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Extractiosn of Oil from Different Cultivars of Oilve Fruits and their Profiling by Gas Chromatography

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ABSTRACT

Olive varieties differ from each other in terms of their morphological attributes, such as leaf size and shape, fruit size, color, texture and shape. These differences arise as a result of combination of different genotypic composition as the variable environmental conditions. The genotypic and phenotypic differences arising in plants are further translated to the level of the fruits, as a consequence of which, olive fruits from different cultivars yield different kinds of olive oils. The current study shows variable oil parameters of olive oil harvested from four different cultivars of oils, namely, [Arbequina (A), Barnea (B), Cortina (C), Koronoiki (K)] which were collected from two different sites, Napasar (N) and Lunkaransar (L), Bikaner (Rajasthan) and furthermore evaluate the variation in oil parameters (oil content as well as fatty acids present in oils) of different olive cultivars. The results of the study show that oil from all the varieties differed from each other in terms of colour as well as fatty acid profile. All these variations were attributed to the difference in genotype of different olive cultivars as well as variable metrological conditions coupled with different physico-chemical attributes of water and soil in both Napsar and Lunkaransar.

Keywords: Arbequina, Barnea, Cortina, Koronoiki, oleic acid, palmitic acid, stearic acid, linoleic acid, linolenic acid

1. INTRODUCTION

The last few years have been marked by increased awareness among the masses about plants and ameliorative role of plant derived products and phytochemicals for betterment of human society. Owing to this, the last few years have witnessed humongous upsurge in the production of olives due to increasing demand among the masses for olive fruits as well as other plant derivatives such as olive oil. Olive oil has been reported to possess numerous benefits such as, antioxidant activity, antiatherosclerosis, anti-diabetic activity, anti-inflammatory activity, cardioprotective and several others; all of which are attributed to the presence of different bioactive secondary metabolites like phenolics, triterpenes, flavonoids, phytosterols, coumarins and other useful fatty acids present in olive oil. Olive oil has been reported to contain a number of essential fatty acids like, oleic acid, palmitic acid, stearic acid, linoleic acid, linolenic acid and alpha linolenic acid.

Oleic acid is the primary monounsaturated fatty acid in the human body and also a key component of olives, thus making olives an indispensable part of human diet. Health benefits of oleic acid include:

- **Oleic acid plays a crucial role in maintenance of brain health since it is an important constituent of membrane phospholipids and also present in neuronal myelin sheaths. Therefore, deficiency of oleic acid has been associated with major depressive disorders and Alzheimer's disease.**
- **Oleic acid is an important antioxidant molecule itself and also controls synthesis and activity of antioxidant enzymes.**
- **Oleic acid plays a major role in inhibiting cholesterol transport as well as reducing cholesterol absorption, thus mitigating dangers associated with atherosclerosis and hypercholesterolaemia.**
- **Oleic acid acts as potent anti-cancer molecule bowing to its inhibitory effects on the overexpression of oncogenes as well as its role in apoptosis induction.**
- **Oleoylethanolamide, a derivative of oleic acid acts as an important anti-inflammatory molecule and therapeutic agent to treat obesity (Pastor *et al.*, 2021).**

Palmitic acid: Palmitic acid is the most common saturated fatty acid found in the human body and can be consumed in the diet or synthesized endogenously from other fatty acids, carbohydrates and amino acids. Health benefits of palmitic acid:

- Palmitic acid supports normal cellular for normal metabolic functions.
- Palmitic acid helps in providing membrane support during cell division, biological reproduction and intracellular membrane trafficking.
- Palmitic acid forms sphingolipids found in cell membranes that help protect brain and nerve cells.
- Palmitic acid helps in biosynthesis of other important fatty acids (Wang *et al.*, 2023)
- Palmitic acid supports skin health by reducing rashes, dryness, itching and other skin disorders.

Stearic acid:

- It helps in lowering cholesterol levels, acts as anti-inflammatory molecule and aids in improved cardiovascular health.
- Stearic acid acts as anticancer agent and prevents occurrence of many types of cancer

Linoleic acid:

- Linoleic acid prevents establishment and progression of atherosclerosis in animal models. Treatment with linoleic acid leads to decrease in both low-density lipoprotein (LDL) cholesterol to high-density lipoprotein (HDL) cholesterol, as well as total cholesterol to HDL cholesterol ratios in animals.
- Linoleic acid acts as anticancer molecule by blocking the growth and spread of malignant tumors, mainly by influencing cell replication and mechanisms of carcinogenesis.
- **Linoleic acid aids in amelioration of reproductive health since linoleic acid contains essential components of all cell membranes and can influence reproductive processes as well as alter the production of prostaglandins (Marangoni *et al.*, 2020).**

Alpha-linolenic acid

- **Alpha-linolenic acid lowers the risk of cardiovascular disease by maintaining normal heart rhythm and pumping blood**
- **Alpha-linolenic reduces the possibility of blood clots.**
- **Alpha-linolenic acid helps in alleviation of arterial and vascular conditions such as atherosclerosis and arteriosclerosis (Bertoni *et al.*, 2023).**

Considering all these health benefits of olive oil, the current study aims to evaluate the fatty acid profile of four different varieties of olives, namely, [Arbequina (A), Barnea (B), Cortina (C), Koronoiki (K)] **were** collected from two different sites, Napasar (N) and Lunkaransar (L), Bikaner (Rajasthan) and accordingly

analyse the variation in oil parameters (oil content as well as fatty acids present in oils) of different olive cultivars.

3. MATERIALS AND METHODS

3.1. Survey and collection of different varieties of olives

During survey, different places of Bikaner were visited to identify cultivars of olives. Finally, 2 olive farms- Napasar (Private farm) and Lunkaransar (Farm from Government project) were selected to collect olives. Out of all olive cultivars, 4 cultivars- Arbequina, Barnea, Cortina and Koronoiki were selected as those were found to be rich at the both selected sites. Healthy leaves of olives of 4 different varieties from 2 different sites of Bikaner were collected. Olive leaf samples were collected from 2 sites: Napasar (N) and Lunkaransar (L), Bikaner. From both sites, 4 varieties of olives were collected- Arbequina (A), Barnea (B), Cortina (C), Koronoiki (K).

3.2 Extraction of oil from olive fruits of different cultivars

20 olive fruits of each sample were weighed and oven dried until constant weight. Dry olives were grinded to make coarse powder. Samples were dipped into n-hexane and kept on shaker at room temperature for 48 hours at 100 rpm. Then those were filtered at kept for evaporation of n-Hexane in pre-weighed beakers. Then the yield of oil samples was measured. The variation in appearance and yield of oil from per gram of dry sample was measured.

Fatty acid profiling of the extracted oil samples: Oil obtained from all the collected fruit samples were subjected for determination of fatty acids by Gas Chromatography technique, Fatty Acid Methyl Ester Analysis (FAME analysis). The process was done by using Flame ionization Detector gas chromatographer.

2. Standards:

- **FAME standard (1000 ppm)**
- **Standard Preparation:**
- **FAME standard was taken into vial and injected for profiling.**

Sample preparation

- Sample was weighed in a suitable glass test tube (50-100mg) and 200mg of anhydrous sodium sulfate was added to remove the moisture.
- After 5 minutes 2.0 mL of sulfuric acid in methanol (2.5%) was added and incubated at 80^{o}C on water-bath for 15 minutes.
- Above mixture was cooled down to room temperature and 200mg of sodium chloride was added to it.
- After few minutes 2.0 mL hexane was added to above reaction mixture and allowed for vortex shaking for about 2 minutes, this mixture was transferred to centrifuge tube and centrifuged for 10 minutes at 3000 RPM.
- After the process of centrifugation, the upper layer (hexane fraction) was taken with the help of micro pipette **and transferred to glass vial for GC analysis (Gas Chromatoghraphy).**

3. Instrument condition for GC-FID (Gas Chromatoghraphy–Flame Ionization Detection) :

Analytical Column	TG-WAXMS; 30 m x 0.25 mm ID x 0.25 µm
Injection volume	1 µL

Flow rate	1.0 mL/min
Inlet temperature	280ºC
Source temperature	250ºC
Transfer Line temperature	300ºC
Inlet	Split (10.0)

4. Temperature Programming:

5. Rate (ºC / min)	**6. Temperature(ºC)**	**7. Hold time**
8. 25.0	**9. 200.0**	**10. 0.0**
11. 3.0	**12. 230.0**	**13. 18.0**

14. Sample Analysis

15. After completion of chromatographic run the peaks observed in sample chromatogram were integrated (peaks on same Rt as observed in FAME standard).

16. Results were generated as area percentage and on basis of area percentage of different components; following were calculated (in % or g/100g):

- **Saturated fat**
- **Monounsaturated fat**
- **Polyunsaturated fat**
- **Transfat**

3.3. Collection of meterological data of the study sites

Month wise climatic data (Temperature and rainfall) of Bikaner district was obtained from https://en.climate-data.org/asia/india/rajasthan/bikaner-6003/

The data was obtained from January to December for average temperature, minimum temperature, maximum temperature, precipitation/rainfall, humidity, number of rainy days, average sun hours.

3.4. Soil and water profiling collected from the study sites

Soil and water samples were collected from both study sites- Napasar and Lunkaransar. Soil samples were tested for pH, EC, organic carbon, phosphorous, potash, zinc, iron, copper and manganese during the month of summer, winter and rainy season. The analysis of soil was done by Soil testing laboratory at Krishi Bhawan, Bikaner.

Water samples were analysed for pH, electrical conductivity, cationic and anionic contaminants at krishi Bhawan, Bikaner, Rajasthan.

4. RESULTS

4.1 Profiling of oil extracted from different cultivars of olive fruits collected from different locations

Olives fruits from four different varieties of olives, namely, Arbequina (A), Barnea (B), Cortina (C), Koronoiki (K)], collected from two different sites, Napasar (N) and Lunkaransar (L), Bikaner, was subjected for extraction of oil. The quantitative variations in olive oil from different varieties is shown in Table 1.2 . As it is shown in table 1.2, in one gram of dry olive, maximum oil was extracted from Karonoiki collected from Lunkaransar (63.612318 mg) followed by BL (48.50 mg)>CN (29.42 mg)>CL (24.92 mg)>AN (23.66 mg)> AL (13.13 mg)>BN (12.29 mg)>KN (8.83 mg) [Terms referred in Table 1.1]. Besides quantity, olive oil also varied in colour. Varieties of Arbequina and Barnea produced yellow

colored oil from both locations, color of oil of Cortina variety was dark green while Karonoiki variety produced green colour oil. No variation was recorded in oil colour of similar variety of olives collected from different locations.

4.2. Gas chromatography for evaluation of fatty acid profile in olive oil

The results of Gas chromatography for analysis of fatty acids show that in all the oil samples except AL, 5 kinds of fatty acids were found which are- palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid. In AL sample, arachidonic acid was also found. % area of palmitic acid was found to be from 15.88% (BN) to 22.61% (AN), stearic acid was recorded in the range of 1.31% (BL) to 6.16% (AL). Oleic acid was recorded from 1.79% (AN) to 2.84% (BL), linoleic acid was recorded from 38.93% (CL) to 61.56% (KL). Linoleic acid was found to be in the range of 11.32% (KL) to 28.66% (BL) while arachidonic acid was found only in ALwhich was 1.52%. From the results, it was observed that maximum content was recorded for linoleic acid followed by linoleinic acid>palmitic acid>stearic acid>oleic acid>arachidonic acid (Table 2). The trend for individual fatty acids was as follows:

17. Palmitic acid: NA>LA>LC>LK>NC>NK>NB>LB
18. Arbequina>Cortina>Koronoiki>Barnea
19. Stearic acid: LA>NA>NK>LK>NC>NB>LC>LB
20. Arbequina> Koronoiki>Cortina>Barnea
21. Oleic acid: LB>NK>NC>LK>NB>LC>LA>NA
22. Barnea>Koronoiki>Cortina>Arbequina
23. Linoleic acid: LK>NK>NB>LB>NA>LA>NC>LC
24. Koronoiki>Barnea>Arbequina>Cortina
25. Linolenic acid: LB>NA>LA>NB>NC>LC>NK>LK
26. Barnea>Arbequina>Cortina>Koronoiki
27.

4.3.Weather conditions and physicochemical characteristics of soil and water

The results of the study showed variable weather conditions in Bikaner district throughout the year with temperature ranging from 7.8 °C (January) to 41.3 °C (June), rainfall ranging from 2 mm (November) to 65 mm (July), relative humidity ranging from 19% (April) to 60% (August), wettest month is July (9.97 days), driest month is November (0.40 days) and sun exposure ranging from 9.1 (December and January) to 12.3 (June) (Table 3, Figure 6)

The results of the study showed variable physic-chemical properties of the soil (pH, EC, organic carbon, phosphorous, potash, zinc, iron, copper and manganese) in the two areas, namely, Napasar and Lunkaransar during summer, winter and rainy season. pH, EC, organic carbon, Phosphorus and Manganese of soil were highest during winter at Lunkaransar which were recorded as 9.05, 0.66 ds/m, 0.23%, 32 and 2.45 ppm respectively. Potash and copper were found to be maximum at Napasar during summer while zinc and iron were maximum at Napasar during Monsoon season.

The results of the study showed variable physic-chemical properties of water [pH. EC (Electrical Conduction), cations- sodium and magnesium, anions- carbonate, bicarbonate and sulphate] in the two areas, namely, Napasar and Lunkaransar. Highest water pH was observed in Napasar while water from Lunkaransar had high values of EC, sodium, magnesium, carbonate, bicarbonate and sulphate (Table 4, Figure 4).

5. DISCUSSION

Olive oil has been reported to exhibit hypolipidemic and antioxidant properties and research studies over the last few decades have demonstrated its pivotal role in alleviating major health conditions such as cardiovascular diseases and neurological issues as well as showcased immense anticancer potential of olive oil in ameliorating the agonizing situation in breast and colon cancer (Bucciantini *et al.*, 2021; Bouhrim *et al.*, 2020). Considering these fateful studies, the scientist community all over the world has suggested supplementation of the current dietary regimen with olive oil. Olive oil possess several important components such as monounsaturated fatty acids, phytosterols, carotenoids, tocopherols, and polyphenols, which are believed to be responsible for beneficial health effects of olive oil (Guclu *et al.*, 2021; Jimenez-Lopez *et al.*, 2021). Based on all these considerations, the current chapter of this thesis focuses on characterizing different varieties of olives, namely Arbequina (A), Barnea (B), Cortina (C), Koronoiki (K)] collected from two different sites, Napasar (N) and Lunkaransar (L), Bikaner (Rajasthan) based on different parameters. The analyzed parameters include: Dry weight of olives, Fresh weight of olives, Moisture content of olives, Oil content of olives followed by oil profiling to determine the composition of olive oil in terms of fatty acid composition. In addition to the quantitative analysis of oils, the pictures of oil harvested from different varieties of olives was captured to visualize the oil color.

The results in Table 1.2 show comparative mean weight of 1 fresh olive (in grams) from four different varieties of olives [Arbequina (A), Barnea (B), Cortina (C), Koronoiki (K)] collected from two different sites, Napasar (N) and Lunkaransar (L), Bikaner, with significant difference between the fresh weights of different varieties of olives, with trend in fresh weight as follows:

Fresh weight: NB>LK>LC>LB>NA>LA>NC>NK

Similar results were seen in case of dry weights with significant difference in dry weights of different varieties of olives, with trend in dry weight as follows:

Dry weight: NB>LB>NA>LC>LA>NC>LK>NK

The difference in weight of olives may be attributed to different genetic makeup of different olive varieties couple with other environmental factors like different soil quality, rainfall pattern, difference in growing and harvesting season and other edaphic factors. Similar result showing variation in weight of olives harvested from different cultivars has also been shown in previous studies (Dag *et al.*, 2011; Mafrica *et al.*, 2021; Wechsler *et al.*, 2022).

The results in Table 1.2 also show significant difference between the moisture content and oil content of different varieties of olives, with trend in moisture content and oil content as follows:

Moisture: LK>LC>NB>LA>NC>NA>NK>LB

Oil: NA>LK>LB>NC>LC>LA>NB>NK

The moisture content of the olive fruit is governed by level of irrigation and rainfall, in addition to the genetic factors. Also, the process of fruit ripening and harvesting as well as the conditions that are prevalent during the ripening as well as harvesting stage greatly affect the moisture and oil content of olives.

Similar result showing variation in moisture and oil content of olives harvested from different cultivars has also been shown in previous studies (Zeleke *et al.*, 2012; Alowaiesh *et al.*, 2016; El Qarnifa *et al.*, 2019).

The results in Table 2 show significant difference between the composition of oil extracted from four different varieties of olives. The oil from all these varieties contained different proportion of fatty acids, namely, palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid. In addition to these,

Arbequina olives grown in Lunkaransar region of Bikaner were found to contain arachidonic acid. Highest content of palmitic and stearic acid was present in Arbequina while the lowest values were obtained in case of Barnea. In complete contrast to this, the results indicated highest content of oleic acid and linolenic acid in Barnea while the lowest values were observed in Arbequina and Koronoiki respectively. Talking about linoleic acid, the highest linoleic acid content was found in Koronoiki and the lowest content in Cortina. Therefore, the results indicate no specific pattern of fatty acid composition of oil harvested from different varieties of olives grown in different regions.

These results indicating no specific pattern in abundance percentage of fatty acids in oils are in complete concordance with previous studies, where too, researchers compared the olive oil profile from different olive varieties and found no specific pattern in fatty acid composition of oils. For instance, Al-Ruqaie *et al.* (2016) compared fatty acid profile of eight olive cultivars from Saudi Arabia and found no species pattern of fatty acid composition. Rondanini *et al.* (2011) observed lowest oleic acid values with the Spanish variety Arbequina (51.8%) and highest values in Picual (71.9%) grown in Northwestern Argentina.

Therefore, the variation in fatty acid profile of olives maybe attributed to a number of reasons:

1. All the four varieties of olives used in this study have significant variation in their origin. For instance, Arbequina is spanish in origin while Barnea (also referred to as K-18) originated from Isarel. Similarly, Cortina originated from Italy while the origin of Koronoiki dates back to Greece. Therefore, all these varieties significantly differ from each other in terms of their genetic constitution and hence different oil composition.
2. Different growth conditions in terms of difference in soil quality in Napasar (N) and Lunkaransar (L) owing to a number of factors like difference in soil pH, electrical conductivity, organic carbon, available phosphorus, potassium, zinc, iron, copper, manganese.
3. Variability in soil conditions in Napasar (N) and Lunkaransar (L) due to supplementation with additional fertilizers and nutrients like urea, diammonium phosphate fertilizer, muriate of potash, zinc sulphate and ferrous sulphate, which further enhances the variability in growth conditions.
4. Variation in oil content due to climatic fluctuations, including the season of growing, ripening and harvesting.
5. Variation in oil composition due to difference in stage of maturity of fruit.
6. The variable effect of growth temperature on oil fatty acid profile from different olive varieties was highlighted in a study by Esmaeili *et al.* (2012), wherein, a negative correlation was observed between oleic acid values in Arbequina and other varieties with the mean temperature during oil accumulation, indicating that oleic acid content decreased at 2% per °C increase in mean temperatures.

Nevertheless, in spite of all the variations, olive oil from all the studied varieties is a rich source of fatty acids and its usage has important health implications.

Furthermore, the results of the study showed significant difference between the oil color of different varieties of olives, with oil from Arbequina and Barnea olives (NA, LA, NB and LB) to be yellow in color, oil from Cortina olives appeared dark green in color (NC and LC) while olive from Koronoiki olives was yellowish green in color (NK and LK).

The color of the oil can be attributed to a number of factors such as the ripening of the olive, the filtration process, the passage of time and the variety of olive used for oil extraction. Based on all these factors, the color of the oil may range from anywhere between light yellow to dark green. The color of the oil is mainly because of the pigments present in oil; if olives are harvested green, the color of the oil is green due to

presence of chlorophyll. In oils with extra harvest, the color of the oil turns dark green due to increase in concentration of chlorophyll. Thereafter, when olives are allowed to ripen to a later stage, the chlorophyll content decreases with increase in xanthophyll and carotenoids; thereby imparting yellow color to the oil. Filtration removes suspended solids from the oil, imparting translucent appearance to it. Also, filtration decreases the green color of the oil due to removal of chlorophyll particles in the filtration process. The color of the oil also changes with time due to degradation of chlorophyll. Apart from these factors, the color of the oil is also affected by the variety of olives used for extraction. In was shown that oil from Arbequina and Barnea olives was yellow in color, indicating that olives belonging to Arbequina and Barnea variety were harvested at ripe stage. The color of oil from Cortina and Koronoiki was dark green and yellowish green in color, indicating that olives belonging to Cortina and Koronoiki variety were harvested at unripe stage. Apart from the ripening stage of the fruit, the variation in color of oil may also be due to the obvious genetic differences between the varieties and differences arising during the harvesting process.

6. FIGURES

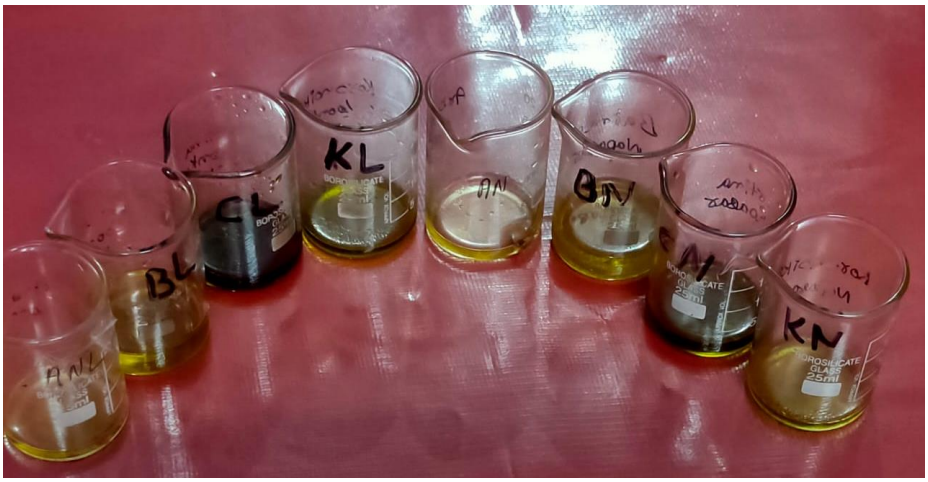

Figure 1: Extracted oil from different varieties of olive fruits collected from different locations.

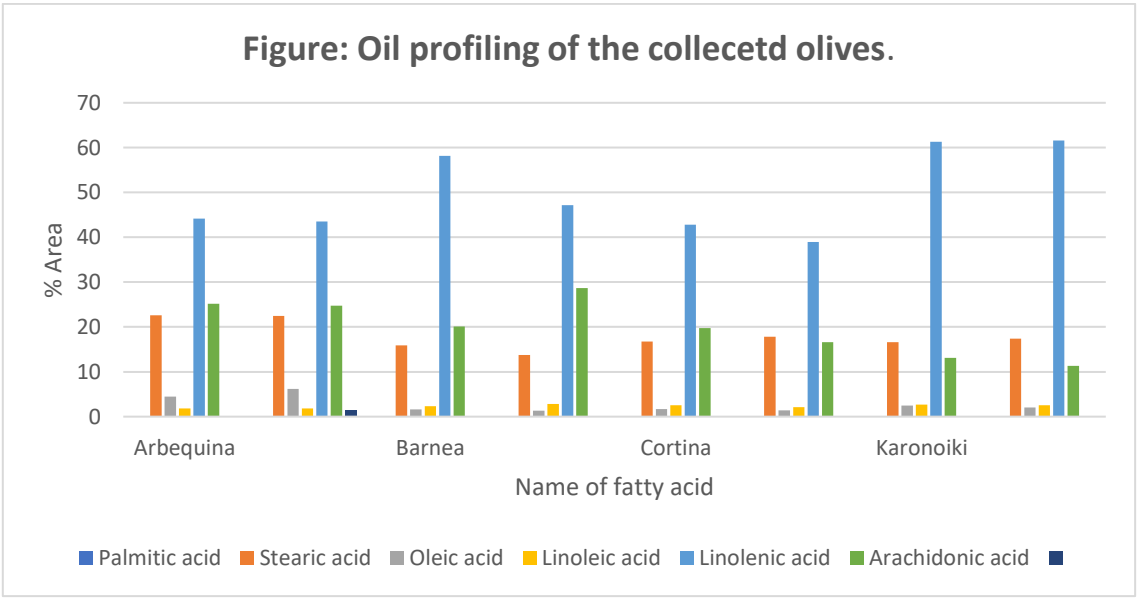

Figure 2: Fatty acid profile of oil from olive fruits collected from different locations

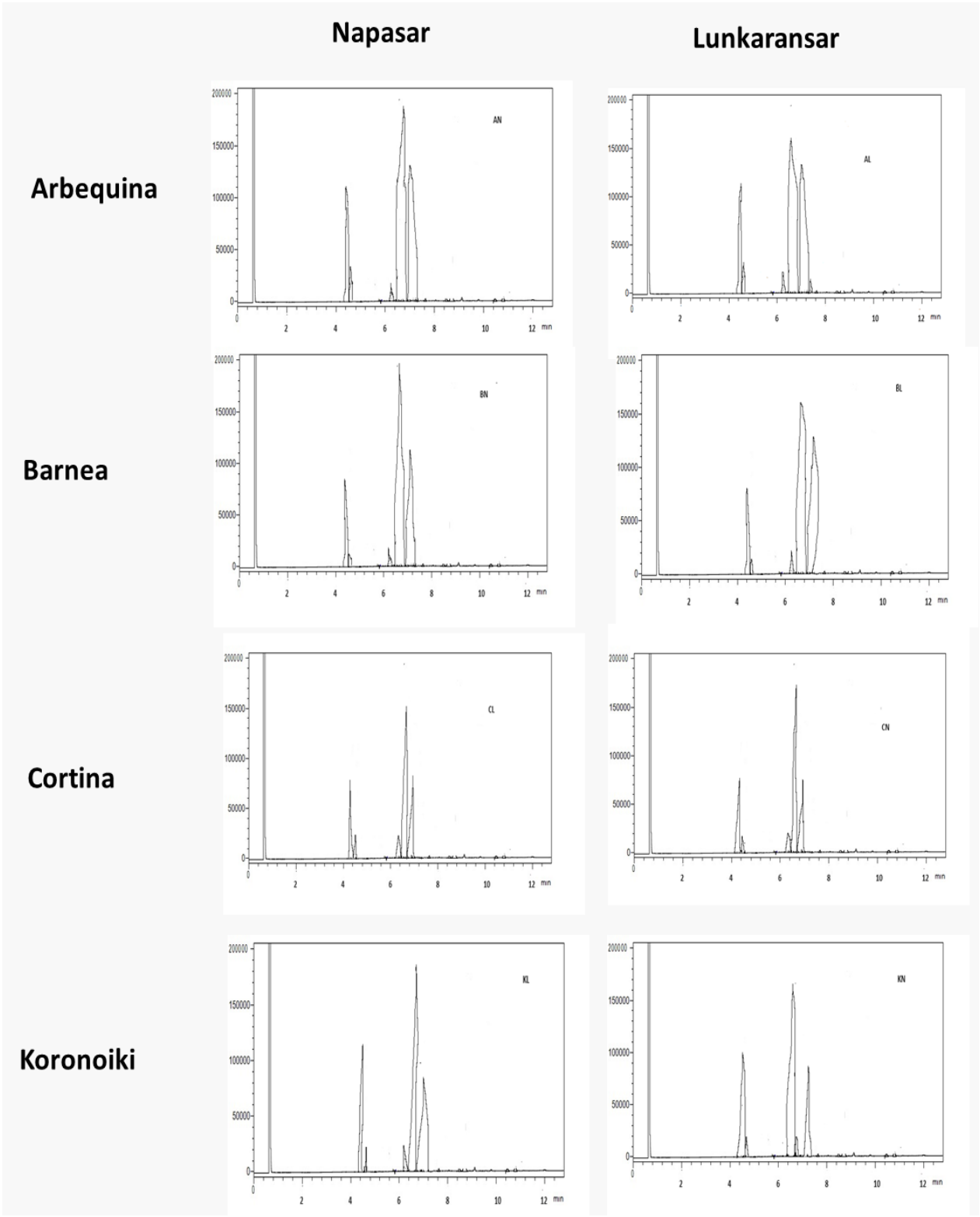

Figure 3: Chromatogram obtained by GC study of oil of different varieties of olives

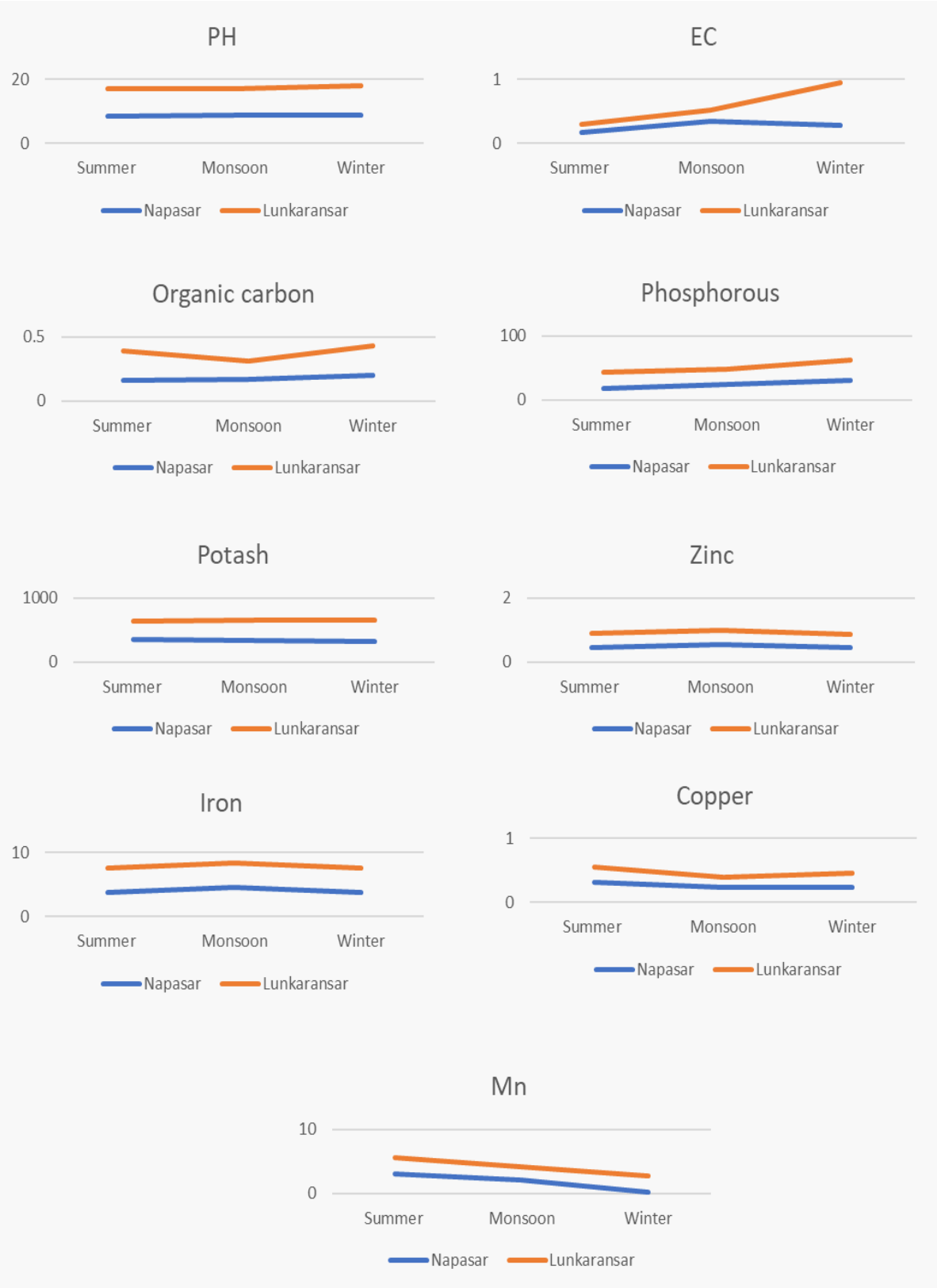

Figure 4: Characteristics of soil samples collected from study locations during different seasons.

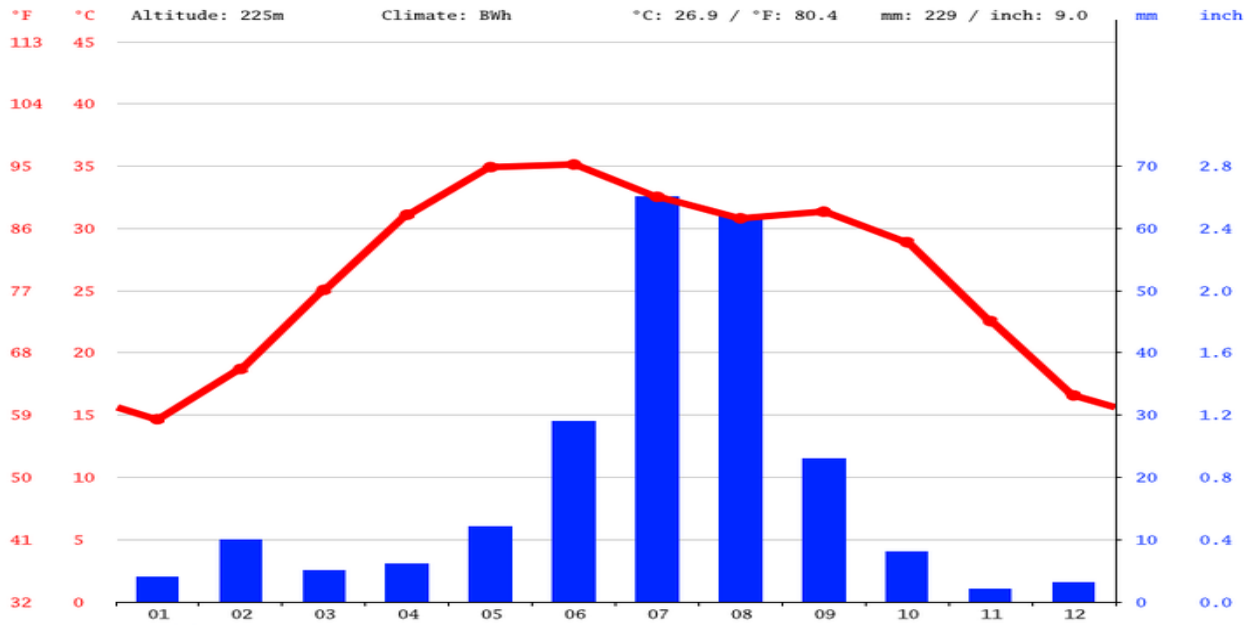

Figure 5: Average rainfall by month in Bikaner district.

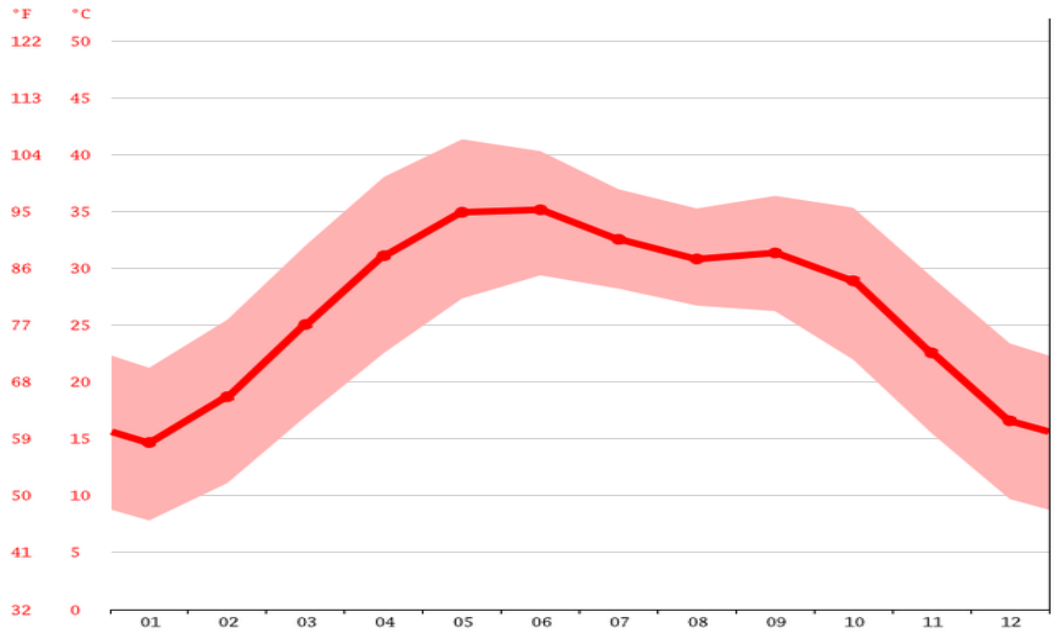

Figure 6: Average temperature by month in Bikaner district.

7. TABLES:

Table 1.1: Sample code for oil profiling.

Sample code	Site	Cultivar
AN	Napasar	Arbequina
BN	Napasar	Barnea
CN	Napasar	Cortina
KN	Napasar	Koronoiki
AL	Lunkarankar	Arbequina

BL	Lunkarankar	Barnea
CL	Lunkarankar	Cortina
KL	Lunkarankar	Koronoiki

Table 1.2: Variation in quantity and colour of oil extracted from different varieties of olives collected from 2 different locations.

		Mean wt of 1 fresh olive (g)	Mean wt of 1 dry olive (g)	Moisture in 1 gm olives (g)	Oil in 1 gm olive (mg)	Oil colour
Arbequina	Napasar	4.7086	3.75715	0.202066432	23.66	Yellow
	Lunkaransar	4.5953	3.4416	0.251060867	13.13	Yellow
Barnea	Napasar	6.0379	4.35835	0.278167906	12.29	Yellow
	Lunkaransar	4.88165	4.0128	0.177982854	48.50	Yellow
Cortina	Napasar	4.4437	3.40345	0.234095461	29.42	Dark green
	Lunkaransar	5.36305	3.66715	0.316219316	24.92	Dark green
Karonoiki	Napasar	3.53145	2.9158	0.174333489	8.83	Green
	Lunkaransar	5.69845	3.0623	0.462608253	63.61	Green

Table 2: Fatty acid determination in olive oil of the collected fruit samples.

Fatty acid name		Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	Arachidonic acid
RT		4.536	4.740	6.234	6.568	7.036	7.77
% Area							
Arbequina	Napasar	22.61	4.46	1.79	44.19	25.17	-
	Lunkaransar	22.43	6.16	1.86	43.56	24.73	1.52
Barnea	Napasar	15.88	1.63	2.36	58.15	20.10	-
	Lunkaransar	13.76	1.31	2.84	47.16	28.66	-
Cortina	Napasar	16.75	1.68	2.54	42.82	19.75	-
	Lunkaransar	17.83	1.37	2.12	38.93	16.64	-
Karonoiki	Napasar	16.64	2.46	2.66	61.28	13.09	-
	Lunkaransar	17.40	2.06	2.54	61.56	11.32	-

Table 3: Temperature by month in Bikaner district.

Table 4: Characteristics of soil samples collected from study locations during different seasons.

	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Avg. Temperature °C (°F)	14.7 °C (58.4) °F	18.7 °C (65.7) °F	25.1 °C (77.1) °F	31.1 °C (88) °F	34.9 °C (94.9) °F	35.1 °C (95.2) °F	32.5 °C (90.6) °F	30.8 °C (87.5) °F	31.3 °C (88.4) °F	28.9 °C (84) °F	22.6 °C (72.6) °F	16.6 °C (61.8) °F
Min. Temperature °C (°F)	7.8 °C (46.1) °F	11.1 °C (52) °F	17 °C (62.5) °F	22.5 °C (72.6) °F	27.3 °C (81.2) °F	29.4 °C (84.9) °F	28.2 °C (82.8) °F	26.7 °C (80.1) °F	26.2 °C (79.2) °F	22 °C (71.5) °F	15.5 °C (59.9) °F	9.7 °C (49.5) °F
Max. Temperature °C (°F)	21.2 °C (70.2) °F	25.5 °C (77.9) °F	32 °C (89.6) °F	38 °C (100.4) °F	41.3 °C (106.4) °F	40.3 °C (104.5) °F	36.9 °C (98.5) °F	35.3 °C (95.5) °F	36.4 °C (97.5) °F	35.3 °C (95.6) °F	29.3 °C (84.7) °F	23.4 °C (74.1) °F
Precipitation / Rainfall mm (in)	4 (0)	10 (0)	5 (0)	6 (0)	12 (0)	29 (1)	65 (2)	62 (2)	23 (0)	8 (0)	2 (0)	3 (0)
Humidity(%)	50%	38%	27%	19%	23%	36%	54%	60%	45%	29%	34%	45%
Rainy days (d)	1	1	1	1	2	3	7	6	3	1	0	1
avg. Sun hours (hours)	9.1	9.8	10.7	11.5	12.1	12.3	11.0	10.3	10.5	10.3	9.6	9.1

Soil sample		pH	EC (ds/m)	Organic C (%)	P	Potash (Kg/ha)	Zn (PPM)	Fe (PPM)	Cu (PPM)	Mn (PPM)
Napasar	Summer	8.50	0.13	0.16	18	347	0.45	3.85	0.31	2.30
	Monsoon	8.80	0.35	0.17	24	336	0.54	4.56	0.23	2.03
	Winter	8.90	0.29	0.20	30	325	0.44	3.77	0.23	2.40
Lunkaransar	Summer	8.46	0.13	0.23	25	302	0.43	3.80	0.24	2.6
	Monsoon	8.22	0.17	0.14	24	325	0.46	3.82	0.16	2.20
	Winter	9.05	0.66	0.23	32	336	0.43	3.79	0.22	2.45

References

1. Alowaiesh B, Singh Z, Kailis SG. Harvesting time influences fruit removal force, moisture, oil content, free fatty acids and peroxide in the oil of Frantoio and Manzanilla olive cultivars. Australian Journal of Crop Science. 2016 Dec 20;10(12):1662-8
2. Al-Ruqaie I, Al-Khalifah NS, Shanavaskhan AE. Morphological cladistic analysis of eight popular Olive (Olea europaea L.) cultivars grown in Saudi Arabia using Numerical Taxonomic System for personal computer to detect phyletic relationship and their proximate fruit composition. Saudi journal of biological sciences. 2016 Jan 1;23(1):115-21

3. Bertoni C, Abodi M, D'Oria V, Milani GP, Agostoni C, Mazzocchi A. Alpha-Linolenic Acid and Cardiovascular Events: A Narrative Review. International Journal of Molecular Sciences. 2023 Sep 20;24(18):14319.
4. Bouhrim M, Daoudi NE, Ouassou H, Benoutman A, Loukili EH, Ziyyat A, Mekhfi H, Legssyer A, Aziz M, Bnouham M. Phenolic content and antioxidant, antihyperlipidemic, and antidiabetogenic effects of Opuntia dillenii seed oil. The Scientific World Journal. 2020 Oct 6;2020
5. Bucciantini M, Leri M, Nardiello P, Casamenti F, Stefani M. Olive polyphenols: Antioxidant and anti-inflammatory properties. Antioxidants. 2021 Jun 29;10(7):1044
6. Dag A, Kerem Z, Yogev N, Zipori I, Lavee S, Ben-David E. Influence of time of harvest and maturity index on olive oil yield and quality. Scientia Horticulturae. 2011 Jan 10;127(3):358-66
7. El Qarnifa S, El Antari A, Hafidi A. Effect of maturity and environmental conditions on chemical composition of olive oils of introduced cultivars in Morocco. Journal of Food Quality. 2019 Dec 14;2019:1-4.
8. Esmaeili A, Shaykhmoradi F, Naseri R. Comparison of oil content and fatty acid composition of native olive genotypes in different region of Liam, Iran. Intl. J. Agric. Crop Sci. 2012;4(8):434-8.
9. Guclu G, Kelebek H, Selli S. Antioxidant activity in olive oils. InOlives and Olive Oil in Health and Disease Prevention 2021 Jan 1 (pp. 313-325). Academic Press.
10. Jimenez-Lopez C, Carpena M, Lourenço-Lopes C, Gallardo-Gomez M, Lorenzo JM, Barba FJ, Prieto MA, Simal-Gandara J. Bioactive compounds and quality of extra virgin olive oil. Foods. 2020 Jul 28;9(8):1014
11. Mafrica R, Piscopo A, De Bruno A, Poiana M. Effects of climate on fruit growth and development on olive oil quality in cultivar carolea. Agriculture. 2021 Feb 10;11(2):147.
12. Marangoni F, Agostoni C, Borghi C, Catapano AL, Cena H, Ghiselli A, La Vecchia C, Lercker G, Manzato E, Pirillo A, Riccardi G. Dietary linoleic acid and human health: Focus on cardiovascular and cardiometabolic effects. Atherosclerosis. 2020 Jan 1;292:90-8.
13. Pastor R, Bouzas C, Tur JA. Beneficial effects of dietary supplementation with olive oil, oleic acid, or hydroxytyrosol in metabolic syndrome: Systematic review and meta-analysis. Free Radical Biology and Medicine. 2021 Aug 20;172:372-85.
14. Rondanini DP, Castro DN, Searles PS, Rousseaux MC. Fatty acid profiles of varietal virgin olive oils (Olea europaea L.) from mature orchards in warm arid valleys of Northwestern Argentina (La Rioja). Grasas y aceites. 2011 Dec 30;62(4):399-409.
15. Wang X, Zhang C, Bao N. Molecular mechanism of palmitic acid and its derivatives in tumor progression. Frontiers in Oncology. 2023 Aug 9;13:1224125
16. Wechsler T, Bakhshian O, Engelen C, Dag A, Ben-Ari G, Samach A. Determining reproductive parameters, which contribute to variation in yield of olive trees from different cultivars, irrigation regimes, age and location. Plants. 2022 Sep 16;11(18):2414.
17. Zeleke K, Mailer R, Eberbach P, Wünsche J. Oil content and fruit quality of nine olive (Olea europaea L.) varieties affected by irrigation and harvest times. New Zealand Journal of Crop and Horticultural Science. 2012 Dec 1;40(4):241-52.