80 a	40.03 a	10.50 a	10.33 a	0.911 a	1.001 a	10.50 a	10.35 b

Means in each column fallowed by the same letter did not differ at $p<0.05$ according to Duncans multiple range tests

3.6 Chemical composition

<u>3.6.1 Total indoles</u>

Regarding to the total indoles concentration of leaves in the studied cultivars (Fig.3), the highest values were recorded by Olinda and Campbell leaves at the three date of sampling at the two experimental seasons, with some exceptions. Moreover, the highest values of total indoles in March and May samples were obtained by Olinda leaves. Also, it was observed that, July sample have the highest concentrations of indoles in the studied cultivars of the study.

In this respect, auxins promote cell enlargement rather than cell division. Also endogenous auxins increase in developing ovaries [35].

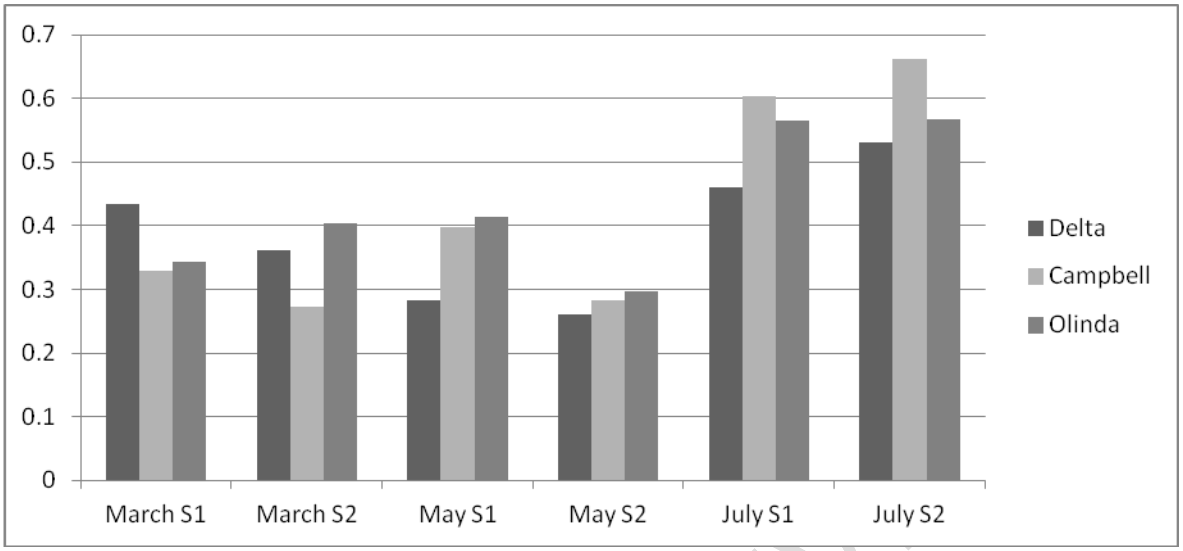


Fig.(3): Total indoles concentration (mg/g.fw) for studied cultivars at three date samples through two successive seasons.

3.6.2 Total phenols

It was noticed that total phenols concentration was increased in March samples at the first season in the studied cultivars when compared with other sampling dates.
This is may be due to phenolic compounds have been implicated in process of division, development and differentiation into new tissues [36].

Also, the highest value of total phenols concentration was recorded by Delta leaves followed by Olinda leaves at the three dates of sampling in both seasons when compared with Campbell leaves, with some exceptions.

Furthermore, from the present results, it can be suggested that, the increasing of total indoles concentration especially in July and decreasing total phenolic compounds in Campbell and Olinda leaves affected positively the enhancing of tree canopy, fruit number, fruit yield and fruit quality of Campbell cultivar as well as the increment of fruit size, fruit weight and fruit juice percent of Olinda cultivar as compared with Delta cultivar.

In this respect, polyphenolic compounds are essential for the growth of plants and affect various physiological events. They actively inhibited or stimulate some physiological process, such as defending system against pathogens and stress, growth as well as development and reproduction. Phenolic compounds have been shown to have both stimulatory and inhibitory effects on plant development [37]. Phenolic compounds are considered as bioactive non nutritional compounds, due to their antioxidant functions [38].

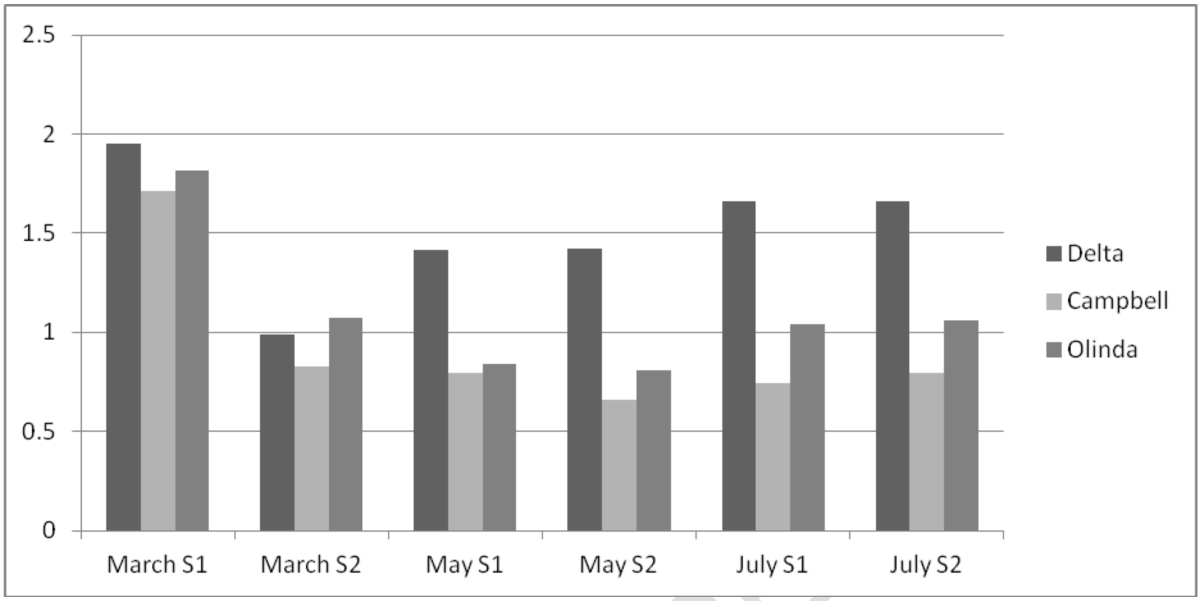


Fig.(4): Total phenols concentration (mg/g.fw) for studied cultivars at three date samples through two successive seasons.

3.6.3 Total carbohydrates

The data presented in Table (6) revealed that, the highest values of total carbohydrates were recorded by Campbell shoots followed by Olinda shoots in the two experimental seasons.

In this respect, the availability of carbohydrates, flower intensity and the competition between them, the competition between fruitlets and fruit weight have been suggested as the most significant factors affecting the final citrus fruit size [39]. Also, a strong relationship between the carbohydrate amounts available for citrus fruitlets, especially soluble sugars, and their probability of abscission has been suggested [40]. Carbohydrates content may be a biochemical signal involved in the mechanisms controlling citrus fruit abscission [41]. Moreover, carbohydrate reserves are used in the formation and development of flowers and fruits of citrus trees [42].

Table (6): Total carbohydrates and minerals concentrations of studied cultivars

Cultivars	Total carbohydrates (mg/g. d.w.)		N (%)		P (%)		K(%)		Fe (ppm)		Mn(ppm)		Zn (ppm)	
	1st	2 nd	1st	2 nd	1st	2 nd	1st	2 nd	1st	2 nd	1st	2 nd	1st	2 nd
Campbell	1.820a	1.836 a	2.39a	2.40a	0.48a	0.47a	1.190a	1.280a	60.65b	58.03b	37.24b	35.60b	24.90b	23.66b
Olinda	1.426b	1.401 b	2.38a	2.67a	0.53a	0.54a	1.325a	1.310a	58.74b	55.57b	45.82a	43.71a	23.13c	23.42b
Delta	1.097c	1.106 c	2.49a	2.30a	0.49a	0.53a	1.490a	1.453a	75.93a	78.05a	33.87b	33.94b	27.02a	26.96a

Means in each column fallowed by the same letter did not differ at $p<0.05$ according to Duncans multiple range tests

3.6.4 Minerals

The data in Table (6) showed that, there is no significant variation between the studied cultivars on nitrogen, phosphorus and potassium leaves concentrations in the two experimental seasons. Concerning to iron and zinc concentration, the highest values were obtained by Delta leaves, while the highest value of manganese leaves concentration was recorded by Olinda trees when compared with the other two cultivars in the two experimental seasons.
In this respect, availability of essential minerals during morphological and physiological process can play an important role in growth and fruit setting in Valencia orange trees [19]. Plant nutrition status has also been associated with citrus flowering [42]. The number of growing citrus fruitlets that survive after June drop is mainly determined by nutritional factors such as photo assimilates [43]. Also, fertilization play important role in the production of fruit for the fresh market and processing [44].

4. CONCLUSION

In conclusion, it could be reported that, microscopically measurements and microphotographs showed distinct differences between the histological leaf and fruitlets characters of the cultivars studied. Whereas, Campbell gave the higher values of most tissues measurements under study than Olinda and Delta trees. Also, the highest values of flavedo thickness were recorded by Delta followed by Campbell fruitlts. Segments width showed the highest value in Olinda followed by Campbell and Delta, respectively. While the thickness of the wall between segments showed the highest values in Campbell followed by Delta. Hence, Campbell trees had the highest values of tree canopy, number of fruits, fruit yield, T.SS/ acid ratio and carbohydrates concentration. The highest values of fruit size, fruit weight as well as fruit juice percentage were recorded by Olinda cvs fruits. On the other hand, the highest values of fruit firmness, fruit peel thickness and total phenols concentration were recorded by Delta cultivar. In addition, Campbell produces the highest yield and best fruit quality parameters, whereas Olinda fruits gave the highest fruit juice percentage which is an extremely important parameter for its industrial processing, being also related to size were obtained by Olinda Valencia trees. So, we can recommend that Campbell and Olinda proved as reliable cultivars under the prevailing agro-climatic conditions of South El Tahrir district, Egypt.

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