STEROLS COMPOSITION OF SOME OLIVE OIL VARIETIES CULTIVATED UNDER EGYPTIAN CONDITIONS

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Abstract

The sterol composition of some Egyptian olive oils (Coratina, Arbequina, Koroneiki and Siwi were analyzed during season (2010–2011), to obtain a more complete characterization of these varietal oils. More than nine compounds were identified and characterized. As expected for virgin olive oil (VOOs), the main sterols found in all VOOs were β-sitosterol, Δ5-avenasterol, campesterol and stigmasterol. Cholesterol, clerosterol, sitostanol, Δ5,24-stigmastadienol, and Δ7-avenasterol were also found in lower amounts for all VOOs . The majority of the Egyptian virgin olive oils analyzed comply with the using EC Regulation No. 2568, except for Arbequina VOO. Total sterol amounts were higher than the minimum limit set by legislation, ranging from 1562.32 to 2550.62 mg/kg. Coratina VOO showed the highest contents of β-sitosterol (84.24 %) while, Siwi VOO showed the highest Δ5 avenasterol (8.66 %). Arbequina VOO had the lowest content of β-sitosterol (50.63%) and Δ5 avenasterol (4.75%).

Quality characteristics (acidity, peroxide value, K_{232}, K_{270}, ΔK,), chemical data (Total phenols, oxidative stability, fatty-acid composition, and sterol composition) were also studied. The obtained results were compared with International Olive Oil Standards. The total phenol content ranged from 105.07 to 195.17 mg/kg, showing the highest values for Coratina and Koroneiki VOOs. Arbequina VOO presented the highest deviations from the IOC in fatty acids and sterol percentages, so that Arbequina virgin olive oil stood out of IOC and EU limits.

Keywords: Sterols composition, olive oils, Coratina, Arbequina, Koroneiki, Siwi cultivars.

INTRODUCTION

Olive oil is obtained from the fruit of olive trees (*Olea europaea L.)* and is a genuine fruit juice with excellent nutritional, sensorial and functional quality. It represents a typical lipid source of the Mediterranean diet, which consumption has been associated with a low incidence of cardiovascular diseases, neurological disorders, breast and colon cancers, as well as with hipolipidemic and antioxidant properties (Matos *et. al.,* 2007). Olive oil is one of the oldest known vegetable oils mainly produced in the countries surrounding the Mediterranean Sea. It is a natural fruit juice, obtained from the fruit of tree *Olea europaea* L., with a unique composition and quality. Olive oil is one of the very few oils that can be consumed in its natural

form, thus preserving all its natural constituents. Several methods of analysis have been proposed and are affected by several factors, including packaging (Kiritsakis, 1998).

The consumption of extra virgin olive oil, the most characteristic component of the Mediterranean diet, is currently increasing because of its nutritional and health-promoting effects, which have been related to the optimal balance between saturated, monounsaturated (MUFA), and polyunsaturated fatty acids (PUFA), as well as to minor components such as sterols, chlorophyll, polyphenols and tocopherols . The chemical composition and quality of virgin olive oil are influenced by a variety of factors, among them geographical production area (altitude and soil composition), climatic conditions prevailing in the production year, cultivar, and extraction process (Kiritsakis, 1998, Dag *et. al.,* 2011).

The chemical compounds of olive oil can be divided into two groups: the saponifiable fraction, which accounts for almost the entire weight of the oil (98–99% of total weight) and the nonsaponifiable fraction, which represents 0.5–2.0% of the total weight and is constituted of diverse components that are of great importance in terms of its biological value, together with some constituents characterized by their antioxidant activities, which can be measured using methods based on diverse radical generating systems (Samaniego -Sanchez *et. al.,* 2010) .

The nutritional quality of virgin olive oil has been related to its composition, in particular the high concentration of oleic acid, which accounts for about 55–83% of the total fatty acids (Codex Alimentarius and IOC). This monounsaturated fatty acid favours the reduction of LDL cholesterol and is related to the prevention of cardiovascular diseases. However, VOO nutritional quality has also been associated with its minor components, mainly antioxidants such as tocopherols (chiefly α-tocopherol) and polar phenols, but also sterols (mainly β-sitosterol), and pigments (chlorophylls, carotenoids), which also play a role in the stability of the oil and the prevention of cardiovascular diseases, tumors and degenerative diseases of aging (Inarejos-García *et. al.,* 2010). Minor compounds are of great importance in the final composition of olive oil because they influence the stability and overall acceptability as well as the nutritional and health related properties of the olive oil. Compounds such as sterols, squalene, and tocopherols are of great interest as high value added products because of their nutraceutical activities (Ibaneza *et. al.,* 2002).

Sterols are nutritionally important lipids that need to be routinely determined in foods. In olive oil, content and composition of sterols can vary due to the agronomic and climatic conditions, fruit or seed quality, oil extraction and refining procedures and storage conditions Plant sterols or phytosterols make up the main part

of the unsaponifiable fraction of olive oil. Their composition depends on the kind of olive oil. Chemical structures of these sterols are similar to cholesterol (EEC, 2003). The most abundant olive oil sterol is β-sitosterol, followed by ∆5-avenasterol. Campesterol and stigmasterol are present in lower concentrations (IOC, 2006). Compositional analysis of the sterol fraction of olive oil can be used to assess the degree of purity of the oil and the absence of other plant oils. This determination also permits characterization of the type of olive oil in question: extra virgin, virgin, refined, etc… (EEC, 2003).

The composition of the steroidal fraction of the olive oil is a very useful parameter for detecting adulterations or to check authenticity, since it can be considered as its real fingerprint (Pardo *et. al.,* 2011). Recently, it has also been proposed that sterol profiles could be used to classify virgin olive oils according to their fruit variety (Rivera del Alamo *et. al.,* 2004).

Sterols are important components in human health and nutrition. Phytosterols found in vegetables and plant oils, such as β-sitosterol have been shown to reduce cholesterol absorption in humans resulting in reduced health problems (Mailer *et. al.,* 2010). Additionally, it has been suggested that phytosterols have anti-inflammatory antibacterial, antifungal, antiulcerative and antitumoral activities . Sterols have also been recognized as cancer-preventive biologically-active substances, together with other secondary plant products. Also, they apparently help to reduce total plasma cholesterol and LDL cholesterol, and as a result these compounds are being considered as ingredients of functional foods (Ben Temime *et. al.,* 2008).

The International Olive Council (IOC) imposes limits or ranges for each type of sterol based on the natural levels found in traditional olive oil types. Sterol profiles outside these ranges could suggest that the olive oil is not genuine. A number of cases have found olive oils which naturally exceed the limits for sterols. This is particularly so in the case of campesterol which is specified to be less than 4% of total sterols according to the standard limits. Cultivars in which the campesterol content has exceeded this limit include Arbequina, Corniche, Koroneiki, Cornicabra, Arauco and Barnea . Erythrodiol levels are high in solvent extracted or refined oils (i.e. pomace oils) and therefore high levels in virgin oils would indicate adulteration with pomace oil (Rivera del Alamo *et. al.,* 2004, Mailer *et. al.,* 2010).

Several factors are known to affect the quantitative sterolic profiles of olive fruits. Among these factors, the ripening cycle of the fruit and the nature of the cultivar , oil extraction and refining procedures and storage conditions. The effects of agronomic and climatic conditions have also been studied. However, the total effect of these variables on sterol profiles is ambiguous. The diversity of these factors and their

interrelationships make it very difficult to completely characterize the sterol profile and erythrodiol + uvaol content of a given product (Ben Temime *et. al.,* 2008).

The objective of this investigation is to define sterol composition of some Egyptian olive oils (Coratina, Arbequina, Koroniki and Siwi cultivars).

MATERIALS AND METHODS

2.1. Virgin olive oil samples:

Olive's fruits (Coratina, Arbequina, Koroneiki and Siwi cultivars) were harvested from Agricultural Research Center, Giza, Egypt during season (2010-2011). On the same day of harvest, olive oil was extracted from the above cultivars using the continuous extraction system two-phases. The oil percent was calculated on fresh weight basis directly after oil extraction. The extracted olive oils were stored in refrigerator until use.

2.2. Analytical methods:

2.2.1: Physicochemical quality parameters:

Free acidity, peroxide value and UV absorption characteristics were carried out following the analytical methods described in Regulations EEC/1989/2003 of the Commission of the European Union (EEC, 2003). Free acidity was expressed as % of oleic acid, peroxide values were expressed as ml-equivalents of active oxygen per kilogram of oil (meq O2/ kg), K_{232} and K_{270} extinction coefficients were calculated from absorption at 232 and 270 nm, respectively.

2.2.2.: Oxidative stability (Rancimat):

The oxidative stability was estimated by measuring the oxidation induction time, on a Rancimat apparatus (Metrohm series 679, Switzerland) (Gutierrez, 1989). Air (20 L/h) was bubbled through the oil (5 g) heated at 100°C, with the volatile compounds being collected in water, and the increasing water conductivity continually measured. The time taken to reach the conductivity inflection was recorded.

2.2.3.: Total phenols:

Total phenols (TP) content of the methanolic extract of olive oil were calorimetrically determined using the Folin-Ciocalteu method (Gamez-Meza *et. al.,* 1999) where an aliquot (1 ml) of methanolic extract was mixed with diluted ethanol amine (1 ml) at room temperature. After 5 min the absorbance was measured at 750 nm using a spectrophotometer (JENWAY 6405 UV/Vis .Spectrophotometer, England).

2.2.4.: Gas chomatography analysis of fatty acid composition:

- **Methylation of fatty acids**

An aliquot of fatty acids, about 10 mg, was dissolved in 2ml hexane and then 0.4 ml Zn KOH in anhydrous methanol was added (Cossignani *et. al.,* 2005), after 3 min, 3 ml water was added. The organic layer, separated by centrifugation, was dried over anhydrous sodium sulfate, and then concentrated, with a N2 stream to around 0.5 ml for GC analysis of fatty acids methyl esters (FAME) as described below.

- **GC analysis of FAME**

Agilent 6890 series GC apparatus provided with a DB-23 column (60 m × 0.32 mm × 0.25 μm) was used. Fatty acids results after the previous procedures steps were transformed into methyl esters and directly injected into the GC.

2.2.5.: Sterols composition

A 5g oil sample was dissolved in 3 ml of hexane, and then 0.5 m1 of 5∝-cholestane (0.4 mg ml $^{-1}$) internal standard was added. The mixture was saponified with sodium hydroxide solution in methanol (2N) at water bath for 1-2 h. Then, unsaponifaible matters were extracted. Then 1 μ1 of the sample was injected into a Agilent 6890 series GC apparatus (setup:DB-5 capillary column, A N_2 carrier gas at 0.9 ml min^{-1} constant flow rate, split/splitless injector at 230°C in the split less mode. Oven temperature: 50°C holds for 2 min, ramped to 230°C at 15°C min^{-1}, ramped to 310°C at 3°C min$^{-1,}$ hold for 10 min. The internal standard method (5∝- cholestane) was used for quantification (Szterk *et. al.,* 2010).

Analytical determinations were carried out at least in duplicate.

RESULTS AND DISCUSSION

3.1. Physicochemical quality parameters:

Table 1 shows the physicochemical quality parameters for some Egyptian olive oils from different varieties. All the oils analyzed showed very low values for the regulated physicochemical parameters evaluated (acidity ≤ 0.8 , peroxide value ≤ 20 meq O_2/kg, K_{270} ≤ 0.22, K_{232} ≤ 2.5), with all of them falling within the "extra virgin" category, as stated by Regulation EC/1989/2003 (EEC, 2003), since the raw material was carefully selected, picked and processed. The lower values for these parameters will indicate the higher quality of oil.

Table 1. Physicochemical quality parameters of some Egyptian olive oils

Characters	Coratina	Arbequina	Koroneiki	Siwi
FFA %(as Oleic acid)	0.49	0.80	0.43	0.63
Peroxide value (meq O_2 / kg oil)	2.23	2.51	2.73	3.85
K_{232}	1.697	2.157	1.891	1.786
K_{270}	0.111	0.128	0.161	0.091
Δk	- 0.003	- 0.009	0.010	- 0.014
Oil Content % (Fresh weight basis)	18.5	13.6	17.2	17.4

3.1.1. Free acidity

Free fatty acid content, as % oleic acid, ranged from 0.43 for Koroneiki VOO up to 0.80 for Arbequina VOO%. None of the oils exceeded the limit of 0.80% free acidity, the upper threshold limit for the 'extra virgin' category (EEC Regulations) (EEC, 2003). . These results agreed with those reported by Elsorady (2011) studying the same varieties (Coratina, Arbequina and Koroneiki).

3.1.2. Peroxide value

Peroxide value, expressed as meq O_2 / kg, ranged between 2.23 and 3.85. All of the oils had not a peroxide value higher than the upper limit of 20 established for the 'extra-virgin' olive oil. Also these results agreed with (Elsorady, 2011)

3.1.3. UV characteristics

Respect to the UV characteristics, none of the oils had K_{232} , K_{270} and ΔK values higher than the limits established for 'extra-virgin' olive oils. K_{232} was between 1.697 (Coratina VOO) and 2.157 (Arbequina VOO). Also, K_{270} was between 0.091 (Siwi VOO) and 0.161(Koroneiki VOO) and ΔK in the range of -0.014 (Siwi VOO) to 0.010 (Arbequina VOO). The results of Coratina and Koroneiki VOOs agreed with the results obtained by Stefanoudaki *et al*. (2011).

Table (1) showed that Coratina cultivar had the highest oil content (18.5%), followed by Siwi and Koroneiki cultivars (17.4, 17.2%), respectively. On the other hand, Arbequina cultivar had the lowest oil content (13.6 %)

3.2.Oxidative stability:

Stability parameters are shown in Table (2). The oxidative stability at 100 °C and the total phenol content were useful for discriminating among varieties.

Table 2. Stability Parameters of some Egyptian olive oils

Characters	Coratina	Arbequina	Koroneiki	Siwi
Oxidative stability (h)	32.51	12.10	31.99	18.8
Total phenols (mg/kg)	195.17	105.07	187.25	145.53

Oxidative stability of the studied olive oils ranged from 12.10 h for Arbequina VOO to 32.51 h for Coratina VOO. These results agreed with (Ceci and Carelli. 2007).

3.3. Total phenols:

Virgin olive oil contains phenolic substances which affect its stability and flavor. The highest content of total phenols was 195.17 mg/kg for Coratina VOO followed by 187.25, 145.53 and 105.07 mg/kg for Koroneiki, Siwi and Arbequina VOOs, respectively.

The antioxidant activity of hydrophilic phenols of virgin olive oil has been extensively studied. As reported by several investigators, the concentration of phenolic compounds, evaluated colorimetrically and expressed as total phenols, shows a correlation with the shelf-life of virgin olive oil as tested by accelerated methods such as Rancimat (Clodoveo *et. al.,* 2007). Direct correlation was observed between total phenol content and oxidative stability by Rancimat (Table 2) . Arbequina VOO, which had the lowest total phenol content, showed the lowest oxidative stability. On the other hand, Coratina VOO, which had the highest total phenols, showed the highest oxidative stability.

3.4.: Fatty acid composition

Results of fatty acids, total saturated fatty acids (SFA), polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), and the ratios $C_{18:1}/C_{18:2}$ and MUFA/PUFA for some Egyptian olive oils are shown in Table 3.

Table 3. Fatty acids composition of some Egyptian olive oils

Cultivar / Fatty acid	Coratina	Arbequina	Koroneiki	Siwi
$C_{16:0}$	15.01	22.10	15.66	13.76
$C_{16:1}$	0.63	3.77	1.31	0.61
$C_{17:0}$	0.04	0.18	0.05	0.05
$C_{17:1}$	0.06	0.20	0.07	0.06
$C_{18:0}$	2.07	1.75	2.20	2.51
$C_{18:1}$	65.83	42.55	70.33	69.80
$C_{18:2}$	13.72	27.62	7.98	10.83
$C_{18:3}$	0.99	1.05	0.90	0.81
$C_{20:0}$	0.45	0.38	0.49	0.36
$C_{20:1}$	0.46	0.21	0.34	0.29
$C_{22:0}$	0.11	0.10	0.13	0.08
$C_{24:0}$	0.63	0.09	0.54	0.84
Σ SFA*	18.31	24.60	19.07	17.60
Σ USFA**	81.69	75.40	80.93	82.40
MUSFA	66.98	46.73	72.05	70.76
PUSFA	14.71	28.67	8.88	11.64
$C_{18:1}$/ $C_{18:2}$	4.80	1.54	8.81	6.45
MUSFA / PUSFA	4.55	1.63	8.11	6.08

* SFA : Saturated Fatty Acids.

** USFA : Unsaturated Fatty Acids.

The distribution of fatty acid composition (Table 3) covered the normal range expected for olive oil (Pardo *et. al.,* 2011) . The highest content of palmitic acid (22.10%) was found in Arbequina VOO. The palmitoleic acid content was also higher in Arbequina VOO (3.77%) than in the others. Also, Arbequina VOO showed the highest linoleic values (27.62%). The oleic and linoleic acid contents were the most useful and significant parameters for differentiating varieties, Koroneiki and Siwi, from the others. Both varieties showed high oleic values .The low oleic and high linoleic acid contents shown by Arbequina VOO seemed to contribute to their low oxidative stability, since this leads to a low mono/polyunsaturated ratio (Pardo *et. al.,* 2011). Coratina, Koroneiki and Siwi varieties produced oils with excellent fatty acid (FA) composition, i.e., a high level of oleic acid (maximum of 70.33%), low palmitic and

linoleic acid content (minimum of 13.76% and 7.98%, respectively). These levels were established for extra virgin olive oil (EVOO) (EEC, 2003). Also, Arbequina VOO was out the legal ranges stated by the IOC for fatty acids (IOC, 2006, EEC, 2003). These results were in agreement with Elsorady (2011) for the same cultivars in a different season and also with (Ceci and Carelli, 2007).

The same results revealed that, Arbequina VOO showed the highest mean value for SFA and PUSFA (24.60 and 28.67%, respectively), while Koroneiki VOO showed the highest mean value for MUSFA (72.05%). Siwi VOO was the highest mean value for USFA (82.40%).

The ratios $C_{18:1}$/ $C_{18:2}$ and MUSFA / PUSFA were also different among the oils, Arbequina VOO was the lowest value for the ratios $C_{18:1}$/ $C_{18:2}$ and MUSFA / PUSFA (1.54 and 1.63, respectively) and Koroneiki was the highest (8.81 and 8.11, respectively). In Siwi and Coratina VOOs, the values were intermediate (6.45, 6.08 and 4.80, 4.55 for the ratios $C_{18:1}$/ $C_{18:2}$ and MUSFA / PUSFA, respectively). The oleic to linoleic acids ratio is frequently used as a stability parameter and, in previous studies, the cultivars with higher ratios were those with higher oxidative stability (Matos *et al.*,2007). Koroneiki and Siwi VOOs had the highest average values for MUSFA/PUSFA ratio (8.11 and 6.08, respectively) in accordance with their higher oxidative stability indexes. Coratina VOO was within fatty-acid legal ranges. Although Coratina sample showed a medium MUSFA/PUSFA value (4.55), its oxidative stability was high (32.51 h). This is due to the fact that oxidative stability is related not only to fatty-acid composition, but also to several other factors, such as pro- and/or anti-oxidant substances (Ceci and Carelli, 2007). In fact, this sample had the highest phenol contents.

3.5.: Sterol composition

Sterols are major constituents of the unsaponifiable fraction. Research has shown that each oily fruit has a characteristic sterol profile which makes it determination an important tool for checking the genuineness of oil. They are important components for the stability of the oil since at high temperature they act as inhibitors of polymerization reactions (Matos *et al.*,2007).The composition of the sterol fraction of olive oil is a very useful parameter for detecting adulterations or to check authenticity, since it can be considered as a fingerprint (Ben Temime *et. al.,* 2008). Besides, their determination is of major interest due to their health benefits, as mentioned before. In the present work, more than nine sterol compounds were detected and quantified and the results obtained are displayed in Table (4).

One observes that in general they lie within the established regulatory limits except Arbequina virgin olive oil (EC Regulation 1989, 2003) (EEC, 2003). As shown in Table (4), the amounts of individual sterols varied according to the varieties. In the Coratina variety, the highest phytosterol levels were found for β-sitosterol, followed by

Δ5-avenasterol, characteristic of the virgin olive oil in the pulp of the olive (Ben Temime *et. al.,* 2008). The other main sterols were stigmasterol, and campesterol. However, small amounts of cholesterol, clerosterol, sitostanol, Δ5, 24-stigmastadienol, and Δ7-avenasterol were also found in all samples except for Arbequina virgin olive oil. These results are in good agreement with data published elsewhere (Rivera del Alamo, *et al*.,2004, Ceci and Carelli., 2007, Ben Temime *et. al.,* 2008, Mailer *et al*.,2010). Authors have reported that β-sitosterol, Δ5-avenasterol and campesterol were the most representative sterols in virgin olive oils from the main Spanish and Portuguese cultivars. β-sitosterol, the most abundant phytosterol in olive oil, its level represents more than 80% of total sterols except for Arbequina virgin olive oil. The highest mean percent value of β-sitosterol was observed in Coratina olive oil (84.24%), whereas Arbequina olive oil had the lowest one 50.63% (Table 4). β-Sitosterol content in the Arbequina variety was significantly lower than in the other varieties, for that Arbequina olive oil stood out of IOC limits (IOC, 2006). These values are similar to those reported for other olive oil varieties (Ceci and Carelli, 2007, Mailer *et. al.,* 2010).

The health aspects of β-sitosterol have recently been reported in several studies . They refer mainly to the reduction of cholesterol levels by opposing its absorption in the intestinal tract and the prevention of many diseases and various types of cancer (colon, prostate, and breast) (Ben Temime *et. al.,* 2008).

Table 4. Sterols fractions of some Egyptian olive oils

Sterols fractions (% of total sterols)	Coratina	Arbequina	Koroneiki	Siwi
Cholesterol	0.30	4.45	0.45	0
5-∝-Cholestane	1.87	1.56	1.85	0.96
Campesterol	3.15	0.67	3.90	1.36
Stigmasterol	0.46	0.37	0.65	0.40
Cleroserol	1.16	0.37	1.10	1.45
β-sitosterol	84.24	50.63	83.63	80.33
Sitostanol	1.82	3.79	1.6	1.25
Δ-5-avenasterol	6.12	4.75	6.32	8.66
Δ-5,24- stigmastadienol	1.03	N.D	1.12	1.47
Δ-7-avenasterol	0.62	N.D	1.24	1.81
Apparent sitosterols	94.37	59.54	93.77	93.16
Total sterols (mg/kg oil)	1562.32	2550.62	1820.42	1912.58
Campesterol / Stigmasterol	6.85	1.81	6.00	3.40
Unsaponifiable matter (%)	1.07	1.57	1.59	1.69

N.D: Not Detected

Regarding to Δ5-avenasterol content, Siwi virgin olive oil showed the highest value (8.66%), whereas Arbequina virgin olive oil recorded the lowest one 4.75% (Table 4). In the literature this compound has been associated with antioxidant activity (Ben Temime *et. al.,* 2008).. Our results seem to agree with this, as Arbequina was one of the least stable varieties.

Stigmasterol is related to various parameters of the quality of virgin olive oil. High levels correlate with high acidity and low organoleptic quality . The analyzed samples contained low levels of this sterol, which is indicative that the oil came from healthy fruit (Ben Temime *et. al.,* 2008).

All the olive oil samples analyzed showed low campesterol content, with a global range from 0.67% (Arbequina olive oil) to 3.90% (Koroneiki olive oil). Campesterol content was below the limits established by EU Regulations (4%) in all of the oils studied (EEC, 2003). The levels of Δ5, 24-stigmastadienol was relatively low in all studied virgin olive oils except for Arbequina olive oil was not detected. Δ5, 24-stigmastadienol percent ranged from 1.03% (Coratina olive oil) to 1.47% (Siwi olive oil). As regards other authenticity indices established by the European legislation (EEC, 2003), cholesterol percentages were below the established limits of 0.5% except for Arbequina virgin olive oil and the percentages of stigmasterol were lower than those of campesterol in studied olive oils varieties (Table 4).

The highest sitostanol content was found in Arbequina olive oil (3.79%), whereas Siwi virgin olive oil showed the lowest (1.25%) (Table 4). The highest Δ7-avenasterol content was observed in Siwi olive oil (1.81%), while Coratina olive oil showed the lowest (0.62%) (Table 4). This compound was not detected in Arbequina olive oil.

In the case of apparent β-sitosterol, expressed as the sum of the contents of β-sitosterol and four other sterols formed by the degradation of β-sitosterol (clerosterol, sitostanol, Δ5-avenasterol and Δ5,24-stigmastadienol), all samples analyzed contained more than the established limit of 93% except for Arbequina olive oil was (59.54%). (IOC, 2006, EEC, 2003).

All of the olive oil samples studied contained more than 1000 mg/kg of total sterols, the minimum value established by EU Regulations (EEC, 2003), for the category "extra virgin" olive oil. The lowest level in Coratina olive oil (1562.32 mg/ kg) whereas the highest level in Arbequina olive oil (2550.62 mg/kg) (Table. 4). This is undoubtedly a good characteristic of olive oils, due to the great benefits of these compounds for health, as referred before.

The campesterol/stigmasterol ratio has been reported as a quality index of an oil (Ben Temime *et. al.,* 2008).The campesterol/stigmasterol ratio ranged between

1.81 and 6.85 for the analyzed oils and the average values were particularly high for Coratina and Koroneiki olive oils (Table 4).

In conclusion, All the analyzed VOOs were classified in the "Extra virgin" category according to the regulated physicochemical parameters, but only 75% of them qualified if the sterols and fatty acid compositions parameters were also taken into account. Arbequina virgin olive oil stood out of IOC and EU limits (IOC, 2006, EEC, 2003) due to its low β-sitosterol content and high Cholesterol content.

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تركيب الاستيرولات لبعض أصناف زيتون الزيت المنزرعة تحت الظروف المصرية

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تعد الاستيرولات من المواد الغير قابلة للتصبن و من المكونات الهامة لصحه الانسان حيث ان لها القدرة على تقليل امتصاص الكوليستيرول و مشاكل القلب. لذا هناك اهمية للتعرف على تركيب الاستيرولات فى زيوت الزيتون المصرية ، لذا تم دراسة الأستيرولات لاصناف (كوراتينا و اربيكينا و كروناكى و سيوى) خلال موسم (2010–2011) و اوضحت النتائج الأتى :

- تم التعرف على اكثر من 9 مركبات استيرولية و هى متوقعه و متعارف عليها فى زيت الزيتون وتعد β-sitosterol, Δ5-avenasterol, campesterol and stigmasterol هى المركبات الاستيرولية الرئيسية بينما Cholesterol, clerosterol, sitostanol, Δ5,24-stigmastadienol, and Δ7-avenasterol فتتواجد بكميات اقل.
- اوضحت ايضا النتائج ان كمية الاستيرولات الكلية اعلى من الحد الادنى المتعارف عليه فى الواصفات القياسية (1000 مجم/ كجم) حيث تراوحت بين (1562.32 – 2550.62 مجم/ كجم).
- احتوى زيت كوراتينا على اعى نسبه من مركب β-sitosterol (84.24%) و زيت اربيكينا على اقل نسبه من نفس المركب (50.63 %).
- احتوى زيت سيوى على اعلى نسبه من مركب Δ5 avenasterol (8.66%) بينما احتوى زيت اربيكينا على اقل نسبه من نفس المركب (4.75%).
- يعد زيت اربيكينا خارج المواصفات القياسيه لانحرافاته العاليه فى نسب الاستيرولات و الاحماض الدهنيه عن هذه المواصفات القياسية.
- اوضحت نتائج خصائص الجودة ((الحموضة ، و رقم البيروكسيد ، K_{232}، K_{270} ، ΔK) ان جميع اصناف زيوت الزيتون المصرية التى تم دراستها تعتبر " Extra virgin olive oil " .