Influence of Environmental factors on Olive Oil Production and Quality in the Northern Region of Kingdom of Saudi Arabia

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Abstract: The aim of the present study was to evaluate the variations in the productivity and oil quality of *Olea europaea* L. cv. Picual fruit trees cultivated in Al-Jouf (JF), Gurayat (GT), Hail (HL) and Tabuk (TK) orchards in the northern region of KSA. The soil type is a sandy loam in Gurayat orchard and sandy in the other three orchards. The pH values for the four orchards were nearly similar while the electrical conductivity (EC) was about 2.40, 2.17, 0.68 and 0.52 dsm^{-1}, respectively for the four regions. Al-Jouf followed by Gurayat orchards attained the highest percentage of oil and the lowest percentage of moisture compared to the other orchards. Variations in free acid value and iodine and saponification values showed that olive oil of Al-Jouf followed by Gurayat orchard had the highest values amongst the other four regions. The variation in refractive index was insignificant among the four orchards. On the other hand, peroxide value attained the maximum value in Tabuk orchards while the minimum was achieved in Al-Jouf orchards in reverse with oxidative stability. The total saturated fatty acids percent did not show a specific trend among the four regions. On the other hand, the percent of the estimated unsaturated fatty acids is much higher than that of the saturated ones. The highest percent (86%) was attained by olive oil extracted from Al-Jouf orchards followed by that of Gurayat (GT) orchard (84.5%).
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Key Words: *Olea europaea,* soil type, oil and moisture content, oil properties, fatty acid composition.

1.Introduction

Olea europaea (olive) is one of the most important tree crop species of the Mediterranean area (95% of the world's olive cultivations) and its global importance is rapidly increasing **(FAO, 2001)**. World olive oil production for 2001-2002 was approximately 2,688,500 tones and that of canned olives was about 1,426,000 tones. At 2010 the world oil production was about 3,269,248 tones **(FAO STAT crops processed 2010 data for olive oil**). Spain is the world's largest producer (45.5%) followed by Italy (16.8%), Greece (10.8%), Syria (5.4), Morocco (5.2 %), Turkey (4.9%) and Tunisia (4.9%).

Olives are considered a new crop in Kingdom of Saudi Arabia (KSA). During the last fifteen years national production of olive oil has increased rapidly and there is an enormous potential for olive oil and table olive production in the KSA, especially in the Northern region (Al-Jouf, Gurayat, Hail and Tabuk) due to its temperate climate. This has stimulated investment and the establishment of olive groves and a number of very large projects have been established. The production was nil till year 2000 thereafter increased from 1000 tons during 2001 to 3000 tons till 2013 with a growth rate of 150%**. IOOC, (2003)** reported that KSA produced about 2,900 tons of olive oil with 0.10% of the world production. However, **Alkhaldi (2008)** reported that since 25 years ago olive oil production in kingdom of Saudi Arabia especially in Al-Jouf area was progressed by a successful percentage of about 99.6% for all olive grades. There are more than 13 million olive trees in the area and that more trees were being planted. Al-Jouf province had given top priority to the cultivation and production of olives. In 2011, the planted area of olive reached about 23245 ha out of which 22495 ha (96.77%) in Al-Jouf, Hail and Tabuk, 95% were at the young age of fruiting (less than 10 years) according to statistics of **MOEP (2010)** and **Mehri *et al.* (2013).** Furthermore, **Mehri *et al.* (2013)** postulated that the five olive cultivars; Picual, Sourani, Zaiti, Nabali and Picholine performed well in Al-Jouf conditions.

The chemical and quality characteristics of a virgin olive oil are influenced by the site of cultivation **(Rotondi *et al.*, 2004; Tura *et al.*, 2007). Ben Temime *et al.*, (2006)** showed that the climatic conditions particularly the rainfall during growing and ripening of olive fruits; influence the concentration of phenolic compounds. According to **Osman *et al.* (1994)** phenols, unsaturated fatty acids, oxidative stability and free acidity are negatively correlated with altitude. **Pannelli *et al.* (1993)** showed that rainfall was correlated positively with total volatiles. **Servili *et al.* (1990)** found that the soil texture was correlated positively with phenol content (possibly because it influences negatively the soil moisture of soil).

Ranalli *et al.*, (1999) reported that the contents of oleic and linoleic acids could be negatively correlated with $CaCO_3$% of the soil.

Olive oil is very rich in monounsaturated (oleic acid), polyunsaturated (linoleic acid) and saturated fats (palmitic and stearic acids) **(Sacks, 1995; El-Darier and Youssef, 2002).** The substitution of saturated fats with monounsaturated fat lowers blood LDL cholesterol, thus reducing cardiovascular risk. Several studies **(Mataix and Martinez, 1988 and Tous and Romero, 1993; Tuck and Hayball, 2002)** confirmed that virgin olive oil helped to lower LDL (bad) cholesterol and, perhaps more importantly, stimulated an increase in HDL (good) cholesterol.

The main objective of this work was to study the variations in the productivity and oil quality of *Olea europaea* L. cv. Picual fruit trees cultivated in four climatic regions specific for oil and table olive production. These regions are Al-Jouf (JF), Gurayat (GT), Hail (HL) and Tabuk (TK) in the northern part of the kingdom of Saudi Arabia which was found to have different responses to environmental and edaphic conditions.

2.Material and Methods

A-Sampling

Four agricultural regions named Al-Jouf (JF), Gurayat (GT), Hail (HL) and Tabuk (TK) were selected to be the study area and to carry out the present study. Four orchards (each in one of the study site) were chosen as representatives for the main olive agro-ecosystems practiced in the northern region of the kingdom of Saudi Arabia. The total area of each orchard was 15±3 ha and was planted at year 2000. There is no application for any kind of chemical fertilizers or pesticides. The trees were commonly fertilized only by organic matter at a rate of 16 m^3/ ha/ year. The trees were planted at planting density of two hundreds trees/ ha. (10 meters distance between the tree rows). Irrigation started at May and continued till October every two weeks. Yet, it was not applied during wintertime.

Five trees of Picual cultivar were selected from each orchard. Two samples of fruits were collected from each tree at the full ripe stage. Each sample enclosed from 50 to 100 fruits according to the size of the fruits. The fruits were wiped free of dust, washed with distilled water, dried with filter paper, weighed and the average fruit weight was then calculated. Moisture content was measured by subtracting the weight of the fruits before and after incubating the samples in a dry oven for two successive equal readings. Sampling procedures were according to **El-Darier (1999)**. The meteorological data (**Table 1)** for the four regions in the northern borders of Saudi Arabia were according to **Meteorologisk Institute (2012).**

B- Chemical Properties of Olive Oil

1. Oil extraction

The oil used in the subsequent analysis was obtained from traditional press olive –mills in the four regions of the present study.

2. Analytical methods of oil properties

2.1 Refractive index (RI)

Reflective index was determined according to the method described by **AOAC (2000)** using a refractometer (NY RL-3-Poland).

2.2 Free Fatty acids (FFA)

Free acidity, expressed as percent of oleic acid (% C18:1), was determined by titration of the solution of oil dissolved in ethanol/peterium ether (1:1, v/v) with 0.1 M potassium hydroxide ethanolic solution. The value was evaluated according to the official methods described in the European Union Commission Regulations EEC/2568/91 and EEC/1429/92.

2.3 Peroxide value (PV)

Peroxide value, given in milliequivalents of active oxygen per kilogram of oil (meq O2 kg^{-1}). It gives a measure of the extent to which an oil sample has undergone primary oxidation. The value was determined as follows: a mixture of oil and chloroform/glacial acetic acid (3:2, v/v) was left to react in darkness in a saturated potassium iodide solution; the free iodine was then titrated with a sodium thiosulfate solution. The value was evaluated according to the official methods described in the European Union Commission Regulations EEC/2568/91 and EEC/1429/92.

2.4 Iodine value (IV)

The iodine value was determined using the Hanus method as described by **AOAC (2000)**.

2.5 Saponification value (SV)

Saponification value was determined according to the **AOAC (2000)**.

2.6 Oxidative stability (OST)

Oxidative stability was evaluated by the Rancimat method **(Gutièrrez, 1989).** Stability was expressed as the oxidation induction time (hr), measured with the Rancimat 743 apparatus (Metrohm Ω, Basel, Switzerland), using an oil sample of 3.6 g heated to 100ºC and an air flow of 10 L hr^{-1}.

2.7 Fatty acid composition

For the determination of fatty acid composition, the methyl-esters of fatty acids were prepared from olive oil, and after cold saponification by vigorous shaking of a solution of oil in hexane (0.2 g in 3 ml) with 0.4 mL of 2 N methanolic potassium hydroxide **(IOOC, 2001)** they were analyzed by gas chromatography (GC) (HP 4890 D, Hewlett–Packard company, Wilmington, DE, USA) equipped with a

capillary column (Supelcowax: 30×0.53 mm; 0.25 µm, Agilent Technologies, USA), an injector split-splitless and a FID detector. The carrier gas was nitrogen, with a flow rate of 1 mL min-1. The temperatures of the injector, the detector and the oven were held at 230, 250 and 210ºC, respectively. The injection volume was 1 µL. Individual fatty acids (palmitic, palmitoleic, stearic, oleic, linoleic and linolenic) were determined by comparison with retention times of known standards.

Statistical Analysis

Data obtained throughout this study were statistically analyzed using the analysis of variance method as reported by **Snedecor and Cochran (1980)** and the differences between means were differentiated by using Duncan's range test.

3.Results

Soil Analysis

The practice analyses for the soil of the four olive orchards in the four regions are presented in **Table 2.** Generally, the results illustrated that soil type is a sandy loam in Gurayat orchard and sandy in the other three orchards. Accordingly, this type of soils contain insignificant amount of organic matter (about 0.7, 1.25, 1.28 and 0.1% for Al-Jouf, Gurayat, Hail and Tabuk, respectively). The pH values for the four orchards were nearly similar (7.85-7.89) indicating that the soil is slightly basic. The electrical conductivity (EC) which indicates the content of the total soluble salts in the soil was about 2.40, 2.17, 0.68 and 0.52 dsm^{-1}, respectively for the four regions.

Oil and Moisture Content

Percentage of oil and moisture showed inverse tendency in the olive oil from the four orchards **(Figure 1).** The highest oil percent on fresh weight bases was obtained for Al-Jouf orchards followed by Gurayat orchard (about 2.84 and 2.51% respectively. The two other orchards attained the lowest percentages of about 0.84 and 0.91% respectively. On the other hand, the highest moisture content recoded was that of Hail orchard (77.13%). Orchard of Al-Jouf and Gurayat showed the lowest value for the moisture content being only 64.19 and 68.20 % respectively.

Variations in Oil Quality Parameters

Free acidity (FA), iodine value (IV), saponification value (SV), refractive index (RI), peroxide value (PV) and oxidative stability (OS) were presented in **Table 3.** Variations in free acidity showed that virgin olive oil of Al-Jouf orchard had the lowest value (0.22) amongst the four regions under the present study. The highest value (0.72) was recorded in Tabuk orchards. Gurayat orchard had a value of 0.34, which is the second to that recorded by Al-Jouf. Iodine and saponification values ranged from 76 to 91 and from 184 t0 195 respectively with Al-Jouf orchard attained the maximum and Tabuk achieved the minimum. The variation in refractive index was insignificant among the four orchards. On the other hand, peroxide value attained the maximum value in Tabuk orchards while the minimum was achieved in Al-Jouf orchards in reverse with oxidative stability.

Variations in Fatty Acid Content

The total saturated fatty acids percent **(Table 4)** did not show a specific trend among the four regions. Rather it showed a "range". It ranged from 10 to 14 with respect to palmitic acid and from 4% to 5.5% with respect to stearic acid among JF, GT, HL and TK regions.

The percent of unsaturated fatty acids (oleic, palmitoleic, linoleic and linolenic) is much higher than that of the saturated ones. The highest percent (86%) of unsaturated fatty acids was reached by olive oil extracted from Al-Jouf virgin olive oil followed by that of Gurayat (GT) orchard (84.5%). Olive oil extracted from the two other orchards attained values of about 82.5 and 80.5% respectively.

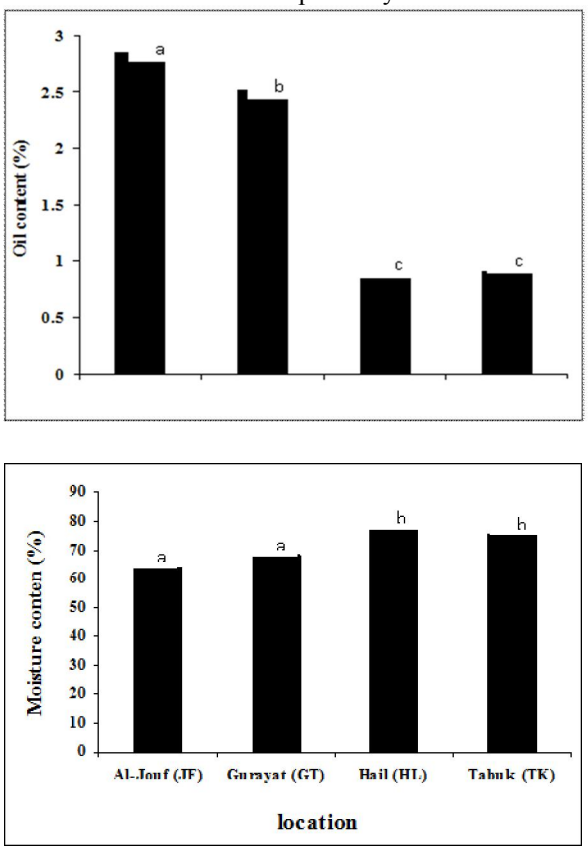

Figure 1. Oil and moisture content (%) of olive oil in the four orchards in the northern region of Saudi Arabia Different letters for each parameter indicate a significant difference at the 0.05 level of probability as evaluated by ANOVA test.

Table 1. Climatic characteristics of the four regions selected in the present study.

Parameter	Al-Jouf (JF)	Gurayat (GT)	Hail (HL)	Tabuk (TK)
Latitude	32.29o	41.31o	27.51o	28.38o
Longitude	42.37o	37.27o	41.68o	36.58o
Altitude (m)	689	499	914	773
Annual average temperature	23.8	24.0	21.6	22.4
Annual average rainfall (mm)	13.98	14.23	51.7	20.38
Annual average wind speed (Km/h)	12.9	22.0	12.4	10.80

Table 2. Means ± SD of six samples representing some physical and chemical characteristics of the soil in the four regions of the study area.

Character	Al-Jouf (JF)	Gurayat(GT)	Hail (HL)	Tabuk (TK)
EC [a]	2.40±0.6	2.17±0.4	0.68±0.6	0.52±0.2
pH	7.85±1.1	7.89±1.3	7.88±0.85	7.87±1.6
Ca^{+2} [b]	63±4.31	9.4±0.90	2.4±0.52	2.00±0.9
Mg^{+2} [b]	51±3.12	6.2±0.21	2.0±0.11	1.40±0.8
Na^{+}[b]	14.91±1.9	10.14±1.0	3.91±0.21	4.13±0.7
K^{+}[b]	1.11±0.11	0.33±0.05	0.33±0.01	0.51±0.04
Cl^{-} [b]	10.0±1.0	6.0±0.41	3.0±0.3	2.0±0.05
SAR	19.19±1.2	19.19±1.4	2.64±0.2	3.17±0.06
SO^{-}_{4} [c]	12.4±0.90	12.4±0.72	0.20±0.01	0.20±0.01
$CaCo_3$[d]	1.37±0.2	1.93±0.20	1.78±0.04	0.83±0.02
OM [d]	0.70±0.01	1.25±0.04	1.28±0.05	0.10±0.01
OC[d]	0.41±0.04	0.73±0.02	0.74±0.02	0.06±0.002
Sand [d]	97±3.0	81±2.5	99±1	97±2.0
Silt[d]	0±0	16±3	0±0	0±0
Clay [d]	3±1	3±1	1±0.01	3±1
Soil Type	Sandy	Sandy loam	Sandy	Sandy

a: ds/m **b:** meq/kg **c:** ppm **d:** %

Table 3. Mean ± SD of some olive oil quality parameters in the four regions of the study area.

Region	Al-Jouf (JF)	Gurayat (GT)	Hail (HL)	Tabuk (TK)
FA	0.22±0.03 [a]	0.34±0.02 [a]	0.28±0.02 [b]	0.72±0.01 [c]
IV	76 ±2.7[a]	82±3.4[b]	89±3.6[c]	91±4.1[c]
SV	184±5.9[a]	186±4.7[b]	190±8.8[c]	197±9.1[d]
RI	1.46±0.01[a]	1.469±0.01[a]	1.470±0.02[a]	1.470±0.02[a]
PV	7±0.8[a]	9±1.0[a]	12±1.1[b]	12±1.3[b]
OSI	24±20[a]	23±1.9[a]	22±2.1[a]	21±1.8[a]

FA: Free acidity (% C18:1) Iodine value: IV Saponification value: SV
Refractive index: RI Peroxide value: PV (meq O_2 kg-1) Oxidative stability: OSI (H)
Different letters within each column indicate a significant difference at probability level ≤ 0.05 according to ONE-WAY ANOVA test.

Table 4. The from oil olive of (%) composition acid Fatty four regions of olive production in the northern region of Saudi Arabia.

Region	Saturated fats		Unsaturated fats			
			Monounsaturated		Polyunsaturated	
	Palmitic acid	Stearic acid	Oleic	Palmitoleic	Linoleic	Linolenic
Al-Jouf (JF)	10±0.9 [a]	4±0.53[b]	79.5±3.2 [a]	2.0±0.01[a]	4±0.20[a]	0.5±0.01[a]
Gurayat (GT)	11±1.01[a]	4.5±0.6[b]	76.5±3.4[b]	2.5±0.20[a]	5±0.31[a]	0.5±0.01[a]
Hail (HL)	12±1.11[a]	5.5±0.55[a]	68±2.65[c]	3.5±0.11[b]	10± 0.54[b]	1.0±0.03[b]
Tabuk (TK)	14±1.42[b]	5.5±0.53[a]	64±2.0[d]	3.5±0.13[b]	12±0.43[b]	1.0±0.02[b]

Different letters within each column indicate a significant difference at probability level ≤ 0.05 according to ONE-WAY ANOVA test.

4.Discussion

The importance of virgin olive oil is related to its high levels of monounsaturated fatty acids (mainly oleic acid) and polyphenole compounds **(Ocakoğlu *et al.*, 2009).** The oxidative stability and health properties of virgin olive oil come from a prominent and well-balanced chemical composition **(Bendini *et al.*, 2007).** The high content of oleic acid in olive oil serves to slow down penetration of fatty acids into arterial walls **(Charbonnier, 1982).** Oil with higher monounsaturated fatty acids (MUFAs) and lower saturated fatty acids (SFAs) are preferred because of the proven beneficial effect of MUFAs on serum cholesterol levels **(Baccouri *et al.*, 2008).** Olive oil

quality is related to the chemical composition of the oil, and its oxidative stability and sensory characteristics. These parameters are affected mainly by climatic conditions **(Vinha *et al.*, 2005; Tura *et al.*, 2007).**

As indicated from the present study, significant differences among olive oil samples of Picual cultivar from different regions were observed ($p < 0.05$). Among them, Al-Jouf (JF) and Gurayat (GT) orchards had the highest total unsaturated fatty acid content (86 and 84% respectively) with percentages of about 79.5 and 76.5% of oleic acid (promising regions). The lowest percentages (82 and 80.5%) were attained in the two other regions with 68 and 64% of oleic acid respectively. The two promising regions also exhibited high percentages of oil content and more appropriate soil properties. Oleic acid values were significantly associated with mean temperature during oil accumulation **(Rondanini *et al.*, 2011)**.

Based on the results of this study, analyzed oil of all samples fall within the ranges established for ''virgin olive oil'' category. The results here showed high levels of oleic acid. The results also highlighted that the analytical parameters were influenced by climatic and edaphic conditions in order to produce olive oils with high quality. Interestingly, Al-Jouf (JF) and Gurayat (GT) orchard was characterized by high yield and quality. Furthermore, the ratio between unsaturated and saturated fatty acids was 6.14 and 5.45 compared to 4.71 and 4.13 for the two other regions.

The present study asserted that discrimination between virgin olive oil samples with different geographical origin and the same cultivar was possible. The mono and polyunsaturated fats composition were found to be useful in discriminating the olive oil samples oils since they was affected not only by the olive cultivars, but also by the climatic and environmental conditions, agronomic practice and the technological processes. Furthermore, the high bioavailability of unsaturated fatty acids lends support to the human health. Olive oil compounds have been shown to beneficially alter lipid composition, platelet and cellular function, as well as reduce oxidative stress and neuro inflammation **(Carluccio *et al.*, 2007). Tuck and Hayball, 2002** confirmed that virgin olive oil helped to lower LDL (bad) cholesterol and, perhaps more importantly, stimulated an increase in HDL (good) cholesterol. This is all very good for those concerned about their cholesterol levels, especially the good HDL cholesterol, and the effects on the human circulatory system.

In conclusion, the present study emphasize the use of the virgin olive oil extracted from **Al-Jouf (JF) and Gurayat (GT)** orchards in animal studies **(e.g. rats)** to document its therapeutic effect to lower the blood cholesterol.

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