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Effect of Various Agro-Climatic Conditions on the Quality and Quantity of Olive Oil

Abdul Wahab[1], Tariq Masood[2], Azmat Ali Awan[3], Muhammad Waqas Aslam Cheema[3]*, Muhammad Arabi Awan[4], Zafar Ali Shah[2], Javed Iqbal[5], Muhammad Arif[6] and Wahid Gul[1]

[1]*Directorate of Soil and Plant Nutrition, ARI, Tarnab, Peshawar, Pakistan*

[2]*Department of Agricultural Chemistry & Bio Chemistry, The University of Agriculture, Peshawar, Pakistan*
[3] *Pakistan Oilseed Department, Government of Pakistan*

[4]*Department of Entomology, The University of Agriculture, Peshawar, Pakistan*
[5]*Department of Botany, Government College University, Hyderabad, Pakistan*
[6]*Department of Human Nutrition, The University of Agriculture Peshawar, Pakistan*

Abstract

The purpose of the research is basically to find the effect of several patterns of climate, for example, a region's weather, rainfall altitude, etc. on the production, quality, and quantity of olive oil. Olive fruits were gathered from a couple of varieties of olive plants i.e., *Arbequina* and *Coratina* in fully young phase from the orchards of different locations of Pakistan namely, Chakwal, Nowhera, and Quetta where the climate patterns are entirely different in regard to weather, rainfall, and altitude. The extracted oil which was taken after the mechanical pressure was analyzed in various quality parameters i.e., Peroxide value, Chlorophyll content, Vitamin E, etc. The average value which was observed was not affected ($P \geq 0.05$), but every figure was lying in the given accepted scale of the International Olive Council. Major change ($P \leq 0.05$) was observed in oil content for K232, K270, Chlorophyll contents, oleic acid, linoleic acid, palmitic acid, palmitoleic acid, total antioxidant potential and total polyphenols in both the cultivars and the different regions which are mentioned above. It was observed that the olive of the Nowshera location acquires maximum average value of linoleic acid (10.99%), Linolenic acid (1.01%) and palmitoleic acid (2.74%). The second highest average value of olive oil was found was that of Chakwal, whereas Quetta has lowest average value of olive oil. The maximum average content of K232 (3.13), K270 (0.48) and total antioxidant (48.48%) were recorded in district Chakwal. The second maximum mean values were found at Nowshera whereas, the lowest mean values of K232 (3.13), K270 (0.48) and total antioxidant (48.48%) were found at Quetta. The maximum content of oleic acid (72.59%), palmitic acid (19.00%) and total polyphenols (28.97) were found in the olive oil of Quetta succeeded by Chakwal whereas, the content of oleic acid (72.59%), palmitic acid (19.00%) and total polyphenols (28.97) were found lowest in the oil of Nowshera. In a nutshell, it is clear from the above-mentioned experiment which was performed at different locations; that changing climatic patterns has a significant effect on the quantity of the oil. It has also a significant impact quantitative production of olive oil.

Keywords: Olive Extractino; Climatic Pattern; Quality Standards

1. Introduction:

Olive is an oldest and most unique plant spread in mainly all parts of the world. Olive comes from a Oleaceae family of plants (Loumous & Giourga, 2003). It has been found by several ancient and modern texts that the first ever olive cultivation was started in the period between 1500 to 3000 BCE (Riley,

*Corresponding author Tel.: +92 3326005818
E-mail address: waqasaslamcheema2006@gmail.com

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2002). Except the Antarctica continent, olive plant is found everywhere in the world i.e., from high altitude to lower one and from the temperate region to moderate region (Wallander & Alber, 2000). The olive oil inculcates magnificent traits such as, the presence of volatile compound and balance fatty acid composition (Sanchez & Harwood, 2002). The temperature, several biotic and abiotic factors and olive fruit cultivars have a significant effect on its chemical composition (Rotondi *et al.,* 2004). The important palmitic and stearic, responsible for 80% of the overall fraction is Oleic (monounsaturated). There may also several other fatty acids present in olive oil such as, poly unsaturated linoleic with the concentration of 2.5-20% and palmitic acid with the concentration of 10-20% (Kiritsakis & Christie, 2000). Olive oil helps in the prevention of heart disease (Visioli *et al.,* 2002). The usage of olive oil and its plant food in the diet of Mediterranean has reduced the rate of cancer in the population compared to the other world (Trichopoulou & Vasilopoulou, 2000).

Other qualities of the olive oil are easy digestibility, reduced risk of heart attack and other heart diseases, reduced risk of blood pressure problems and its high oxidative stability (Gurr, 1992). The olive tree is considered as one of the oldest trees which can even bear the climatic severities. It can bear tolerate the drought stress, the low temperature of up to -8.5^0 C while in arable region its toleration is below 350 mm per year due to less rains (Connor & Fereres, 2005). The ideal yearly rainfall for the cultivation of olive plant is above 500 mm (Ponti *et al.,* 2014).

The specifications of olive oil significantly depend on the area of cultivation, the genetic factors and most importantly the environmental factors which greatly impacts the chemical composition of virgin olive oils (Criado *et al.,* 2004). The quality of olive oil also gets affected by the altitude for example, the olive plants which are grown in relatively lower altitudes have low chemical stability, and those which are cultivated at higher altitudes have high chemical stability (Mousa *et al.,* 1996). The quality and quantity and also the mature growth of the olive plant fruits is greatly impacted by the seasonal variation in climate (Cantini *et al.,* 1999). There is a relatively inverse relation between the concentration of linoleic acid and temperature, so the fallen temperature suits the accumulation of linoleic acid (Alberdi *et al.,* 1991). The other important factors on which the characteristics of olives depend are the type of soil and the number of water vapors in that particular area (Vasilopoulos, 2013). Inadequate availability of water at the initial stages of fruit causes serious olive fruit size reduction, and if there is a sufficient amount of water being supplied at regular intervals then it will nourish the fruit dramatically (Servili *et al.,* 2004). Various studies have shown that if a sufficient amount of water is provided to the plants, then it greatly affects palmitic and stearic. It also increases the parameter value of oxygen, importantly, hydro peroxides value in the soil (Servili *et al.,* 2007).

1.1. Objectives:

- To study how the climatic condition of three different regions can affect or are affecting the extracted olive oil (*Coratina* and *Arbequina*).
- To explore the effect of several patterns of climate, for example, a region's weather, rainfall altitude, etc. on the production, quality, and quantity of olive oil.

2. Materials and Methods:

2.1. Sampling:

Olive oil of *Arbequina* and *Coratina* were taken from the above-mentioned three districts having entirely different climate patterns i.e., average rainfall, average temperature, etc. whereas the ongoing agronomic activities remained constant in the recent year. Olive oil samples were forwarded to the Department of Agricultural, The University of Agriculture, Peshawar and for more chemical observations the samples were put under specific environmental storage conditions. Every olive oil specimen collected from three different districts was tested for several chemical parameters.

2.2. Biochemical Analysis:

2.2.1. Peroxide Value (PV):

The peroxide content of the oil was found based on the EC Regulation 2568, 1991 which is mentioned as milli eq of O_2/kg of olive oil. Add 30 ml Acetic acid in 1.5 g olive oil in a conical flask and shake until the mixture colour changes to yellow colour. Then add 30 ml of distilled water and a saturated potassium iodide solution of 0.5 ml. Then add 0.5 ml volume of starch solution 1%. Then stir for at least two minutes until the colour changes to brown from yellow. Then titrates against sodium thiosulphate N/10. Titrate until the brown colour disappears. By putting the measured content below the given formula, the peroxide content of the olive oil was found.

$$\mathbf{POV} = \frac{(\mathrm{S} - \mathrm{B}) \times \mathrm{N} \times 1000}{\text{Weight of Sample in gm}}$$

S= Sample, B= Blank

2.2.2. Antioxidant and Phenolic Portion Extraction:

The extraction of the olive oil was performed according to (Minioti & Georgiou, 2010). 1 ml of n-hexane was diluted with 1 g of olive oil. Then add 1 ml mixture of water-methanol 20:80 (v/v). Then centrifuge at 5000 rpm for at least 5 minutes. In the aqueous methanolic solution, the extraction of olive oil was 3 times.

2.2.3. Total Phenolic Content:

It was found according to (Houshia *et al.,* 2014) with little change. In a test tube, take a 0.2 ml methanolic extract and add 1 ml solution of standard FCR. Then add Na_2CO_3 solution to the mixture of 0.2 ml of 20% (w/v). Then stir for at least 3 minutes and then incubate at 45^0C for at least half an hour. Then shift the centrifuged specimen to the spectrophotometer. Then measure the assimilation for 725 nanometers (nm). This specimen was compared with a standard solution of gallic acid of 50, 75,100, and 150 ppm.

2.2.4. Antioxidant Activity:

With minor changes, the Olive oil antioxidant potency was found in accordance with (Minioti & Georgiou, 2010). Firstly, take 0.4 ml of (0.1 mM) DPPH solution. Along with the DPPH 1.2 ml methanolic, extracted oil was mixed strongly with the help of a vortex mixer and was kept dark for a quarter an hour. At 516 nm against ethyl acetate, the absorption of the mixture was observed. With the help of below-given formula, the percent inhibition of the oil specimen was determined.

$$\%\,\textbf{Anti}-\textbf{radical Activity} = \frac{\text{Control Absorbance} - \text{Sample Absorbance}}{\text{Control Absorbance}} \times 100$$

2.2.5. Chlorophyll Content:

Olive oil colorant for chlorophyll is termed as mg pheophytin. And it is approximately equivalent to:

$$C = 345.3 \times (A670 - 0.5 \times A630 - 0.5 \times A710/L$$

Here, C is the Chlorophyll value in mg, A is the absorbance at desired frequency, L is density.

Chlorophyll value of the olive oil was found based on (Pokorny *et al.,* 1995). Whatman filter paper had been used to filter the olive oil and to measure the absorbance as 630nm, 670nm, and 710nm by using distilled water as a blank.

2.2.6. Specific Absorption Co-efficient (K_{232} and K_{270}):

The olive oil-specific absorption coefficient was found based on (EEC / 2568 / 91 and EEC / 2472 / 97 regulations). Olive specimen adulterated with Hexanaphthene by using 1cm as cuvette length. Assimilation was done at 232, 260, 270, and 2774nm respectively. By the following formula, the result was made:

$$\mathbf{K\lambda} = \frac{\text{abs}\lambda}{C} \times L$$

$$\Delta = K270 - [\frac{(K266 + K274)}{2}]$$

Where, C = Concentration of Olive Oil [g/100 mL], L= Path Length [cm], K= Extinction coefficient [100 mL/ (g × cm)]

2.3. Depiction of Acid (Fatty):

2.3.1. Preparation of FAME:

Extraction process of FAME was performed according to the International Olive Council (EC Regulation 2568, 1991). The extracted olive oil of 100 mg was diluted with n-hexane of 10 ml. Then pour 100ul methanolic solution of 2N potassium hydroxide. Then mix stir the mixture for at least 30 seconds with the help of vortex. Then the same mixture was centrifuged at exactly 500 rpm for almost 15 minutes. Then the layer on the top was obtained for further analysis of FAME.

2.3.2. Chromatographic Separation-Detection:

Then every single fatty acid detected and was performed based on (Li *et al.,* 2019) with small modification. For the analysis, Varian 450-GC (Agilent Technologies, Santa Clara, CA, USA) was used. The extracted olive oil specimen of volume 0.2ul was inserted in the injection port of chromatographic system. The temperature at which the olive oil sample was injected was 270^0C. As a carrier, Nitrogen gas was used with the rate of 1.5ml per minute. The capillary column of 60 m × 0.25 mm × 0.25 um DB-23 was used. For 8 minutes the temperature of oven was kept for almost 100^0C. And then it was increased slowly with 6.5^0C up till 170^0C. Followed by 2.7^0C the temperature was increased up till 215^0C. Lastly, to erase and boil other remains +from the system, the temperature was further increased by 15^0C per minute for almost 9 minutes. The individual fatty acid was detected at the temperature of 280^0C with the help of FID detector.

2.4. Statistical Analysis:

The data obtained from all variables were statistically analyzed through Randomized Complete block Design by using software like Statistics 8.1.

3. Results:

3.1. Climatic Normal of Nowshera, Chakwal and Quetta:

From the agriculture research institute, the data on climate was gathered in the 3 mentioned districts. Nowshera, with an altitude of 298 meters has been found to have a subtropical climate having an annual rainfall of 530-540mm. And importantly, Nowshera has a mean annual temperature of 22.56^{0}C, and this makes Nowshera the hottest district among the three under-researched districts. After Nowshera, Chakwal has an altitude of 498 meters and has average yearly rainfall of 515-525mm. The average yearly temperature of Chakwal is 22.25^{0}C. The last district Quetta has basically a semi-arid climate with an altitude of 1679 meters. The average annual rainfall in Quetta is 390-400 mm whereas the mean temperature in Quetta is 15^{0}C (Table 1).

Table 1: The climatic data of three districts

Districts	Average Rainfall (mm/ Year)	Average Temperature (^{0}C)	Altitude (m)
Nowshera	530-540	22.56^{0}C	298
Chakwal	515-525	22.25^{0}C	498
Quetta	390-400	15^{0}C	1679

3.2. Effect of Three Different Agro-Climatic Conditions on the Oil Quality of Two Varieties Cultivated Olive (Olea europea L.*):*

The average data of cultivars and districts for peroxide, K232, K270, total polyphenols, percent antioxidant, Oleic acid, Linoleic acid, palmitic acid, palmitoleic acid has been given in Table no.1. The results show that, Coratina, as compared to Arbequina has the maximum average value of peroxide (17.444 meq of O_2 kg^{-1}). For the peroxide figures, which were obtained from three different districts, the obtained olive oil from both the *Arbequina* and *Coratina* was non-significantly different ($p \geq 0.05$), but for the other parameters it was found significant ($p \leq 0.05$). Nowshera district have found to be the average maximum value of peroxide (16.83 meq of O_2 kg^{-1}). After Nowshera, Chakwal has the maximum average content of (16.33 meq of O_2 kg^{-1}). Least value for peroxide (15.00 meq of O_2 kg^{-1}) had been observed at Quetta (Table 2).

Table 2: The average data of different parameters of cultivars and 84districts

Parameter	Cultivar	Locations			LSD $_{0.05}$ value for V versus L
		Nowshera	Chakwal	Quetta	
Peroxide (meq of O_2 kg^{-1})	Coratina	14.67± 0.57 b	18.33± 1.52 a	19.33± 1.52 a	2.32
	Arbequina	19.00± 1.00 a	14.33± 1.52 b	11.66± 1.15 c	
K_{232}	Coratina	2.76± 0.02d	3.36± 0.05a	2.35± 0.03e	0.05
	Arbequina	2.83± 0.01c	2.88± 0.01b	2.29± 0.00 f	
K_{270}	Coratina	0.35± 0.01 b	0.59± 0.01 a	0.13± 0.01 e	0.09
	Arbequina	0.26± 0.00 c	0.35± 0.00 b	0.19± 0.01 d	
Chlorophyll (mg Kg-1)	Coratina	6.51± 0.02 d	4.83± 0.11 f	11.42± 0.02 b	0.09
	Arbequina	13.10± 0.01 a	5.53± 0.01 e	9.30± 0.01 c	
Antioxidant potential (%)	Coratina	35.91± 0.25 b	18.06± 0.82 e	24.36± 0.56 d	1.1

	Arbequina	32.60± 0.39 c	78.90± 0.48 a	35.56± 0.63 b	
Total polyphenol (mg kg^{-1})	Coratina	14.75± 0.02 c	43.32± 0.58 b	13.37± 0.03 d	0.44
	Arbequina	8.64± 0.20 e	8.00± 0.01 f	44.56± 0.07 a	
% Oleic acid (18: 1)	Coratina	65.69± 0.00 f	70.85± 0.01 b	74.75± 0.01 a	0.02
	Arbequina	69.55± 0.05 d	68.37± 0.01 e	70.44± 0.01 c	
% Linoleic acid (18:2)	Coratina	11.96± 0.01 a	11.65± 0.04 b	10.55± 0.01 c	0.06
	Arbequina	10.02± 0.02 d	9.54± 0.04 e	9.41± 0.52 f	
% Linolenic acid (18:3)	Coratina	0.93± 0.09 d	1.21± 0.01 a	1.01± 0.02 c	0.04
	Arbequina	1.11± 0.05 b	0.76± 0.01 f	0.85± 0.03 e	
% Palmitic acid (16:0)	Coratina	17.22± 0.05 c	16.08± 0.01 d	18.86± 0.01 b	0.03
	Arbequina	13.00± 0.02 f	14.53± 0.01 e	19.14± 0.0 a	
% Palmitoleic acid (16:1)	Coratina	2.44± 0.01 d	2.01± 0.01 e	1.72± 0.01 f	0.02
	Arbequina	3.03± 0.01 b	3.43± 0.05 a	2.66± 0.01 c	

Coratina has the higher average values (2.83) for K232 than *Arbequina* (2.67). At Chakwal, it was found that for the average value of location effect K232 is highest (3.13). After Chakwal, Nowshera with 2.80 had the second high average value of location effect K232. At last Quetta district has the lowest average value of location effect K232 (2.32). (El-Gharbi *et al.,* 2018). Coratina had a higher average value (0.36) than Arbequina which was (0.27) for the K270 value. Chakwal had the maximum average value (0.47) for the olive oil. After Chakwal, Nowshera had an average value of (0.31). And the lowest possible average value was found to be in the Quetta district. Arbequina was found to have higher values for chlorophyll content (9.31 mg kg^{-1}) as compared to the cultivar Coratina (7.59 mg kg^{-1}). In district Quetta, the highest average values for chlorophyll were found (10.36 mg kg^{-1}). After Quetta, it was found that Nowshera had the second-highest average values for chlorophyll (9.81 mg kg^{-1}). The lowest average values for chlorophyll were found in the Chakwal district (5.18 mg kg^{-1}). For oleic acid, Coratina had a higher average value (70.76%) as compared to the *Arbequina* cultivar (69.45%). Maximum average contents of oleic acid were found in the olive oil of the Quetta district (72.59%). After Quetta, Chakwal had a higher average content of oleic acid (69.11%). And the lowest possible average values of oleic acid were found to be in the Nowshera district (69.62%). As far as the linoleic acid is concerned, it was found that the maximum average linoleic acid was observed in linoleic acid (11.39%) than in *Arbequina* (9.65%). At district Nowshera, the maximum mean value of linoleic acid was observed (11.00%). The second maximum mean value of linoleic acid was recorded in the Chakwal district (10.60%). And at district Quetta, the lowest average value was noticed (10.00%). Riachy *et al.* (2018) and Li *et al.* (2019) noticed that Coratina cultivar had a higher average value of linolenic acid (1.05%) than the Arbequina cultivar. The maximum concentration of linolenic acid was noticed in the Nowshera district (1.01%). The second maximum concentration of linolenic acid was observed in Chakwal district (0.98%), and the least content was observed in the Quetta district (0.93%). (Palmitic acid (17.39%) concentration was found higher in Coratina cultivar than Arbequina cultivar (15.55%). Both the cultivars i.e., Arbequina and Coratina showed the maximum average value for palmitic acid in the Quetta district (19.00%). The second maximum average value for palmitic acid for both cultivars was recorded in the Chakwal district (15.30%). And the lowest value in this regard was found in the Nowshera district (15.10%). (Li et al., 2019). Overall, it was observed that regardless of any district, the Arbequina cultivar has the maximum concentration of palmitic acid (3.04) than the Coratina cultivar (2.05%). The maximum average value of palmitic acid was found in the olive oil of the Nowshera district (2.73%). The second average value of palmitic acid was found in the olive oil of the Chakwal district (2.72%). And the lowest average value of palmitic acid was recorded in the olive oil of

Quetta district (2.19%). As far as the total antioxidant potency of olive oil is concerned, it was recorded maximum in Chakwal district (48.48%). The second total antidote oxidant of olive oil was noticed in Nowshera district (34.26%). And the lowest average total antioxidant potency was recorded in district Quetta (30.00%). It was also noticed that the *Coratina* cultivar had the maximum average value of TPP (23.81 mg kg^{-1}) than *Arbequina* cultivar (20.40 MG KG-1). As far as the district effect is concerned, the maximum average TPP content was noticed in the Quetta district (29.00 mg kg^{-1}). Second maximum average value of TPP was recorded in district Chakwal (25.63 mg kg^{-1}). And the lowest average value of TPP was recorded in Nowshera district (11.70 mg kg^{-1}) (Table 2).

4. Discussion:

Based on the enriched amount of Omega 3, omega 6 and omega 9 fatty acid values, the extracted oil from *Coratina* had significantly higher value of nutrition as compared to the Arbequina variety. In comparison to *Coratina* olive oil, oil extracted from the Arbequina variety has significantly high antioxidant value, low average peroxide potential, and low unsaturated fatty acid value. This makes the Arbequina olive oil more chemically stable than the olive oil extracted from *Coratina.* As far as the maximum values for linolenic acid, palmitoleic acid, and peroxide are concerned, olive oil collected from district Nowshera has the maximum average values. The reason for this is that the chemical constituents kept on increasing as the yearly average temperature and yearly rainfall escalates, whereas the ongoing agronomy-related actions were kept unchanged. Youssef *et al.* (2006) and El Qarnifra *et al.* (2019) opined that climatic conditions, geography and location do affect the oil characteristics of olive oil and maturation if in frequent terms can enhance the linolenic acid, palmitoleic acid, peroxide. The same was narrated by El-Gharbi *et al.* (2018) who determined that the oxidative stability of Olive oil also dependent upon the location and geography. They further were of the view that soil characteristics and climatic normal like rainfall also play an important role in determining the quality of the olive oil. The maximum average contents for oleic acid, palmitic acid, total polyphenolic, and chlorophyll values were produced in the olive oil of Quetta. The reason behind these maximum average values is that these chemical constituents were greatly benefitted with the altitude but adversely effected with the mean annual temperature and annual rainfall whereas other on-going agronomic practice were kept unchanged. The results are being validated by Riachy *et al.* (2018) and Rouas *et al.* (2016) who after conducting rigorous research on the subject matter opined that total polyphenolic contents are met in the EVOO extracted from areas of lower precipitation. Awan & Rab, (2014) reported similar patterns for palmitic acid which was also confirmed by Li *et al.* (2019) who reported that areas with lower rainfall can have high palmitic acid concentration and linolenic acid. With the increase in altitude, the content of Chlorophyll in olive oil increased, but in areas where the rainfall was significantly high, the Chlorophyll concentration was low and other agronomic practices which were going were remain constant. The same was determined by Besbabis *et al.* (2008).

The maximum average values for total antioxidant potential, K232 and K270 were found in the olive oil which was extracted from the Chakwal region. The major reason behind these high values is that those synthetic substance ingredients were affected productively for example, as the mean annual temperature increases, these synthetic substances increase whereas when there is a decreased mean annual temperature, these chemical constituents decreased. Borges *et al.* (2019) claimed that antioxidant activities depend upon the cultivar of the olive and may be linked with phenolic activity in the fruit at large. He further described that EVOO quality in terms of antioxidant may be wholly dependent on the harvest and crop stage. In his previous studies Borges *et al.* (2017) also confirmed that areas with high rainfall and other climatic normal can have olive oil with more antioxidant potentials, and these results are also seconded by Kelebek *et al.* (2015). No significant interaction was either found for K_{232} and K_{270}. The Palmitoleic acid was higher in arbequina variety than Coratina variety and amongst locations, In Nowshera District. It may be possible that orchard from where the sampling was done, may be well irrigated as Gharbi *et al.* (2018) and Dabbou *et al.* (2015) pointed out this reason for high palmitoleic acid concentration.

5. Conclusion:

It is concluded that because of enriched omega 3 and omega 9 unsaturated fatty acids, but weak in antioxidant capability, one can recommend the *Coratina* olive oil to be used in impure form as salad dressing. In order to check the olive oil shelf-life stability from *Arbequina* or *Coratina* varieties, regions with changing climate patterns should be monitored under several storage and processing circumstances if one is to use olive oil in daily diet.

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