EFFECT OF FOLIAR FERTILIZATION FOR OLIVE TREES ON THE BIOACTIVE COMPOUNDS, PURITY AND ORGANOLEPTIC ATTRIBUTES OF OLIVE OILS

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Abstract

This investigation was carried out during two seasons 2014 and 2015 at farm located EL -Nobarya, EL-Behera governorate, Egypt, to study the influence of foliar fertilization with soluation of potassium and magnesium sulphate at ratios of 3 and 5% and 0.5 and 1.5%, respectively, on the organolyptic attributes, purity, overall quality index, stability, bioactive compounds (tocopherols, pigments, polyphenols and di-ortho phenols) and phenolic compounds of Koronaki olive oil under the environmental condition. The results were as follows : the spraying with potassium and magnesium sulphate at ratios of 5% and 1.5% foliar fertilization, respectively, gave the highest positive attribute (fruity) of olive oil, follwed by 3 and 0.5%, respectively compared with the control samples in seasons 2014 and 2015, while the defect properties of olive oil were equal to zero in both treated (foliar fertilized) and untreated (control) samples during two seasons under study. Results showed that the lowest parameters for K232 and K270 nm. of olive oil were obtained when olive trees were foliar fertilization by potassium and magnesium sulphate at different concentrations in two seasons compared with control samples, while Δk recorded slight increase as a result of all previous treatments. Oleuropein, ellagic and E-vanillic phenolic compounds recorded high content compared to other phenolic compounds in the control samples while ellagic compound decreased compared with the control samples during two seasons.. Commonly, most phenolic compounds increased as a result of all folair fertilization under study. Foliar fertilization with solution of potassium and magnesium sulphate at all concentrations caused a high increment in Epi-catechin and cinamic compounds in season 2015, whilst these compounds decreased in seasons 2014 compared to control samples . But it caused decrease in carotonoids content in two seasons and also in chlorophylls content in season 2014 only. On the other hand, it caused increase in total tocopherol in two seasons with a higher value (5%) for foliar fertilization. Therefore, folair fertilization by potassium and magnesium sulphate at different concentrations caused increment in di-o-phenols of olive oil compared to the control samples during two seasons..

Kaywords: Olive oil, organolyptic attributes, purity, polyphenols, tocophenols, pigments, di-O-phenols, overall quality index and phenolic compounds.

INTRODUCTION

Olive (Olea europeal) is a widely distributed tree grown healthy in many arid zone of the world native to the Mediterranean region. Olive is an overgreen tree, which are used for oil extraction and pickling. Olive fruits are considered as a rich source of phenolic compounds with a wide array of biological activities, the phenolic compounds in olives are recognized as potentially bioactive products and may have antioxidant and therapeutic properties that produce anti-cancer, anti-viral, anti-inflammatory, hypolipidaemic and hypoglycaemic effects (Obied et al., 2005). The main phenolic compounds in olive fruit are oleuropein, ligstroside, hydroxytyrosol and tyrosol (Ryan et al.,1999). Luteolin glucoside and rutin were detected only in olive peel. Similarly, Rovellini et al., (1997), analysed the flavonoid composition of fruit, husks, and leaves plus olive oil.

The pool of minor compounds may be shifted towards the accumulation of antioxidants based on the availability of precursors, enzymes activators (or co-factors) and or other effectors, such as nutrients availability during the vegetative growth of the plant . Oil quality could be influenced by the levels of available nutrients in foliar fertilizer that is possible to optimize oil composition and to obtain the oils enriched with beneficial phytochemicals, especially polyphenols which were significantly correlated with oxidative stability (Meriem et al., 2013).

Foliar application of nutrients is in general helpful to satisfy plant requirement and has a high efficiency. Potassium application to trees is an attractive method especially in arid zones where a lack of water under low rainfall conditions in summer drastically depresses absorption of soil nutrients .Potassium is known, not only to play an important role in olive yield and quality but also in water use efficiency, it is easily absorbed and distributed through leaf tissues and plays an important role in growth of olive (Hegazi et al., 2011).

Del Rio et al., (2003) described the phenol enhancing effect of a nutrient solution. After spraying it on olive trees, several phenolic compounds (tyrosol, catechin oleuropein) increased in leave stems roote and fruits. Besides, giving the increasing evidence of the role of nutrients and nutrient status of olive tree in the final oil quality .Potassium fertilization decreases the chlorophyll content with low value for folair treatment which could be an indication of fruit maturity, but it caused increase in polyphenols (Ben Mimoum et al., 2004).

The main objectives of this study were to study the changes in phenolic compounds, organoleptic attributes,overall quality index, purity and some bioactive compounds of olive oil as a result foliar fertilization.

MATERIALS AND METHODS

Materials:-

1- Olive fruits : This experiment was carried out during two successive seasons (2014 & 2015) on ten-years-old Koroneiki olive trees planted at 5 X 5 m and grown in sandy soil at the Experimental research station of National Research Center at El Nobarya, El Behera governorate, Egypt. The soil was characterized by: pH = 8.82, EC =1.11 dS/m, organic matter = 0.31%, $CaCO3$ =12.8 %, Sand = 63 %, Silt = 13 % and clay = 3%. Drip irrigation system was applied using river Nile water. Trees were of normal growth, uniformed in vigour and received the same horticultural practices. The experiment followed complete randomized block design on 15 trees as 5 treatments were applied. Each tree was considered a replicate, three replicates trees per each treatment. Selected trees were sprayed with potassium sulphate K_2So_4 (3 and 5 %), and magnesium sulphate $MgSo_4$ (0.5 and 1.5 %) besides control (spraying with water only). The response to investigated treatments was evaluated through determining the following parameters: -

Methods:-

1. Oil extraction: 5 Kg fruits from treated and untreated olive trees of koroneki cultivar were crushed and packed in cheese cloth then pressed using a laboratory hydraulic press. The pressure was 12.000 Ib/in^2 for 30 min/ one which was reached gradually. The extracted oil was dried over anhydrous sodium sulfate, through a whatman filter paper No.1 and kept in brown glass bottles at -5ºC till their analysis.

2. Some chemical properties of olive oil samples:-

- **Acidity (as oleic acid %) and peroxide values** (meq O_2 /kg oil) were determined according to the methods of the A.O.A.C. (1995).

- **Determination of fatty acid composition:** The fatty acids methyl esters were prepared using trans-estrification with cold methanolic solution of potassium hydroxide. The fatty acids methyl esters were identified by GC- capillary column according to the method of IOOC (2001).
- **Oxidative stability** was evaluated by the Rancimat method (Mendez et al., 1997). Stability was expressed as the oxidation induction time (hours), measured with the Rancimat 679 apparatus (Metrohm Co., Switzerland), using 5g oil sample and heated to 100ºC with air flow rate of 20 L/h**.**

3. Organoleptic attribute: The organoleptic assessment of virgin olive oil was conducted according to the method (profile sheet) described by IOC (2007).

4. Purity of olive oils: The purity of olive oils cab be determined from three parameters K_{232} , K_{270} nm and Delta K.(Jorge and Perkin Elmer, 2008).

• **Absorbancy in ultraviolet** at 232, 270, 266 and 274 nm. as deseribed by Kates (1972).

• Δk was calculated according to the method in the IOOC (2001) as the following equation:

$$\Delta k = A270 - (A266 + A274)/2$$

5. Overall Quality Index (OQI):-

The overall quality index (OQI) was introduced by the International Olive Oil Council (IOOC) to express virgin olive oil quality numerically (IOOC, 1990). This is a scale from 0 to 10 that considers four quality parameters: the score for sensory evaluation (SE), free acidity (FA), K_{270} and peroxide value (PV) according to the following equation:

$$OQI = 2.55 + 0.91SE - 0.78FA - 7.35K270 - 0.066PV.$$

6. Determination of some bioactive compounds in olive oil samples:-

• **Determination of total polyphenols** was determined in olive oil samples according to the method of Gutfinger (1981).

• **Identification of phenolic and flavonoid compounds** was done by HPLC according to the methods of Goupy et al. (1999).

• **Determination of total tocopherols** was determined according to the method described by Wong et al.(1988).

• **Determination of total pigments (chlorophyll and β – carotene):** The chlorophylls of oil samples were determined according to the method of Mosquera et al. (1991) , while the
β carotene as described by Pupin et al. (1999).

RESULTS AND DISCUSSION

Chemical composition of olive oil samples:-

As shown in Tables (1 & 2) . Folair fertilization with potassium and magnesium sulphate during two seasons (2014 and 2015) caused increase for acidity in two seasons and for peroxide value in season only 2014 of olive oil compared to control sample, but it decreased in season 2015. Also, the data in the same previous tables showed the changes in fatty acid composition of olive oil as a result of folair fertilization for olive trees by potassium and magnesium sulphate at different percentages (3 and 5%) and (0.5 and 1.5%), respectively, during seasons (2014 and 2015). From the results in season 2014; the saturated fatty acids found in control sample were palmitic acid (C16:0) (14.46%) followed by stearic acid (C18:0) (2.20%). Palmitic acid decreased in all samples, while stearic acid recorded slightly increased in all samples as a result of all folair fertilization. Oleic acid (C18:1) is the major unsaturated fatty acid in olive oil, it was 69.70% in control sample, this value increased to 72.55 and 70.94% at ratios of potassium sulphate (3 and 5%, respectively), but decreased to 69.44 and 68.29% at ratios of magnesium sulphate (0.5 and 1.5%, respectively). While lenolenic acid (C18:3) recorded a slightly decreased at different ratios of potassium and magnesium sulphate. On the contrary, in season 2015 folair fertilization by potassium and magnesium sulphate at different ratios caused increase in palmitic and linoleic acids (C18:2), but it caused decrease in oleic acid compared with the control samples. While linolenic acid decreased by only folair fertilization with potassium sulphate at different ratios. Generally, no clear effect of all folair fertilization was detected on total saturated fatty acids (TSFA) and total unsaturated fatty acids (TUSFA) in season 2014, but TSFA recorded slightly increase as a result of all folair fertilization contrary with TUSFA during season 2015. This difference in some chemical and fatty acid composition of olive oils as a result of folair fertilization during two season may be due to environmental conditions during the vegetable growth of the olive trees.

Table 1. Some chemical characteristices of foliar fertilized and control samples of olive oils in season 2014.

Item / Samples	Control	Foliar fertilization with			
		K_2So_4 at ratios of		$MgSo_4$ at ratios of	
		3%	**5%**	**0.5%**	**1.5%**
Acidity %	0.13	0.23	0.51	0.58	0.71
PV (meq O_2 /kg oil)	6.58	7.79	6.47	8.03	6.10
F.A. composition%: C16:0	14.46	13.24	14.35	12.59	14.33
C16:1	2.12	2.04	2.35	2.11	2.26
C18:0	2.20	2.36	2.33	2.5	2.54
C18:1	69.70	72.55	70.94	69.44	68.29
C18:2	10.76	8.98	9.33	12.61	11.85
C18:3	0.76	0.7	0.70	0.75	0.73
TSFA	16.66	15.60	16.68	15.09	16.87
TUSFA	83.34	84.4	83.32	84.91	83.13

Table 2. Some chemical characteristices of foliar fertilized and control samples of olive oils in season 2015:

Item \ Samples	Control	Foliar fertilization with			
		K_2So_4 at ratios of		$MgSo_4$ at ratios of	
		3%	5%	0.5%	1.5%
Acidity %	0.08	0.17	0.15	0.12	0.15
PV (meq O_2 /kg oil)	1.16	1.00	0.84	0.77	0.76
F.A. composition%:					
C16:0	14.76	16.09	15.5	15.60	15.08
C16:1	2.24	2.48	1.91	2.18	2.23
C18:0	2.28	2.04	1.95	2.28	2.15
C18:1	72.38	69.66	70.55	70.76	71.2
C18:2	7.45	9.15	9.26	8.21	8.44
C18:3	0.89	0.85	0.83	0.97	0.9
TSFA	17.04	18.13	17.45	17.88	17.23
TUSFA	82.96	81.87	82.55	82.12	82.77

Effect of foliar fertilization on the organoleptic attributes of olive oil samples:

Data in Tables (3 and 4) indicate the influence of folair fertilization with potassium and magnesium sulphate at (3 and 5%) and (0.5 and 1.5%) respectively, on the organolyptic attributes of olive oils in both two seasons 2014 and 2015 . Potassium sulphate at 5% and magnesium sulphate at 1.5% gave the highest fruity attribute (3.5 and 3.75) of olive oil respectively, followed by potassium and magnesium sulphate at 3 and 0.5%, respectively, while control treatment gave the lowest fruity (2.00) in the season 2014 . Also, in season 2015 , folair fertilization with potassium and magnesium sulphate at different percentages gave the highest positive properties (fruity attribute), in contrast the control treatment gave the lowest fruity attribute (2.5). Concerning the defect properties of olive oils, they were equal zero in both treated (folair fertilized) and untreated (control) samples in two seasons. Generally, all positive properties of olive oils recorded higher increment as resulting of folair fertilization compared with control sample. This result may be attributed to the highest content of total polyphenol, especially oleuropein, (which responsible for the bitternes attribute) in olive oil under study (as will shown in Table 11).

Table 3. Effect of foliar fertilization on the organoleptic attributes of olive oil samples in season 2014.

Samples / Organoleptic attributes	Control	Foliar fertilization with			
		K_2So_4 at ratios of		$MgSo_4$ at ratios of	
		3%	5%	0.5%	1.5%
Positive attributes :					
fruity	2.00	3.00	3.50.	3.00	3.75
bitternes	0.50	1.25	1.00	1.50	1.00
punget	0.75	0.75	0.75	1.00	1.00
Defect properties	0.00	0.00	0.00	0.00	0.00

Table 4. Effect of foliar fertilization on the organoleptic attributes of olive oil samples in season 2015.

Samples / Organoleptic attributes	Control	Foliar fertilization with			
		K_2So_4 at ratios of		$MgSo_4$ at ratios of	
		3%	5%	0.5%	1.5%
Positive attributes :					
fruity	2.50	3.00	3.20	2.75	3.60
bitternes	1.00	2.75	1.25	2.25	1.50
punget	1.50	2.50	2.00	3.00	3.00
Defect properties	0.00	0.00	0.00	0.00	0.00

Effect of foliar fertilization on the purity of olive oil samples:

The purity of the olive oil was studied by measuring the characteristic of absorption bands between 200 and 300 nm. These are frequencies related to conjugated diene and triene systems . A low absorption in this region is indicative of a high quality extra virgin olive oil . The purity of olive oil can be determined from three parameters; K_{232} K_{270} (absorpance at 232 and 270 nm.) and Delta k (Jorge and Perkin Elmer, 2008). Data presented in Tables (5 and 6) recorded that the lowest parameters (K_{232} and K_{270}) of olive oils were observed in the two seasons (2014 & 2015) when olive trees were foliar fertilization by potassium and magnesium sulphate foliar fertilization at different concentrations, while control treatment gave the highest K_{232} and K_{270} of oils in both seasons. On the contrary, Delta K (Δk) of oil recorded a slight increment as a result of previous treatments compared to control samples in two seasons. The lowest K_{232} and K_{270} nm. may be influenced by the levels of available nutrients in folair fertilizer which is possible to obtain oils enriched with beneficial phytochemicals especially polyphenols which preserved the oil from deterioration and oxidation. This is related to decrease in the K_{232} and K_{270} nm. of oil .

Table 5. Effect of foliar fertilization on the purity of olive oil samples in season 2014.

Samples / Purity	Control	Foliar fertilization with			
		K_2So_4 at ratios of		$MgSo_4$ at ratios of	
		3%	5%	0.5%	1.5%
K_{232} nm.	1.867	1.795	1.660	1.660	1.76
K_{270} nm.	0.140	0.110	0.107	0.111	0.134
Δk	0.0005	0.005	0.002	0.001	0.001

Table 6. Effect of foliar fertilization on the purity of olive oil samples in season 2015.

Samples / Purity	Control	Foliar fertilization with			
		K_2So_4 at ratios of		$MgSo_4$ at ratios of	
		3%	5%	0.5%	1.5%
K_{232} nm.	1.939	1.783	1.640	1.803	1.872
K_{270} .nm	0.171	0.098	0.115	0.132	0.136
Δk	- 0.003	- 0.002	- 0.001	- 0.002	- 0.001

Effect of foliar fertilization on some bioactive compounds of olive oil samples:

Data in Tables (7 and 8) show that effect of the foliar fertilization with potassium and magnesium sulphate (3 and 5%) and (0.5 and 1.5%) ,respectively on some bioactive compounds of olive oils during seasons (2014 and 2015). From these results, it could be observed that foliar fertilization with potassium sulphate at ratios of 3 and 5% in seasons 2014 and 2015 caused increase in total polyphenols of olive oils. On the other hand, foliar fertilization with magnesium sulphate at ratio of 0.5 and 1.5% occurred decrements in two seasons compared with the control samples. While di-ortho-phenols recorded a higher increase as a results of folair fertilization by potassium and magnesium sulphate at different treatments in two seasons compared with control samples. Potassium sulphate at (5%) foliar fertilization caused increase in the total tocopherols at ratios of 69.18 and 24.6%, respectively, in both seasons compared to the control sample, but magnesium sulphate (1.5%) foliar fertilization increase the total tocopherols at ratio of 55.14% in only season 2014. On the other hand, potassium and magnesium sulphate foliar fertilization at different ratios decrease in the carotonoids and chlorophylls contents of olive oils in season 2014, while chlorophyll contents recorded increments in season 2015. Also magnesium sulphate foliar fertilization at different treatments increased the carotenoids at ratios of 28.45 and 12.2%, respectively while potassium sulphate foliar fertilization at 3 and 5% decreased it at ratios of -21.10 and -13.8%, respectively in the same season (2015) . This may be due to change in enviromental conditions.

Table 7. Effect of foliar fertilization on some bioactive compounds of olive oil samples in season 2014.

Samples / **Item**	**Control**	**Foliar fertilization with**			
		K_2So_4 at ratios of		**$MgSo_4$ at ratios of**	
		3%	**5%**	**0.5%**	**1.5%**
T.Polyphenol (ppm)	201.20	225.62	242.80	182.30	193.37
Di-o-phenols (ppm)	27.65	35.99	29.15	28.00	30.12
T.tocophenol (ppm)	35.18	22.05	59.52	16.02	54.58
Pigments (mg/kg):-					
Carotonoids	0.88	0.79	0.76	0.76	0.73
Chlorophylls	1.63	1.50	1.39	1.38	1.34

Table 8. Effect of foliar fertilization on some bioactive compounds of olive oil samples in season 2015.

Samples / **Item**	**Control**	**Foliar fertilization with**			
		K_2So_4 at ratios of		**$MgSo_4$ at ratios of**	
		3%	**5%**	**0.5%**	**1.5%**
T.Polyphenol (ppm)	312.28	357.40	402.17	287.10	297.91
Di-o-phenols (ppm)	42.9	57.01	44.97	44.09	46.44
T.tocophenol (ppm)	85.06	68.67	106.02	77.83	61.20
Pigments (mg/kg):-					
Carotonoids	1.23	0.97	1.06	1.58	1.38
Chlorophylls	1.63	1.70	1.75	2.64	2.76

Effect of foliar fertilization on the overall quality index (OQI) , some ratios of fatty acids and oxidative stability of olive oil samples:

There are three most important parameters related to fatty acid composition of any oil, The first is the ratio of total saturated fatty acids / total unsaturated fatty acids (T.SFA/T.USFA) which related to the oxidation stability of oil, while the second is oleic acid/ lenoleic acid (C18:1/C18:2) ratio which has a positive effect on the taste of the oil (Ranal et al., 2001). The third is lenoleic acid/palmitic acid ratio (C18:2/C16:0) which indicate the degree of oxidative deterioration of oils, espicailly frying oil (Che-Man and Tan 1999) . Generally, results in Tables (9 and 10) indicated that the ratio of C18:1/C18:2, C18:2/C16:0 , T.SFA/T.USFA, oxidative stability and OQI of olive oil were affected by different folair fertilization with potassium and magnesium sulphate in both seasons 2014 and 2015.

From the results season (2014), It is clear that, foliar application of potassium sulphate at 3 and 5% occurred increase in C18:1/C18:2 ratio, but it caused decrease in C18:2/C16:0 ratio compared with the control samples, contrary with foliar application with magnesium sulphate at 0.5 and 1.5%. On the other hand, potassium and magnesium sulphate folair fertilization caused slight increase in the TSFA/TUSFA ratio with high values for folair treatments at 5 and 1.5 % respectively, but its caused slight decrease it with low values (at 3% and 0.5%). While the OQI of all olive oils increased as a results all folair fertilization under investigation. With concerning the previous parameters of olive oils obtained from season 2015, it is obvious from Table (10) that, potassium and magnesium sulphate foliar fertilization occurred decrease in the C18:1/C18:2 ratios for all samples compared to control samples, but these caused increase in OQI for all samples, while C18:2/C16:0 and TSFA/TUSFA ratios, its nearly the same as a result of folair fertilization. Also, the oxidative stability of olive oil affected by different folair fertilization in the first and second seasons (2014 and 2015). Potassium sulphate at 3 and 5% gave the highest oxidative stability, while magnesium sulphate gave the lowest oxidative stability at 0.5 and 1.5% compared to the control samples during two seasons . The increase in the stability of olive oil as a result of folair fertilization with potassium sulphate at (3 and 5%) may be influenced by the levels of available nutrients in folair fertilizer is which possible to obtain oils enriched with beneficial phytochemicals especially polyphenols which were significantly correlated with oxidative stability (Meriem et al., 2013).

Table 9. Effect of foliar fertilization on the overall quality index (OQI) , some ratios of fatty acids and oxidative stability of olive oil samples in season 2014.

Samples / Item	Control	Foliar fertilization with			
		K_2So_4 at ratios of		$MgSo_4$ at ratios of	
		3%	5%	0.5%	1.5%
C18:1/C18:2	6.48	8.08	7.6	5.51	5.76
C18:2/C16:0	0.74	0.68	0.65	1.00	0.83
TSFA/TUSFA	0.199	0.178	0.203	0.185	0.200
Oxidative stability (hr.) at 100 °C	34.90	43.10	44.73	32.31	32.73
OQI	2.83	3.17	3.76	3.10	4.32

Table 10. Effect of foliar fertilization on the overall quality index (OQI), some ratios of fatty acids and oxidative stability of olive oil samples in season 2015.

Item \ Samples	Control	Foliar fertilization with			
		K_2So_4 at ratios of		$MgSo_4$ at ratios of	
		3%	5%	0.5%	1.5%
C18:1/C18:2	9.66	7.61	7.62	8.62	8.44
C18:2/C16:0	0.51	0.57	0.62	0.53	0.56
TSFA/TUSFA	0.205	0.22	0.21	0.22	0.21
Oxidative stability (hr.) at 100 °C	39.5	43.89	45.14	33.85	33.48
OQI	3.20	5.15	5.09	4.77	5.57

Effect of foliar fertilization on the phenolic compounds of olive oil samples:-

Phenolic compounds of olive oil have been of major interest to researchers due to their positive effects on both human health and preservation of olive oil . Results in Tables (11 and 12) show the influence of folair fertilization by potassium and magnesium sulphate at different concentrations
(3 and 5%) and (0.5 and 1.5%) respectively during two seasons (2014 and 2015) on the phenolic compounds of olive oils. From these results, it could be noticed that, twinty five phenolic compounds were detected in all olive oil samples, whereas E-vanillic, oleuropein and ellagic compounds recorded a high levels, followed by benzoic, Epi-catechin, pyrogallol, salicylic and alph-coumaric compounds comparing with other phenolic compounds in control and treated samples during two seasons. From the results, it could be observed that, the concentration of all phenolic compounds were increased especially, E-vanillic, oleuropein and salicylic compounds at different treatments. While ellagic, Epi-catechin and cinamic compounds decreased as a results of folair fertilization, in season 2014, but Epi-catechin and cinamic compounds increased in season 2015 by potassium and magnesium sulphate at different treatments. As shown previously, the rate of increase for catechin , catechol, coumarin and protocatchouic phenolic compounds as a result of the folair fertilization by potassium sulphate was more pronounced than those obtained by the folair fertilization with magnesium sulphate in two seasons. This increase in phenolic compounds of olive oils as a result of folair fertilization under study may be due to the role of neuitrants in folair fertelizer l in ameliorating the biosynthesic of phenolic oil in plants.

Table 11. Effect of foliar fertilization on the phenolic compounds (ppm) of olive oil samples in season 2014.

Samples / Item	Control	Foliar fertilization with			
		K_2So_4 at ratios of		$MgSo_4$ at ratios of	
		3%	5%	0.5%	1.5%
pyrogallol	12.39	14.80	16.30	25.30	13.93
Gallic	0.54	0.74	0.94	0.64	0.84
4-amino benzoic acid	0.25	0.99	0.88	0.47	0.39
Catechin	3.08	14.62	22.49	3.65	4.17
Chlorogenic	1.26	2.36	3.30	7.97	2.35
Catechol	2.35	4.50	6.77	1.7	1.36
Oleuropein	183.32	365.14	309.03	451.74	331.98
Epi-catechin	15.01	7.68	6.40	12.01	8.59
Caffeine	0.42	1.25	0.94	1.82	0.95
p-OH-benzoic	0.58	2.72	3.72	3.65	4.90
Caffeic	0.80	0.61	1.24	0.66	0.81
Vanillic	1.28	2.66	3.53	2.28	3.11
p-coumaric	1.87	1.99	2.96	2.42	3.65
Ferulic	1.46	4.97	6.89	1.52	1.70
Iso-ferulic	1.44	1.46	4.52	2.71	1.98
Resveratol	0.46	1.38	3.16	1.96	1.05
Ellagic	96.36	73.79	63.75	93.09	58.59
E-vanillic	247.49	497.49	402.21	595.88	365.20
Alpha-coumaric	9.43	11.78	12.87	15.21	19.12
Benzoic	18.93	20.44	22.10	36.53	19.47
3,4,5methoxy cinamic	3.89	4.40	7.07	4.9	4.79
Coumarin	2.89	6.86	7.89	3.99	3.55
Salicylic	14.83	24.46	28.19	33.5	30.37
Cinamic	2.67	1.57	0.96	1.38	1.74
Protocatchouic	3.11	10.67	6.67	2.56	1.13

Table 12. Effect of foliar fertilization on the phenolic compounds (ppm) of olive oil samples in season 2015.

Samples / Item	Control	Foliar fertilization with			
		K_2So_4 at ratios of		$MgSo_4$ at ratios of	
		3%	5%	0.5%	1.5%
pyrogallol	19.65	84.32	114.05	40.70	25.56
Gallic	0.22	0.72	0.87	0.25	0.38
4-amino benzoic acid	0.51	1.28	1.07	0.73	0.66
Catechin	1.41	23.37	26.47	2.66	6.64
Chlorogenic	1.30	9.44	12.08	17.71	5.94
Catechol	4.75	6.34	8.56	2.9	3.18
Oleuropein	242.77	508.34	407.00	497.67	443.66
Epi-catechin	20.57	62.02	64.27	52.12	56.33
Caffeine	1.40	4.70	4.37	5.12	1.70
p-OH-benzoic	1.76	4.78	4.42	5.54	6.92
Caffeic	0.98	1.39	1.95	1.71	1.07
Vanillic	3.83	5.85	6.45	4.19	4.66
p-coumaric	1.71	2.84	14.95	3.54	5.88
Ferulic	1.10	2.02	2.75	1.20	1.42
Iso-ferulic	1.96	2.40	15.25	3.65	2.34
Resveratol	1.29	2.29	3.57	2.45	1.61
Ellagic	111.20	75.20	63.80	99.95	60.25
E-vanillic	358.10	510.44	511.29	503.63	520.69
Alpha-coumaric	16.07	18.32	21.10	17.94	17.82
Benzoic	24.61	25.98	31.21	48.11	26.66
3,4,5methoxy cinamic	4.13	4.57	7.71	7.31	6.27
Coumarin	2.05	6.73	7.08	5.93	5.12
Salicylic	9.64	23.35	42.24	21.06	36.40
Cinamic	1.07	5.71	5.95	6.28	11.49
Protocatchouic	4.16	13.05	11.44	5.96	4.21

Effect of foliar fertilization on the flavonoid compounds of olive oil samples

Flavonoids play an important role in the quality of virgin olive oil because of their antioxidant activity. As shown in Tables (13 and 14), naringenin compound recorded a high level in season 2014 followed by rutin hispirdin and luteolin compounds, while luteolin compound recorded the highest content in season 2015 followed by naringenin and hispirdin compared with those in control sample. Also, the data show that, luteolin, apigenin, rosmarinic, naringenin, quecetrin, hispirdin, rutin compounds recorded increments in two (seasons 2014 and 2015), while the values of kaempferol, quercietin and narigin compounds decreased by folair fertilization compared with the control sample in season 2014. On the other hand, apigenin, kaempferol, hespirtin, naringenin, quercitin and hispirdin compounds recorded increase, but lutin, rosmarinic, quecetrin, rutin and naringin compounds decreased as a result folair fertilization in season 2015. Commonly, most flavonoid compounds in season 2014 recorded increase with folair fertilization by potassium and magnesium sulphate at different treatments.

Table 13. Effect of foliar fertilization on the flavonoid compounds (ppm) of olive oil samples in season 2014.

Samples / Item	Control	**Foliar fertilization** with			
		K_2So_4 at ratios of		**$MgSo_4$ at ratios of**	
		3%	**5%**	**0.5%**	**1.5%**
Luteolin	0.001	0.00718	0.00606	0.00562	0.0052
Apigenin	0.00030	0.00035	0.00040	0.00030	0.00050
Rosmarinic	0.00002	0.00006	0.00016	0.00009	0.00005
Kaempferol	0.00055	0.00049	0.00023	0.00034	0.00026
Hespirtin	0.00053	0.00048	0.00219	0.00011	0.00072
Naringenin	0.00053	0.00062	0.00073	0.0006	0.00083
Quercitin	0.00030	0.00025	0.00022	0.00028	0.00015
Quecetrin	0.00014	0.00015	0.00016	0.00016	0.00018
Hispirdin	0.00129	0.00143	0.00208	0.0014	0.00209
Rutin	0.00051	0.00166	0.00056	0.00143	0.00142
Naringin	0.05624	0.00167	0.00150	0.00061	0.00055

Table 14. Effect of foliar fertilization on the flavonoid compounds (ppm) of olive oil samples in season 2015.

Samples / **Item**	**Control**	**Foliar fertilization** with			
		K_2So_4 at ratios of		**$MgSo_4$ at ratios of**	
		3%	**5%**	**0.5%**	**1.5%**
Luteolin	0.00773	0.00047	0.00222	0.00164	0.00504
Apigenin	0.00025	0.00031	0.00033	0.00075	0.00064
Rosmarinic	0.00028	0.00019	0.00027	0.00017	0.00016
Kaempferol	0.00029	0.00040	0.00052	0.00030	0.00070
Hespirtin	0.00030	0.00066	0.00477	0.00066	0.00104
Naringenin	0.00 050	0.00078	0.00123	0.00056	0.00134
Quercitin	0.00011	0.00017	0.00078	0.00047	0.00029
Quecetrin	0.00043	0.00038	0.00039	0.00022	0.00030
Hispirdin	0.00183	0.00264	0.00549	0.00333	0.00256
Rutin	0.00252	0.00059	0.000203	0.00117	0.00249
Naringin	0.00208	0.00079	0.00151	0.00168	0.00201

CONCLUSION

From all the above results, it can be concluded that, olive oils obtained from olive fruits trees treated with folair fertilization with solution of potassium and magnesium sulphate at all concentrations were the best in organolyptic attributes, purity, the total polyphenol, di-o- phenols, overall quality index , total tocopherols and the major phenolic compounds compared to those obtained from the control samples.

Folair fertilization by solution of potassium sulphate at ratios of 3 and 5% for olive trees gave the highest stability of the oils extracted from their fruits compared to the other samples in two seasons under study.

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تأثير الرش الورقى لاشجار الزيتون على المركبات الحيوية والنقاوة و الخواص الحسية لزيت الزيتون

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أجريت هذه الدراسة خلال موسمى ٢٠١٤ و ٢٠١٥ فى مزرعة بالنوبارية– البحيرة– مصر لدراسة تأثير الرش الورقى لاشجار الزيتون (صنف كوروناكى) بمحلول كبريتات البوتاسيوم والماغنسيوم بتركيزات مختلفة (٣%،٥%) و (٠,٥%،١,٥%) على التوالى الخواص الحسية و درجة النقاوة ومعامل الجودة والمكونات الصغرى والمركبات الفينولية لزيت الزيتون تحت الظروف البيئية.

وقد أوضحت النتائج المتحصل عليها أن:

- أعطى التسميد الورقى بالبوتاسيوم (٥%) والماغنسيوم (١,٥%) أعلى صفات حسية ايجابية (صفة الفاكهى) يليه التسميدعلى مستوى ٣% و٠.٥، % على التوالى لزيت الزيتون خلال موسمى ٢٠١٤ و ٢٠١٥ مقارنة بالعينة الكنترول .بينما كانت الخواص السلبية لعينات زيت الزيتون مساوية للصفر فى كل من العينات المعاملة (التسميد الورقى بمحلول كبريتات بالبوتاسيوم والماغنسيوم) ولغير معاملة (العينة الكنترول) خلال الموسمين تحت الدراسة.
- أقل قياسات سجلت فى المركبات الزوجية الثلاثية التبادلية خلال الموسمين لعينات زيت الزيتون نتيجة للتسميد الورقى لاشجارالزيتون بمحلول كبريتات البوتاسيوم والماغنيسيوم بمستويات مختلفة مقارنة بعينات الكنترول فى حين سجلت ΔK زيادة بسيطة نتيجة لهذه المعاملات.
- أدى التسميد البوتاسى بمختلف معاملاته الى زيادة كمية الفينولات الكلية فى الموسمين مقارنة بالعينة الكنترول الا انه سبب نقص فى نسب مكونات الكاروتينات خلال الموسمين و نسب الكلوروفيل فى موسم ٢٠١٤ فقط بينما تسبب التركيز العالى للتسميد البوتاسى الورقى (٥%) زيادة فى التوكوفيرولات الكلية فى كلا الموسمين.
- أدى التسميد الورقى بمحلول كبريتات البوتاسيوم والماغنسيوم بمختلف التركيزات الى زيادة مركب داى ارثوفينول فى زيت الزيتون مقارنة بالعينات الكنترول أثناء الموسمين.
- أوضحت النتائج أن معظم المركبات الفينولية زادت نتيجة التسميد الورقى تحت الدراسة خاصا مركبات (Oleuropein, Ellagic, Vanillic) خلال الموسمين مقارنة بالعينة الكنترول.
- أحدث التسميد الورقى بواسطة محلول كبريتات البوتاسيوم والماغنسيوم على مستوى كل التركيزات الى زيادة كلا من المركبات الفينولية cinamic, Epi-catechin فى موسم ٢٠١٥ فى حين نقصت هذه المركبات فى موسم ٢٠١٤ مقارنة بالعينة الكنترول.