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Morpho-Chemical and Sensory Profiling of Some Egyptian Table Olive Cultivars and New Genotypes

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Abstract: As the climatic change has a direct effect on olive trees productivity and negatively affects olive manufacturing process in Egypt. So, it has become necessary to re-evaluate the cultivars which are more resistant to climatic conditions especially local cultivars and selected new olive genotypes to achieve a distinguished competitive in entering global markets. For this reason, three of local olive cultivars (Toffahi, Aggizi Shame and Aggizi Akse) that appears tolerance to climatic conditions were selected to re-evaluate with seven genotypes (G102, G97, G67, G55, G54, G24 and G16) produced from the project of "Genetic improvement of Olive" (CFFC) IOC. The present investigation was conducted during two successive seasons (2022 and 2023) to find out the most important characteristics of these cultivars and genotypes and selecting the most superior ones in fruit quality and productivity, which meeting the international market requirements and are suitable to expand in the new regions. The genotypes and cultivars have been analyzed according the methodology for primary characterization of International Olive Council. The results indicated that, all tested genotypes are classified as a table olive and compete in their characteristics of flesh weight and flesh/stone weight ratio with the other common table cultivars. Whereas, G97, G102 and G55 were the highest genotypes in the industrial parameters and sensorial characteristics which means the recommendation to expand their cultivation especially with the declined production as a result of the climate changes.

Keywords: *Olea europaea*, evaluation, genotypes, cross breeding, fruiting, sensorial analysis

1. Introduction

The cultivation of the olive tree (*Olea europaea* subsp. Europaea) is of great importance in terms of its ecology, economy and culture in the Mediterranean Basin **(Carrion *et al.*, 2010)**. Olive cultivation is considered to be an agricultural ecosystem with significant potential for production opportunities (e.g. oil and wood), environmental impacts (e.g. water availability, CO_2 emission contribution) and cultural heritage e.g. biodiversity conservation **(Hains-Young *et al.*, 2012)**. Table olives are food product consumed worldwide, with significant importance in the Egyptian diet due to their unique flavor, aroma, and nutritional properties. The quality and marketability of table olives can be affected by their morphological, chemical, and sensory characteristics, which can vary significantly among different cultivars. Therefore, evaluating these characteristics is essential for selecting the appropriate cultivars for the production of high-quality table olives. Moreover, the introduction of new olive cultivars could enhance the productivity and quality of the Egyptian olive industry **(Tovar *et al.,* 2019** and **Nasr and Mohamed, 2020)**.

Morphological characteristics of olive cultivars, such as size, shape and color can provide an initial indication of their quality and potential use. However, the chemical composition of table olives is also important, as it can affect their nutritional value and stability. The main components of table olives are water, fat and carbohydrates with variations in their concentrations among different cultivars. Furthermore, table olives contain several bioactive compounds, such as polyphenols which have been associated with several health benefits **(Cicerale *et al.,* 2009** and **Dabbou *et al.,* 2011)**.

Sensory properties (aroma, flavor, and texture) are essential characteristics that determine the overall quality, acceptability and marketability of table olives. Sensory evaluation can provide information on the consumer preferences and acceptability of different table olive cultivars **(El-Riachy *et al.,* 2019; Amira *et al.,* 2020** and **IOC, 2021)**.

The changes in climate conditions and water availability in recent years have to led a significant decrease in the olive tree flowering phenology that impact on the productivity and quality of the olive industry **(Oteros *et al.,* 2013; Aybar *et al.,* 2015** and **Garcia-Mozo *et al.,* 2015)**.

It has become necessary to study and evaluate new olive genotypes resulting from breeding programs that have shown good specifications in terms of high productivity and tolerant for climatic changes **(Bellini *et al.,* 2002; Arsel and Cirik, 1994** and **Pannelli *et al.,* 2006)**. Description the morphological characterization of olive cultivars and genotypes are considered the most important parameters in distinguishing different cultivars, specially the new genotypes that produced from breeding programs and nominated for registration **(Konstantions *et al.,* 2024)**.

In Egypt, over the past years, olive cultivations have been significantly impacted by climatic change, therefore, there has been interested in highlighting on newly introduced genotypes resulted from the olive breeding program which has been initiated in Egypt since 1994 in Horticultural Research Institute, by crossing between local and foreign cultivars; evaluation the agronomical behaviors, traits of fruit quality and resistant to current climate conditions provide valuable information about the potential of new genotypes for producing high-quality table olives before cultivated in newly reclaimed areas **(El-Sayed, 2014; Mikhail, 2015; Shereen, 2019; El-Husseiny and Shaker, 2020** and **Omran, 2021)**.

Through this research, light will be shed on the morphological, chemical, and sensory analysis of three local olive table cultivars and seven of table newly genotypes by using the international ranking of table olives, for helping to know valuable information about the potential of new genotypes for producing high-quality table olives the and the market demand and profitability of the final product.

2. Materials and Methods

2.1. Site description

This investigation was conducted in the experimental orchard of Horticulture Research Institute, Agricultural Research Center, Giza, Egypt., during 2022 and 2023 seasons on eight years old tree of three of local olive cultivars (Toffahi, Aggizi Shame and Aggizi Akse) and seven genotypes (G102, G97, G67, G55,G54,G24 and G16) produced from the project of “Genetic improvement of Olive” (CFFC) IOC at Horticulture Research Institute, Giza, Egypt (1994) by crossbreeding between several local and foreign cultivars with desirable characteristics as shown in table (1).

All studied genotypes and cultivars were propagated by leafy cutting under mist propagation system and established in olive collection farm of Horticulture Research Institute. The complete randomized design with three replicates and each replicate was represented by two trees. All of them were received the same agricultural practices as well as free from pathogens and physiological disorders.

Soil chemical and physical characteristics and water chemical properties were determined by the laboratory of Soil, Water and Environmental Research Institute, Agricultural Research Center, according to the methods described by **Jakson (1973)** and was summarized in Tables (2 & 3).

Table (1). Cultivars and genotypes according to the project map of Olive improvement program

Cultivars and Genotypes	Mother	Derived from
Toffahi	Local Cultivar	
Aggizi Shame	Local Cultivar	
Aggizi Akse	Local Cultivar	
G16	Aggizi Shame	open pollination
G24	Aggizi Shame	♀ Aggizi Shame x Kalamata ♂
G55	Manzanillo	open pollination
G97	Manzanillo	open pollination
G102	Manzanillo	open pollination
G54	Kalamata	open pollination
G67	Kalamata	open pollination

Table (2). Physical and chemical properties of the soil under study

Property	Value	Property	Value
Sand (%)	27.48	Available micronutrients (mg kg^{-1})	
Silt (%)	34.22	Fe	6.71
Clay (%)	38.30	Mn	6.52
Texture	Clay loam	Zn	4.68
$CaCO_3$ gkg$^{-1}{}_3$	45.6	Soluble ions (meq/L)	
EC (dS m^{-1})	2.92	Ca^{++}	13.8
pH (1:2.5) susp.	7.88	Mg^{++}	10.5
Organic matter (%)	2.29	Na^{+}	4.6
Available macronutrients (mg kg^{-1})		K^{+}	0.70
N	33.30	HCO_3^{-}	5.8
P	5.50	Cl^{-}	8.0
K	360	$SO^{--}{}_4$	15.8

Table (3). The chemical analyses of the tested water sample (Nile water) collected from the experimental area

E.C (dS/m)	**pH**	**Cations (meq/L)**				**Anions** (Meq/L)			SAR
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}	
0.55	7.84	1.50	1.53	1.32	0.18	1.40	1.40	1.73	1.07
Some macro micro nutrients (ppm)									
N	**P**	**K**	**Fe**	**Mn**	**Zn**	**Cu**	**Pb**	**Ni**	**B**
1.36	0.54	7.02	0.02	0.04	0	0.04	0.01	0.01	0.07

2.2. Measurements

(I) Morphological characterization

(A) Quantitative measurements

- Tree: according methodology for primary characterization of olive **(IOOC, 1997),** the following parameters were obtained:

- Tree height (m)

It was classified to: Very small (< 2.0m), small (2.0-3.0m), medium (3.0-4.0m), large (4.0-5.0m) and very large (> 5.0m).

- Trunk perimeter (cm)

It was obtained by wrapping a flexible measuring tape around the tree trunk in the point 10 cm above soil surface

- Canopy perimeter (m)

It was obtained by measuring the average of 5 diameters of the tree canopy and calculating according to the following equation:

Canopy Perimeter = 2r*3.14   2r= the average of 5 diameters

- Leaf and vegetative measurements

Samples of approximately 40 adult leaves taken from the middle section of one years old shoots to determine the following measurements:

- Leaf length (L), width (W) and leaf shape index (L/W ratio).

- Leaf surface area(cm^2) according to following equation:

Leaf area =0.53 (length x width) +1.66 **(Ahmed and Morsy 1999)**.

- Shoot length, no. of leaves per shoot and internode length.

- Vegetative density: It was calculated by the following deducted equation:

No. of leaves per meter = 100* no. of leaves / shoot length (cm)

Fruit Characteristics

Fifty of fresh olive fruits were randomly hand-picked from the evaluated cultivars and genotypes to determine the length, width and weight of both fruit and stone as well as the flesh weight and the percentage of flesh/fruit were analyzed according to the International Olive Council standard method **(IOC, 2015).**

(B) Qualitative assessments

The morphological characteristics were used to distinguish olive cultivars and genotypes based on those described by International Olive Council **(IOOC, 1997)**, and all parameters of tree, leaf, fruit and stone were characterized as shown in table (4).

(II) Chemical Analysis

Chemical compositions of green olives were expressed in term of dry matter, oil% (dry weight), crude protein%, crude fiber%, ash% and reducing sugars % were determined according to the **A.O.A.C. (2005).**

(III) Sensorial Analysis

Sensorial analysis was occurred by the panel taste of (8 specializers) in this field and the data was recorded regarding the following model

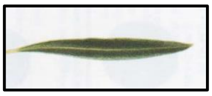
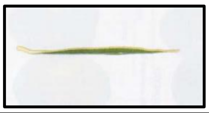
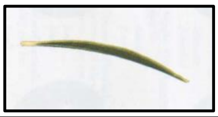
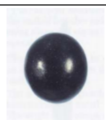
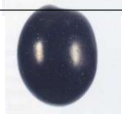
(1) Descriptive gustatory attributes (Basic flavors)

- Salty: Typical taste of salt or brined food (flavor of sodium chloride).

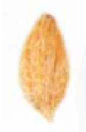
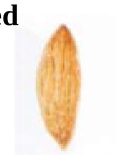
- Bitterness: Typical taste of caffeine or quinine.The bitterness index was measured following an adaptation of **Rodrigues *et al.* (2019)** method.

- Sour (acid): Odor and taste typical of the fermented foodstuffs (flavor of citric acid).

Table (4). The key of qualitative assessments of morphological characterization

Characteristics					
Tree	Vigor	Weak	Medium	Strong	
	Growth habit	Dropping	Spreading	Erect	
	Canopy density	Sparse	Medium	Dense	
Leaf	Shape	Elliptic (L/W<4) 	Elliptic-lanceolate (L/W4-6) 	Lanceolate (L/W >6) 	
	Length	Short (<5 cm)	Medium (5-7 cm)	Long (>7 cm)	
	Width	Narrow (<1 cm)	Medium (1-1.5 cm)	Broad (>1.5 cm)	
	Longitudinal curvature of the blade (L.C.B)	Epinastic 	Flat 	Hyponastic 	Helicoid 
Fruit	Weight	Low (<2g)	Medium (2-4g	High (4-6g)	V. high (>6g)
	Shape	Spherical (L/W <1.25) 	Ovoid (L/W 1.25-1.45) 	Elongated (L/W >1.45) 	
	Symmetry (in position A)	Symmetric 	Slightly Asymmetric 	Asymmetric 	
	Max. Transverse (in position B)	Towards Base 	Central 	Towards apex 	
	Apex	Pointed 	Rounded 		
	Base	Truncate 	Rounded 		
	Nipple	Absent 	Present 		
	Lenticels Presents	Few 	Many 		
	Lenticels size	Small 	Large 		
	Location of color	From apex	From base		

Cont. Table (4)

Characteristics					
Endocarp	**Weight**	**Low (<0.3g)**	**Medium (0.3-0.45g)**		**High (>0.45g)**
	Shape (L/W) (in position A)	**Spherical (<1.4)** 	**Ovoid (1.4 -1.8)** 	**Elliptic (1.8-2.2)** 	**Elongated (>2.2)** 
	Symmetry (in position A)	**Symmetric** 	**Slightly Asymmetric** 		**Asymmetric** 
	Max. Transverse Diameter (in position B)	**Towards Base** 	**Central** 		**Towards apex** 
	Apex (in position A)	**Pointed** 		**Rounded** 	
	Base (in position A)	**Truncate** 	**Pointed** 		**Rounded** 
	Surface (in position B)	**Smooth** 	**Rugose** 		**Scabrous** 
	No. of grooves	**Low (<7)**	**Medium (7-10)**		**High (>10)**
	Apex Termination	**With mucro** 		**Without mucro** 	

* Some characteristics refer to two positions. "Position A" is the position in which the fruit generally displays the greatest asymmetry when held by either end between the index finger and thumb. "Position B" is reached by turning 90^{o} from position "A" in such a way as to present the most developed part to the observer.

(2) Kinesthetic sensations (texture/ mouthfeel)

• Hardness: Necessary strength which is needed to compress the drupe between the thumb and the forefinger, or to bite the fruit between the molars or the incisive and can be: soft, firm and hard

• Fibrousness: The texture of some raw vegetables.

• Crunchiness: Mechanical strength to fracture the fruit with the molars

The recommended method of sensory analysis for Table Olives by **IOC (2021).**

(IV) Statistical Analysis

The experiment was arranged in a complete randomized design and the obtained data were subjected to analysis of variance and significant differences among means were determined according to **Snedecor and Cochran (1967)**. In addition, significant differences among means were distinguished according to the Duncan's multiple range test at 0.05 level of probability **(Duncan, 1955).**

3. Results and Discussions

(I) Morphological Characterization

(A) Quantitative Measurements

Tree height, trunk and canopy perimeter

According to the methodology for primary characterization of olives cited by the International Olive Oil Council **(IOOC, 1997)**, phenotypic characterization was estimated using certain parameters for tree vigor, as tree height and perimeter of the trunk and canopy, as shown in Table (5), The values of tree height significantly differed according to olive cultivars and genotypes (Table 5), it varied from 3.93 (m) in Aggizi Akse to 2.73 (m) in each of Toffahi, G24 and G54 in the first season, whereas Aggizi Shame was superiority in the second one and recorded the highest values of tree height 3.80 (m).

According to the methodology for primary characterization of olive varieties, the tree height of Toffahi, G97, G54 and G24 are classified as ***(medium)***, while, Aggizi Shame, Aggizi Akse, G102, G97, G55 and G16 classified as ***(large)***.

Trunk perimeter (cm) cleared vast variability between local cultivars and the tested genotypes. Each of G55 followed by Aggizi Shame and G97 cultivar acquired the highest trunk perimeter during two studied seasons.

Regarding to the canopy perimeter (Table 5), it has been stated that, significant difference was found among cultivars and genotypes it ranged from 13.19 to 21.04 in 1st season and from 13.71 to 22.08 in 2nd season. Aggizi Akse followed by G102, G16 and Aggizi Shame had the largest values in both seasons.

Table (5). Tree height (m), trunk perimeter (cm) and canopy perimeter (m) of ten of local olive cultivars and genotypes during 2022 and 2023 experimental seasons

Cultivar & Genotype	2022 Season			2023 Season		
	Tree height (m)	Trunk perimeter (cm)	Canopy perimeter (m)	Tree height (m)	Trunk perimeter (cm)	Canopy perimeter (m)
Toffahi	2.73e	42.67f	13.19d	2.80d	44.67f	13.71c
Ag. Shame	3.73ab	56.67b	18.84b	3.80a	58.33b	19.78b
Ag. Akse	3.93a	51.67d	21.04a	3.43b	53.33d	22.08a
G102	3.43bc	54.33c	19.78b	3.27bc	54.33d	20.41b
G97	3.17cd	55.00c	14.03cd	2.30e	56.67c	14.38c
G67	3.00de	50.00e	13.82cd	2.30e	52.00e	14.28c
G55	3.20cd	60.00a	13.82cd	2.27e	62.00a	14.13c
G54	2.73e	37.67h	13.19d	2.17e	39.67h	13.65c
G24	2.73e	51.67d	14.44c	2.35e	53.67d	14.74c
G16	3.73ab	41.00g	19.47b	3.17c	43.00g	19.80b

Values have the same letter are not significantly different at 5% level using Duncan's New Multiple Range Test

Leaf and vegetative measurements

Data presented in Table (6) exhibit significant mark variation in leaf and vegetative measurements.

Leaf length (cm)

The greatest values of the leaf length were significantly coupled with genotypes G67& G54 in both seasons on the contrary, there were a narrow statically variations among other cultivars and genotypes. The lowest values were in concomitant to each of Aggizi Shame and Aggizi Akse in 2022&2023 seasons.

According to the methodology for primary characterization of olive varieties leaves length of the tested cultivars and genotypes are classified as follow:

Toffahi, Aggizi Shame, Aggizi Akse, G102, G24 and G16 ***(short)***, G67, G67and G55 ***(medium)*** and G54 ***(long).***

Leaf width(cm)

Data of leaf width in Table (6), illustrated that, the G67 statistically acquired the maximum records (1.80& 1.82 cm) in both seasons respectively. On the other side, the lowest value was concomitant to G102 in both seasons.

The leaves width of tested cultivars and genotypes are described as follow:

Toffahi, Aggizi Shame, Aggizi Akse, G102 and G24 ***(medium)***, G97, G67, G 54 and G16 (***broad).***

Leaf shape index (L/W ratio)

Concerning to the calculated ratio between length and width (L/W), it could be noticed that, although there were no statically differences among Toffahi, G102, G67 and G54 but G54 was superiority in this concern in both seasons. On the other hand, although, each of Aggizi Shame, G 97 and G16 gave the least values in both seasons, but Aggizi Shame was the minimal one.

According the description of the International Olive Oil Council **(IOOC, 1997)**. The tested cultivars and genotypes are classified as follow:

Toffahi, G102, G67, G55, G54 **(*Elliptic-lanceolate*)**, while, Aggizi Shame, Aggizi Akse, G97, G24 and G16 ***(lanceolate)***.

Leaf surface area (cm^2)

As regard to leaf surface area in Table (6), it showed obviously the superiority of genotypes (G97, G67 and G54) which gave the highest values. On the other side genotypes G102 and Toffahi cv., had the lowest values in both seasons.

The internode length (cm)

The internode length measurements scored the highest values by each of genotypes G 55 & G54 in both seasons. The reverse was true with G102 that acquired the lowest values through two seasons of study.

Shoot length (cm)

The data in Table (6) recorded that, the values of shoot length significantly differed among cultivars and genotypes. The G55 produced the longest shoots in both seasons. Otherwise, shortest shoots were recorded by Toffahi, Aggizi Shame cultivars and G67 in both seasons.

The average number of leaves/shoot

The average number of leaves/shoot that presented in Table (6) showed considerable variations in this respect, herein, the greatest values of leaves number/shoot was cleared in G102 in both seasons. Whereas the lowest values attained by Toffahi & Aggizi cultivars and G67 in both seasons.

Vegetative density

Concerning the vegetative density of tested cultivars and genotypes (Table (6) it could be noticed that, the greatest value scored by genotype G102 during two studied seasons respectively. Whereas the least one attained by Aggizi Akse cultivars and genotypes G55, G54 and G67 respectively.

Differences in vegetative growth characteristics among olive cultivars and genotypes are supported by finding of **Aiachi *et al*., (2016)**; **El-Husseiny and Arafat, (2020)** and **Omran, (2021)**.

Fruit characteristics

Physical fruit and stone characteristics of tested cultivars and new obtained olive genotypes during 2022& 2023 were evaluated as follow:

Fruit length (cm)

As regard to the statistical analysis of fruit length (Table, 7) during 2022 & 2023 seasons, it cleared significant differences among cultivars and genotypes. The maximum length of fruit (3.27cm) was recorded by genotype G16 in the first season. Whereas, each of G 67 and G54 was superiority in the second one (3.15 & 3.12 cm) respectively. Otherwise, each of genotypes G102 & G 97 gave the least one in both seasons.

Fruit width (cm)

Displayed data of fruit width appears superiority of Toffahi cultivar (2.57& 2.58) in both seasons respectively, comparing with other cultivars and genotypes that acquired a narrow variation among them.

Fruit shape index (Fl/Fw)

The fruit shape index was one of the most stable traits used for evaluation the cultivars in breeding programs. Tabulated data in Table (7) demonstrated that, genotype (G54) was the superior to other genotypes and recorded significantly the highest fruit shape index in both studied seasons. Whereas, Toffahi cultivar tended to be the least in the first season and Aggizi Shame was in the second one.

Fruit weight (g)

In this regard, the collected data of olive fruit weight (Table, 7), it has been stated that, Toffahi cv., achieved the maximum weight (10.75 & 10.05 g) in both seasons respectively. Whereas, G97 gave the minimal weight (6.14G&5.47g) in 022&2023 seasons.

According to the International Olive Council standard method **(IOC, 2015)**. The fruits of tested cultivars and genotypes are classified as ***(very high weight)***

Stone length (cm)

Results in Table (7) demonstrated that, the highest values of stone length were observed in G54 in both seasons (2.21&2.21 cm) shared with G67 in the second one. On the other side G 16 & G 102 recorded the lowest values.

Stone width (cm)

Concerning the stone width, it could be noticed a narrow variability between the tested cultivars and genotypes during two studied seasons.

Shape stone index (Sl/Sw)

With regard to shape stone index of the olive cultivars and genotypes (Table, 8) it obviously that, the highest value was obtained by genotype (G24) in 1st and 2nd seasons. The lowest value was noticed by (G16) in both studied seasons. According to the description of International Olive Council **(IOC, 2015)**, the shape stone index of all cultivars and genotypes under study are classified as ***(Elliptic)*** except for each of genotypes G97&G 16 were ***(Ovoid).***

Stone weight (g)

The average of cultivars and genotypes stone weight that presented in Table (7) illustrated that, the greatest average stone weight was statistically detected by G 54 in the first and second season, shared with Toffahi and Aggizi Akse in the second season. On the other side, G24 in both seasons ranked least in this concern, shared with G102 in the first season. According to data analysis of stone weight, it was above (0.45g). According to International Olive Council standard, all of tested cultivars and genotypes stoned are classified as a **(*High stone weight).***

Flesh weight (g)

As regard to flesh weight, it could be noticed the superiority of Toffahi cv., which had the highest values (9.96& 8. 97) in both seasons respectively. On the other hand, the least values recorded in G97 in both seasons shared with G 55 in the first season.

Flesh/ stone weight ratio

Data in Table (7) displayed that, all investigated cultivars and genotypes was differing in flesh/ stone weight ratio during the first and the second studied seasons. The highest values were acquired by Toffahi in the first season (12.61%), whereas, the genotype (G24) was superiority (9.65 %) in the second one. On the contrary, the Aggizi Akse and G54 ranked statistically the least flesh/ stone weight ratio in the first season, whereas, G97 was in the second one.

There was a significant correlation between qualitative and quantitative traits of olive varieties under investigation that appears in fruit shape, endocarp shape, leaf shape.

Most morphological studies are based on a simplified scheme that has been adopted by International Olive Oil Council **(IOOC, 1997)** which focuses on the morphological characteristics of leaves, fruits and endocarps. These characteristics have been widely used for descriptive purposes to distinguish olive cultivars. According the methodology description, fruit weight and flesh to seed ratio are important criterion for table olive cultivar and genotypes and considered a primary characterization and commercial point of view in breeding studies **(IOC, 2015).** The obtained results regarding quantitate characteristic and qualitative fruit and stone characteristics allowed classified the studied genotypes, this result is in line with those of **Rallo (2014), Dridi *et al.* (2019)** and **El-Husseiny and Arafat (2020),** who reported that those agronomic characteristics allowed classification of different olive cultivars.

Moreover, **El-Riachy *et al.* (2019), Nasr and Mohamed (2020)** and **Omran (2021)** mentioned that, morphological and biological characteristics widely for distinguishing olive cultivars**.**

(II) Chemical analysis

Analysis of moisture (%), oil percentage (DW), proteins (%), fibers (%), ash (%) and reducing sugars (%) on the fruits from different investigated cultivars and genotypes are illustrated in Table (9), the results indicated the existence of significant differences among them with few exceptions in both seasons.

Moisture percentage

Data in Table (9) showed that, the moisture percentage ranged from (77.48 &76.51) in Toffahi cultivar in the first and second season to (59.28) in G54 in first season and (64.82) in G55 in the second one.

Oil percentage in dry weight

As regard to oil percentage (DW), it appears significant differences among olive cultivars and genotypes. The highest oil percentage was attained by G54, genotype G24 ranked statistically the second in both seasons. Otherwise, the opposite was recorded by Toffahi cultivar which recorded the lowest percentage in both studied seasons.

Crude protein content

Data in Table (9) indicated that, there was a variation among olive cultivars and genotypes during two seasons under study. Toffahi cultivar was superiority and gave the highest value in the first season. Moreover, in the second season, the highest values recorded by each of Toffahi, Aggizi Shame and Aggizi Akse cultivars. Conversely, the lowest values noticed by G102, G97 and G 16 in both seasons respectively.

Fibers percentage

Concerning the fibers (%), data presented in Table (9) showed differences during first and second season. Aggizi Akse was superiority in both seasons and recorded the highest percentage (12.89 &12.55%) followed by genotype G55& G16 in the first season and G67, G54&G24 in the second one. Conversely, Toffahi cultivar recorded the lowest percent during 2022&2023 seasons.

Ash percentage

It quite evident from the tabulated data (Table, 9) that, ash values were quite similar among all olive cultivars, varying from 3.71% to 3.01% in the first season and from 2.90 to 1.22 in the second season. The highest ash value was concomitant to Toffahi and Aggizi Akse cultivars in both seasons shared with Aggizi Shame in the first seasons. On the other side the lowest percentage were attained by G102 in both seasons.

Reducing sugars percentage

Results in Table (9) showed that, Toffahi cultivar recorded the maximum reducing sugar (5.69& 3.76) in both seasons respectively. While, the reverse was true with G97 which recorded significantly least value in both seasons shared with G 102 in second one. Moreover, the rest cultivars and genotypes were in between.

Table (6). Leaf and vegetative measurements of ten of local olive cultivars and genotypes and during 2022 and 2023 experimental seasons

Cultivar & Genotype	Leaf length (cm)	Leaf width (cm)	Leaf shape index (L/W)	Leaf area surface (cm^2)	Internode length (cm)	Shoot length (cm)	No. of leaves /shoot	Vegetative density
2022 season								
Toffahi	4.67cd	1.07fg	4.39ab	4.29d	1.46d	17.00g	21.33ef	124.7c
Ag. Shame	4.47d	1.40d	3.19d	4.97c	1.76b	17.67f	22.67de	134.50b
Ag. Akse	4.47d	1.17e	3.84c	4.42d	1.89ab	21.50d	24.00d	111.1d
G102	4.50cd	1.03g	4.37ab	4.12d	1.16e	20.83e	39.33a	189.0a
G97	6.10b	1.80a	3.39d	7.48a	1.51d	23.83c	31.33b	133.5b
G67	6.80a	1.60b	4.26b	7.43a	1.75bc	17.50fg	20.00f	115.6d
G55	4.75cd	1.15ef	4.13bc	4.56cd	1.97a	29.17a	32.00b	109.1d
G54	7.17a	1.53bc	4.67a	7.49a	2.07a	25.17b	28.00c	111.1d
G24	4.60cd	1.20e	3.83c	4.60cd	1.55cd	21.67d	28.00c	133.6b
G16	4.93c	1.51 bc	3.29d	5.58b	1.72bc	23.33c	30.00bc	130.8b
2023 season								
Toffahi	4.70cd	1.08ef	4.35ab	4.35ab	1.50e	17.57e	22.67e	128.4d
Ag. Shame	4.50d	1.43c	3.14d	5.08c	1.80bc	18.20e	24.33de	139.3bc
Ag. Akse	4.50d	1.20d	3.77c	4.51d	1.92a-c	21.82d	25.33d	115.7e
G102	4.55cd	1.06f	4.31ab	4.21d	1.18 f	21.27d	41.00a	192.8a
G97	6.14b	1.82a	3.37d	7.59a	1.52e	24.17bc	33.67b	141.4b
G67	6.84a	1.63b	4.21ab	7.56a	1.78b-d	17.92e	22.00e	123.7d
G55	4.78cd	1.17de	4.10bc	4.62cd	1.99ab	29.63a	34.00b	114.2e
G54	7.19a	1.57b	4.57a	7.66a	2.09a	25.55b	29.00c	113.3e
G24	4.64cd	1.23d	3.77c	4.70cd	1.58de	22.00d	30.00c	140.2b
G16	4.97c	1.53b	3.24d	5.70b	1.75cd	23.67c	31.33c	134.4c

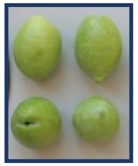
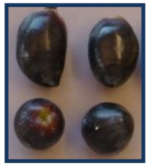
Values have the same letter are not significantly different at 5% level using Duncan's New Multiple Range Test

Table (7). Physical fruit and stone characteristics of ten of local olive cultivars and genotypes and during 2022 and 2023 experimental seasons

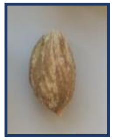
Cultivar & Genotype	Fruit length (cm)	Fruit width (cm)	F.L/F.W	Fruit weight (g)	Stone length (cm)	Stone width (cm)	S.L./S.W	Stone weight (g)	Flesh weight (g)	Flesh/stone weight ratio
2022 season										
Toffahi	2.90c	2.57a	1.128e	10.75a	1.75e	0.90bc	1.944f	0.79e	9.96a	12.61a
Ag. Shame	2.92c	2.40b	1.217d	8.91c	1.88c	0.92b	2.043e	0.97c	7.95c	8.20 f
Ag. Akse	2.73d	2.16d	1.264c	6.97e	1.79de	0.92b	1.946f	1.04b	5.93ef	5.70 i
G102	2.60e	2.11d	1.232d	6.14g	1.62f	0.77d	2.104d	0.57f	5.57fg	9.77d
G97	2.68de	2.12d	1.264c	6.42fg	1.80c-e	0.95ab	1.895g	0.94cd	5.47g	5.82 h
G67	3.09b	2.27c	1.361b	8.69c	2.05b	0.84c	2.440b	0.93cd	7.76c	8.34 e
G55	2.70d	2.11d	1.280c	6.26fg	1.77de	0.85c	2.082d	0.80e	5.47g	6.84 g
G54	3.14b	2.09d	1.502a	7.58d	2.21a	0.96ab	2.302c	1.14a	6.44d	5.65 i
G24	2.87c	2.11d	1.360b	6.71ef	1.85cd	0.75d	2.467a	0.58f	6.13de	10.57b
G16	3.27a	2.56a	1.277c	10.18b	1.62f	0.99a	1.636h	0.89d	9.30b	10.45 c
2023 season										
Toffahi	2.91bc	2.58a	1.128c	10.05a	1.98b	0.96a	2.063e	1.08ab	8.97a	8.31 c
Ag. Shame	2.79c	2.39b	1.167g	8.01c	1.74cd	0.94a	1.851g	0.99c	7.02c	7.09 e
Ag. Akse	2.87bc	2.18de	1.317c	7.67c	2.01b	0.95a	2.116d	1.11ab	6.56cd	5.91 g
G102	2.58d	2.00f	1.290d	6.35e	1.67de	0.87b	1.920f	0.75e	5.59e	7.45 d
G97	2.57d	2.01f	1.279de	5.47f	1.75cd	0.98a	1.786h	0.86d	4.61f	5.36 i
G67	3.15a	2.32bc	1.358b	9.04b	2.13a	0.88b	2.420b	1.06bc	7.98b	7.53 d
G55	2.80c	2.00f	1.400a	6.56e	1.81c	0.88b	2.057e	0.84d	5.72e	6.81 f
G54	3.12a	2.20d	1.418a	7.66c	2.21a	0.94a	2.351c	1.15a	6.51d	5.66 h
G24	2.88bc	2.11e	1.365b	7.03d	1.92b	0.76c	2.526a	0.66f	6.37d	9.65 a
G16	2.93b	2.31c	1.268e	9.00b	1.63e	0.95a	1.716 i	0.90d	8.10b	9.00 b

Values have the same letter are not significantly different at 5% level using Duncan's New Multiple Range Test

Table (8). The most important qualitative Assessments of three local olive cultivars and seven genotypes

Characteristics		Toffahi	Ag. Shame	Ag. Akse	G102	G97	G67	G55	G54	G24	G16
Tree	Vigor	Medium	Medium	Strong	Medium	Medium	Medium	Weak	Strong	Medium	Medium
	Growth habit	Spreading	Spreading	Spreading	Spreading	Spreading	Spreading	Dropping	Spreading	Spreading	Spreading
	Canopy density	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Leaf	Shape	Elliptic-lanceolate	Elliptic	Elliptic	Elliptic-lanceolate	Elliptic	Elliptic-lanceolate	Elliptic-lanceolate	Elliptic-lanceolate	Elliptic	Elliptic
	Length	Short	Short	Short	Short	Medium	Medium	Short	Long	Short	Medium
	Width	Medium	Medium	Medium	Medium	Broad	Broad	Medium	Broad	Medium	Medium
	L.C.B	Flat	Flat	Flat	Flat	Flat	Flat	Flat	Flat	Flat	Flat
	Photo										
Fruit	Weight	V. high	V. high	V. high	V. high	V. high	V. high	V. high	V. high	V. high	V. high
	Shape	Spherical	Spherical	Ovoid	Spherical	Ovoid	Ovoid	Ovoid	Elongated	Ovoid	Ovoid
	SymA	Symmetric	Slightly asymmetric	Symmetric	Slightly asymmetric	Symmetric	Slightly asymmetric	Slightly asymmetric	Asymmetric	Asymmetric	Slightly asymmetric
	Max. Transverse	Central	Central	Central	Central	Central	Towards apex	Central	Central	Central	Towards apex
	Apex	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Pointed	Pointed	Rounded
	Base	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated
	Nipple	Absent	Obvious	Obvious	Tenuous	Obvious	Tenuous	Tenuous	Tenuous	Tenuous	Tenuous
	Lenticels Presents	Few	Few	Few	Many	Few	Few	Many	Many	Many	Few
	Lenticels size	Large	Small	Small	Small	Small	Small	Small	Large	Small	Small
	Location of color	From Apex	From Apex	From Apex	From Apex	From Apex	From Apex	From Apex	From Apex	From Apex	From Apex
	Photo										

Cont. Table (8).

Characteristics		Toffahi	Ag. Shame	Ag. Akse	G102	G97	G67	G55	G54	G24	G16
Endocarp	Weight	High	High	High	High	High	High	High	High	High	High
	Shape	Elliptic	Elliptic	Elliptic	Elliptic	Ovoid	Elongated	Elliptic	Elongated	Elongated	Ovoid
	SymA	Slightly asymmetric	Slightly asymmetric	Symmetric	Slightly asymmetric	Slightly asymmetric	Slightly asymmetric	Slightly asymmetric	Asymmetric	Asymmetric	Slightly asymmetric
	Max. Transverse	Central	Central	Central	Central	Central	Central	Central	Towards base	Towards apex	Towards apex
	Apex	Pointed	Pointed	Pointed	Pointed	Rounded	Pointed	Pointed	Pointed	Pointed	Rounded
	Base	Truncated	Pointed	Rounded	Rounded	Rounded	Pointed	Rounded	Truncated	Pointed	Rounded
	Surface	Scabrous	Scabrous	Rugose	Rugose	Rugose	Rugose	Scabrous	Scabrous	Rugose	Rugose
	No. of groves	Medium	High	Medium	High	Medium	Medium	Many	High	Medium	Medium
	Apex Termination	With mucro	With mucro	With mucro	With mucro	With mucro	With mucro	With mucro	With mucro	With mucro	With mucro
	Photo										

Olive ID is a computer approach for morphological study of olives that finds distinctive geometrical characteristics which are linked to distinct morphological traits that enables us to quantitatively and qualitatively analyze the morphology of the olives traits of each cultivar as shown in Table (8).

Table (9). Some chemical analysis of ten of local olive cultivars and genotypes and during 2022 and 2023 experimental seasons

Genotype	Moisture (%)	Oil % (Dry weight)	Proteins (%)	Fibres (%)	Ash (%)	Reducing sugars (%)
First Season						
Toffahi	77.48a	8.45j	2.85a	10.01h	3.71a	5.69a
Ag. Shame	74.02b	11.11i	2.70b	11.78c	3.66a	3.74e
Ag. Akse	68.34g	12.70g	2.67b	12.89a	3.56a	3.77e
G102	73.44c	19.00f	1.40f	11.23e	3.03d	3.92de
G97	71.81d	12.44h	1.39f	11.56d	3.55b	3.30f
G67	65.05i	19.89e	2.24d	11.25e	3.23bc	4.67c
G55	69.52e	21.55c	1.67e	11.90b	3.23bc	4.53cd
G54	59.28j	33.84a	2.44c	11.00f	3.35b	4.49cd
G24	66.82h	31.68b	2.45c	10.45g	3.29b	5.10b
G16	68.55f	20.52d	1.37f	12.00b	3.11cd	4.00d
Second Season						
Toffahi	76.51a	8.90i	2.90a	9.93f	2.90a	3.76a
Ag. Shame	75.12c	9.81h	2.65a	11.98c	2.65b	3.66c
Ag. Akse	73.10d	9.70h	2.78a	12.55a	2.78ab	3.56d
G102	72.66e	20.90e	1.34d	11.45d	1.22f	2.98f
G97	75.86b	11.48g	1.22d	11.23e	1.34ef	3.00f
G67	68.10g	18.67f	2.15b	12.37b	2.15c	3.68bc
G55	64.82i	21.75c	1.78c	11.87c	1.78d	3.21e
G54	65.70h	34.85a	2.23b	12.40b	2.23c	3.78a
G24	68.01g	34.36b	2.26b	12.45ab	2.26c	3.69b
G16	72.16f	21.45d	1.370d	12.00c	1.37e	3.76a

Values have the same letter are not significantly different at 5% level using Duncan's New Multiple Range Test

Moisture content of the fruit is important to fruit quality for a number of reasons, if the fruit moisture level drops to a point where desiccation occurs cell break down follow leading to increase free fatty acids therefore lowering oil quality **(Montano, *et al.*, 2010** and **Anabella *et al.*, 2011)**.

Results appear an inverse relationship between oil content and moisture content. Moreover, there were an inverse relationship between oil and sugars content, gave rise to a hypothesis on their biochemical relationship. Sugars decrease in a continuous manner when oil is accumulated in the fruit **(El-Sorady, 2010** and **Badawy *et al.*, 2020)**. Three olive cultivars (Toffahi, Aggizi Shame, and Aggizi Akse) showed an inverse association between fruit oil and protein percent; in contrast a positive correlation between oil and protein content during ripening was demonstrated **(Marsilio *et al.*, 2001; Kailis and Harris, 2007** and **Namrata *et al.*, 2023)**.

Determined the suitable harvesting stage is important for fibers and ash content. A decreasing trend for dietary fiber content, from the early-ripening stage to the late-ripening stage. Moreover, an increase of ash content in table olives, during ripening stage, presents lower levels in the earlier ripening stages. Such fact is in accordance with the ripening stages of the different cultivars of table olives that were hand-picked still green. A low content of ash also means low salt contents (sodium chloride) which is nutritionally more suitable **(Menz and Vriesekoop, 2010** and **Yasin and Sefik, 2016)**.

Soluble reducing sugars are the most important components with respect to the fermentation and preservation stages in all types of table olive processing. The changes in these compounds affect greatly the processing of olives because their preservation is highly dependent on strong lactic acid fermentation **(Kailis and Harris, 2007)**. Sugars are the main soluble components in olive tissues and play an important role, providing energy for metabolic changes **(El-Badawy *et al.*, 2019).** In table olive processing sugars act as carbon source for microorganisms for producing secondary metabolites responsible for good characteristics and the distinctive flavor of the commodities **(Medina *et al.*, 2012)**.

(III) Sensorial analysis

Sensory analyses of pickled fruits were investigated after 6 months of fermentation process under control conditions. Average values of 6 sensory parameters were divided as two groups, the main groups included (salty, bitterness and sour), the second included (hardness fibrousness and crunchiness). Each parameter receives a rating from (0 to10); the tested cultivars and genotypes were evaluated as shown in Fig. (1). Comparing the sensory characteristics of the tested cultivars and genotypes, results revealed that, each of Aggizi Shame, Aggizi Akse and genotype 97 showed the highest salty values. Moreover, all of tested cultivars and genotypes were characterized by lower level of bitterness (2.0); the highest of them appears in both genotypes 97 and 54. Additionally, each of Aggizi Akse and genotypes (G67& G24) were characterized by higher level of acidity (sour) as comparing with other tested cultivars and genotypes. As regard to the hardness and crunchiness (Figure, 1), it noticed that, the highest value of hardness (7.0) and crunchiness (5.0) scored by each of Aggizi akse and G97. Finally, the highest value of fibrousness (5.5) attained by each of Aggizi Shame and Akse cultivars with G97.The results of sensory characteristic were in agreement with **Ricardo *et al.* (2011)** and **Lopez *et al.* (2024)**.

4. Conclusions

This study of tested olive cultivars and genotypes successfully developed specific descriptors for morphological characterizes (tree height, trunk perimeter and canopy perimeter, leaf and vegetative measurements, physical of fruit and stone characteristics), chemical characterizes (moisture%, oil%, protein %, ash %, fibers% and reduction sugars) and sensory profiles, including (crunchiness, hardness, bitter, fibrousness, salty and sour) and from the correlation between the physicochemical and sensory characteristics, it can be concluded that, all tested genotypes are classified as a table olive and compete in their characteristics of flesh weight and flesh/stone weight ratio with the other common table cultivars. Whereas, G97, G102 and G55 were the highest genotypes in the industrial parameters and sensorial characteristics which means the recommendation to expand their cultivation especially with the declined production as a result of the climate changes.

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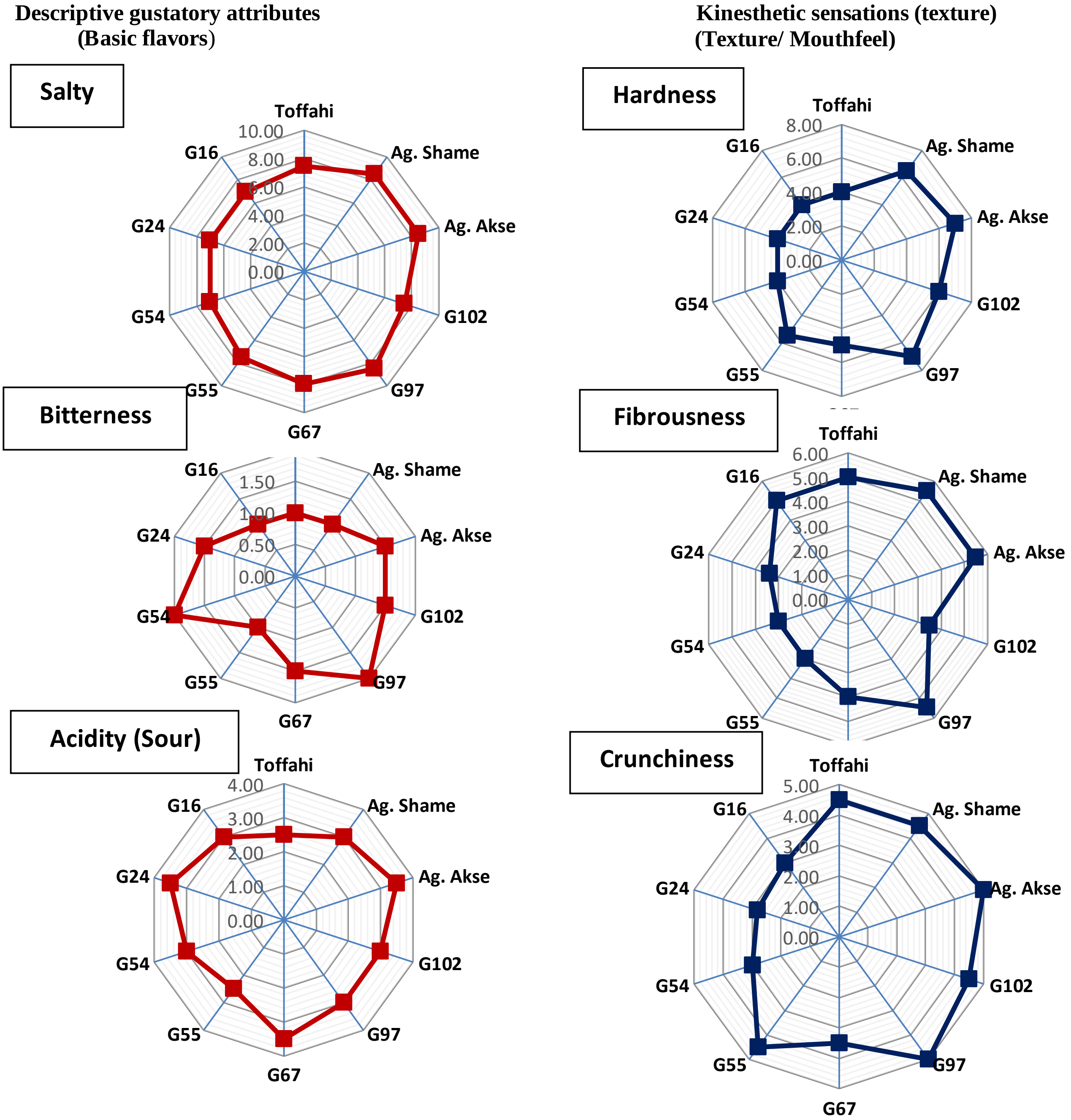

Fig. (1). Descriptive gustatory attributes Kinesthetic sensations of three of local cultivars and seven of genotypes produced from Genetic improvement of Olive

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