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Evaluation of some Physicochemical Characteristics of Qazwan (*Pistacia* Species) Fruit Oil from Different Regions in Kurdistan–Iraq

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Abstract:

Pistacia khinjuk and *Pistacia atlantica*, known as Qazwan in Kurdish, are important wild species widely distributed in the Kurdistan region of Northern Iraq. This study aimed to investigate the effect of storage period on quality indices and physical characteristics of fixed oil extracted from Qazwan fruits. The study also evaluated the fatty acid composition, antibacterial activity of the extracted oils, and the proximate composition of Qazwan fruits. The proximate compositions of fruit samples were evaluated through the determination of moisture, oil, protein, fibre, and ash contents. Fruits are rich in oil, which ranged between 21.60% to38.47%,fibre content was relatively high, ranging from 19.95% to 27.19%, suggesting that the fruits may serve as a good dietary fibre source, indicating the presence of essential mineral elements, moisture ranged between 11.37% to 14.02% and crude protein ranging from7.61% to 9.01%. The major fatty acids were oleic, linoleic and palmitic, which comprised 48.88–54.93%, 13.89–22.78%, and 19.61–22.26%, respectively. The effect of storage period on the quality indices and physical characteristics, such as viscosity, color intensity, and refractive index of fixed oils extracted from Qazwan fruits, was assessed. Also, the quality index, including acid value, peroxide value, and iodine value, was measured during storage periods of one day, one month, and three months. The results showed that the storage period significantly affected oil quality after the three-month storage period. Acid values of fresh oil were 3.41 -3.99 mg KOH/g, which increased to 4.98–5.88 mg KOH/g oil after three months of storage, as well as peroxide values increased from 0.64- 0.69 meqO_2/kg to 0.85–1.60 meqO_2/kg, while iodine values decreased from 89.23- 78.23 g/100 g to 71.30–72.86 g/100, despite the changes that occurred at the end of the storage period, the values were within limits of standard specifications.. The study revealed that the fruit samples possess valuable nutritional characteristics and may be considered promising sources of edible oil, dietary fiber, and other nutrients for food. *Pistacia of khinjuk* oil from Duhok exhibited the highest antibacterial activity, producing inhibition zones of 21 mm against *P. aeruginosa* and 16 mm against *S. aureus*, while the zone diameter of *P. khinjuk* oil from Sulaymaniyah was 15 mm against *P. aeruginosa* only

Keywords: Qazwan, *Pistacia atlantica*, *Pistacia khinjuk*, *Anacardiaceae,* Fixed oils, storage period, .

Introduction:

The *Pistacia* plant(qazwan) belongs to the *Anacardiaceae* family, and it has been broadly used in many sectors from the beginning of time, particularly found throughout the Mediterranean region and central Asia, with Northern and Eastern Iraq, Western and Northern Iran, Southern Turkey, and Northern Syria being its main distribution centers (Sharifi, 2014 and Ben Ahmed et al., 2021).

Iraqi Kurdistan is renowned for its rich diversity of wild plants, owing to its varied geography and climate conditions, creating an ideal environment for Pistacia tree growth. Some researchers have indicated that the wild Pistacia plant prefers arid environments with dry, stony, or rocky slopes. They can be found near fields, along roadsides, at the foot of dry stone walls, and in similar environments. The tree of the qazwan fruit possesses unique physical characteristics that enable it to survive in the arid mountains of Kurdistan, where it is considered an important wild resource (Ahmed 2016 and Biruni et al. 2017).

Pistacia plant has considerable economic, nutritional, and medicinal value (Kaskoos et al.,2021). Also, Ahmed (2017) ; Belyagoubi-Benhammou et al. (2024) and Al-Edany et al.(2025) mentioned that the production of the tree, including leaves, fruits, resin and other aerial parts, has a wide range of uses for a variety of industrial and traditional uses, including food, herbal medicine, pharmaceutical and cosmetics felids, these parts contain phytochemical constituents such as phenolic compounds, flavonoids. terpenoids, oil, unsaturated fatty acids, sterols and minerals (Hatamnia et al.2014; Labdelli et al., 2019; Hasheminya and Dehghannya, 2020; Ahmad et al. 2022), Previous studies have shown antioxidant, anti-inflammatory and antimicrobial properties of (Dorehgirae and Pourabdolah, 2015; Hacıbekiroğlu et al., 2015), all those characteristics made its fruits an important food source, since nowadays, consumers choice has played an important role in food supply worldwide as they prefers natural foods with high nutritional value that promote the defense from some adverse conditions, such as protection against some cardiovascular diseases, hypercholesterolemia, hyperglycemia, low efficient intestine function and contribute to the trapping of free radicals and prevent some types of cancer and as is well known consumers are more aware of food and dietary issues and are monitoring and adjusting what they consume as they have become more proactive and diligent in improving their overall health through their daily diet (Wallace et al.,2020).

Regarding the uses of wild *Pistacia* in the food sector, the fruits are widely consumed as a source of nutrients by the local population. The unripe fruits of *Pistacia* ssp. are often consumed as a snack, but both ripe and unripe fruits are used as ingredients in the preparation of various culinary dishes, as well as being used to flavor yoghurt drinks, ghee, pickles and jams, drinks like qazwan coffee .), furthermore, Its fruits produce a considerable yield of edible oil (Mahdyavi, 2015 and Ahmad,2023), also Pistacia's gum is used to make natural Kurdish chewing gum (Paraschos *et al*., 2007).

Wild edible plant oils of the genus Pistacia have significant potential as sources of nutritional lipids. The seeds of these fruits have a high oil content and high essential fatty acids, in which the most common fatty acids found were oleic acid, linoleic acid, and palmitic acid. The ratio of unsaturated to saturated fatty acids showed that unsaturated fatty acids were about three times more common than saturated ones and they contain bioactive compounds, particularly those of *Pistacia atlantica* and *Pistacia khinjuk* in the Kurdistan Region of Iraq, which are a common source of fruit and oil (Kaskoos et al.,2021 ; Al-Marazeeq et al.,2022 and Ahmad etal,2023).

Environmental conditions, such as geographical location, soil properties, temperatures, and moisture levels, influence the extent of oil biosynthesis in wild plants, leading to variations in chemical composition. Pistacia seeds, common in Iraqi Kurdistan, produce Qazwan fruit oil through cold-pressing, and it maintains its physicochemical properties, such as density, refractive index, and low peroxide values, which enhance oxidative stability. (Shakerardekani, & Rahdari, 2024).

The objective of this study is to examine the physicochemical properties of oil obtained by cold extraction from *Pistacia atlantica* and *Pistacia khinjuk* growth in three different locations of the Kurdistan region, Iraq.

2. Materials and Methods

2.1 Sample Collecting

Two types of fresh wild Qazwan were collected from their trees growing in different locations of the Kurdistan region,*Pistacia khinjukn* (Bnawsh), from Erbil (**A**), Duhok (**B**) and Sulaymaniyah (**C**), and *Pistacia atlantica* from Erbil (**D)**, Duhok (**E),** and Sulaymaniyah (**F)**. The fruits remain green throughout the spring season, subsequently maturing and undergoing color changes in late summer to early autumn, which are harvested in October 2024.

2.2 Chemical Compositions of Raw Materials

The fresh wild Qazwan samples were analyzed for moisture (hot air oven), crude protein (micro-Kjeldahl, N*5.7), fat (Soxhlet extraction), and ash percentage according to the methods of (AoAC,2021).The crude fiber was analyzed according to weende method which was mentioned by Möller (2014).

2.3 Extraction and Characterization of Qazwan Oil

Cold pressing was used for oil extraction, as described (Cakaloglu, et al. 2018). This method includes mechanical cleaning and dehulling of seeds, then pressing to produce oil at 25-35°C with specialized expellers, which rupture the oil cells, The applied pressure 200 bar.

2.4 Physical properties of oil

2.4.1 Viscosity determination

The viscosity of Pistacia oil was measured by an Ostwald viscometer at a constant temperature of 25 °C. The flow time of the oil sample was measured and compared to a reference liquid, usually distilled water. The viscosity was determined as the density/flow time ratio of the sample to the reference liquid, and it was expressed in m Pa s. (Kachel-Jakubowska and Sujak 2016).

2.4.2 Color measurement

A portable precision colorimeter was used to determine the color of the Pistacia sp. oli (A1-F1) Samples. The measurement was carried out after the colorimeter was calibrated with a white and black calibration interface. The results were stated in terms of L* (lightness), a* (redness to greenness), and b* (yellowness to blueness) values. The measurement was carried out in triplicate. The whiteness index (WI) was calculated according to the following equation (Hsu et al., 2003).

$$WI = 100 - \sqrt{(100 - L^*)^2 + a^{*2} + b^{*2}}$$

2.4.3 Refractive Index

Abbe refractometer was used to determine a refractive index of oil of the plant, which was controlled at 20 c^0 temperature. The sample was dropped onto the refractometer prism and the refractive index value was determined . This is a parameter that is usually employed to determine the purity, identity and the unsaturation of the oil.(Khoddami, a., & roberts, t. H. ,2014).

2.5 Fatty acids contain of oil samples

The analysis of the fatty acids was done by gas chromatography-mass spectrometry (GC-MS) according to a standard protocol that was modified to analyze plant lipids. The Folch method was used to extract total lipids in homogenized samples of Pistacia fruit or seed samples (about 1 g fresh weight) by homogenizing the sample in chloroform: methanol (2:1, v/v) solution, centrifugation at 2400 × g, and collection of the organic lower phase after centrifugation. The fatty acids were converted to fatty acid methyl esters (FAMEs) by adding 1 mL of 14% boron trifluoride in methanol (BF3-methanol) and 1 mL hexane then allowed to react 10 minutes at 100 °C with a few vortexes. Upon chilling, 2 mL of distilled water was used, the hexane layer that contained FAMEs was isolated, dried using anhydrous sodium sulfate, and concentrated using nitrogen stream. An aliquot of 1 µL of the extract of FAME was injected in splitless contact in to an Agilent 7890 GC with a 5977 MSD, containing a DB-23 capillary column (60 m × 0.25 mm, 0.25 0.25 mm film thickness). The constant flow of the carrier gas was 1.2 mL/min of helium. Oven temperature program was initiated at 70 °C (held 1 min), then at 175 °C (held 10 min) and at 220 °C (held 5 min), 25min/run. The MS was run in electron impact (70 eV) with full scan (m/z 50-550) or selected ion monitoring (SIM) (a specific quantifier ions are targeted, e.g., m/z 74) to C16:0 (m/z 87 C18:1). Comparison of retention times and mass spectra with the NIST library standards identified fatty acids which were measured as relative percentages using heptadecanoic acid (C17:0) as an internal standard (Ren, et al, 2013).

2.6

Quality Indices of the Oil

2.6.1 Acid Value

The measurement of acid value was done in accordance with JOCS Standard Method 2.3.1..(Endo, 2018a). Precisely, 5 g of the oil sample was measured and placed in a 250 mL conical flask, then 50 mL of neutralized ethanol was added, and 1ml of phenolphthalein indicator were added. The mixture was titrated with 0.1 N KOH in ethanol until a persistent pink endpoint. Also, a blank titration was done. AV (mg KOH/g) was determined according to the question below

$$AV = (V_{sample} - V_{blank}) \times N \times 56.1)/W$$

V is KOH volume (mL), N is normality, 56.1 is KOH molecular weight, and W is sample weight (g). Triple analyses were performed

2.6.2 Peroxide Value

The peroxide value was obtained under JOCS and Endo, Y.,2018 (acetic acid-isooctane titration). The 5 g oil sample was dissolved in 30 mL of isooctane: acetic acid (3:2 v/v) mixture, 0.5 mL of saturated potassium iodide was added and shaken for 1 minute, then diluted with 30 mL of distilled water. Using starch indicator, the liberated iodine was titrated using 0.01 N sodium thiosulfate. The peroxide value was determined according to the question below.

PV (meq/kg) = [(V sample-V blank) N 100)/W].

V is volume of $Na_2S_2O_3$ (mL), N is the normality, and W is sample weight (g).

2.6.3 Iodine Value

The value of iodine was determined according to JOCS Standard About 0.2 g of oil was placed in a stoppered flask, 25 mL reagent was added, the mixture was incubated at 20-25 °C in darkness for over 30 minutes. Then 20 mL 20% KI and 100 mL of water were added, and titration was done with 0.1N sodium thiosulfate until the starch endpoint.

IV = (V blank – V sample)2N12.69)/W,

where the 12.69 is the atomic weight of iodine. The determinations were done with three replicates (Endo, Y.,2018c)

2.7 Antimicrobial Activity

The antimicrobial effect of the qazwan oils was assessed via the well-diffusion technique. The turbidity of the overnight of multi-drug resistant clinical isolates of Pseudomonas aeruginosa and Staphylococcus aureus was adjusted to 0.5 McFarland and swabbed onto the surface of Mueller-Hinton agar plates. Then, 6mm wells were bored, and 150µl of each type of oil was added to the wells. The plates were incubated for 24 hours at 37ºc. A ruler was employed to measure the diameter of the formed inhibition zones around the wells (Hetta et al., 2021)

2.8 Statistical Analysis

The data was analyzed using the SPSS software, which employed a 2×3×3 Factorial Complete Randomized Design and a general linear model (SPSS, 2020). Descriptive statistics were used to examine the data results, such as means at the 0.05 level, Duncan's multiple range test was used to identify significant differences among the various results (Duncan, 1955).

3.Results and Disscusion

3.1 Chemical Compositions of Raw Materials

The proximate compositions of Qazwan fruits collected from different locations are illustrated in Table 3.1. The results show that there are significant differences in the moisture, oil, total protein and fiber contents for species and geographic region between most of the samples, but no significant difference in ash content was found.

Table 3.1. Proximate compositions of Qazwan fruits

Treatment	Moisture%	Oil%	Protein%	Fibre%	Ash%
A	12.55±0.50 [bc]	34.97±2.23 [b]	9.01±0.40 [a]	23.45±0.33 [c]	2.52±0.22 [a]
B	14.02±0.27 [ab]	38.47±0.06 [a]	7.48±0.25 [c]	19.95±0.11 [e]	3.13±0.26 [a]
C	13.94±0.55 [ab]	22.06±0.06 [e]	8.34±0.23 [abc]	25.45±0.26 [b]	3.22±0.25 [a]
D	11.37±0.33 [c]	25.06±0.62 [d]	7.61±0.45 [bc]	22.09±0.19 [d]	2.28±0.14 [a]
E	14.85±0.15 [a]	26.03±0.03 [c]	7.87±0.29 [bc]	27.19±0.23 [a]	2.89±0.35 [a]
F	12.84±0.87 [abc]	21.60±0.03 [e]	8.56±0.27 [ab]	24.97±0.12 [b]	2.89±0.08 [a]

Results of three (n=3) replications were expressed as mean± standard error, values with

different superscript letters are significantly different ($p < 0.05$).*P. khinjukn*

(A- Erbil , B-Duhok , C-Sulaymaniyah):*P..atlantica* (D- Erbil , E-Duhok ,E-Sulaymaniyah)

The values for moisture ranged from 14.85% to 11.37%; for oil, from 38.47% to 21.60%; total protein from 9.01% to 7.48%; fiber from 27.19% to 19.95%; and ash from 3.22% to 2.28%. It is noticeable that *Pistacia atlantica* collected from Duhok (E) has the highest moisture and fiber content, while the same species from Erbil (D) has the lowest value. *Pistacia khinjuk* collected from Duhok (B) has the highest oil content, while *Pistacia atlantica* from Sulamanya (F) has the lowest value. These results were similar to those found by Hazrati et al.2020, who pointed out significant differences in the oil content between the two species of *Pistacia* collected from the mountains surrounding Kazerun city in Iran. The Soxhlet extraction gave a higher oil yield for *Pistacia khinjuk* (31.00%) when compared to *Pistacia atlantica* (24.33 %) . Additionally, *Pistacia khinjuk* from Erbil (A) has the highest protein content. In general, the qazwan samples were collected from Duhok and characterized by high levels of moisture, oil, fiber, and ash. The results differed from those previously reported by Benhassaini,et al. (2007) and Shahid and Akbar (2022) Algerian (North Ecotype) and Iranian *Pistacia*, the differences in values of chemical composition might be due to the diversity of variety, maturity, growing region, growing environmental conditions, and method of analysis.(Khoshnaw and Esmail, 2020) mentioned that soil contains a high proportion of organic matter, which was considered to have a significant impact on the physiochemical properties of the soil. The main consequence was an improvement in the uptake of micro and macro elements.

3. 2. Oil Extraction

Figure3 .1 shows the oils extracted from Qazwan with Cold pressing and the results of fruit oils extraction for samples (A-F) are illustrated in Figure 3. 2 ,which shows that the oil yield varied from 210ml \kg to 380ml/kg. *Pistacia. khinjukn* collected from Duhok(B1) has the highest content of fixed oil, while the same species from Sulamanya (C1) has the lowest value.

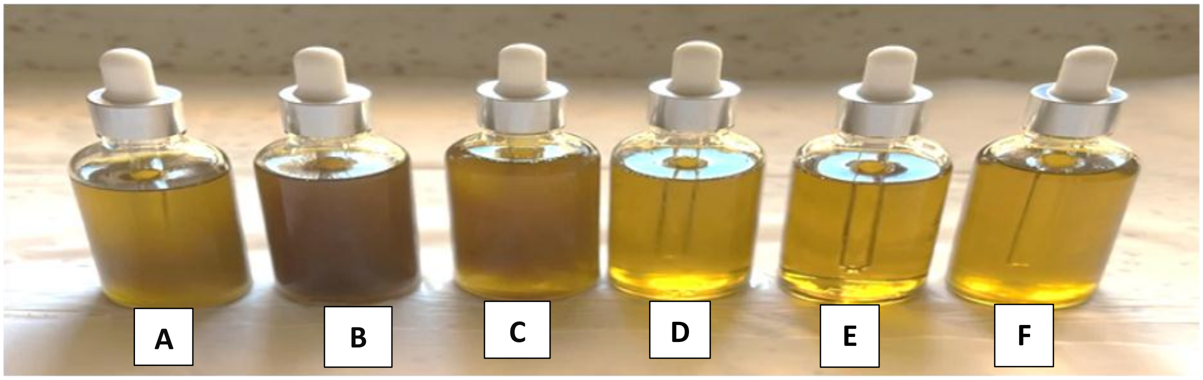


Figure. 3.1.Qazwan fruit oil extract

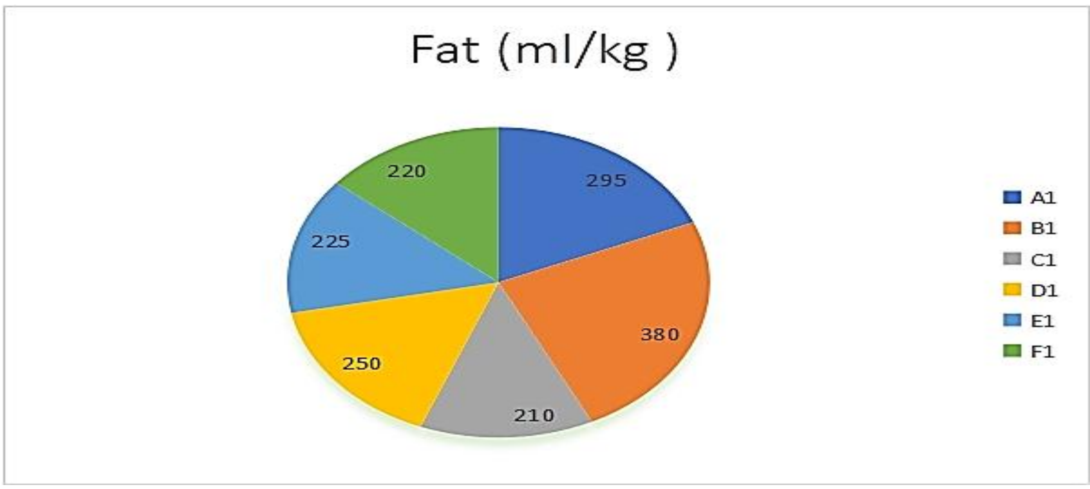


Figure.3. 2 Qazwan fruit oils Quantity extracted by Cold pressing

In general, the samples of *Pistacia khinjukn* were characterized by containing a larger quantity of oil than those of *Pistacia atlantica*, and the quantity was similar to that of *Pistacia atlantica* despite the difference in location. Similar results were obtained by Hazrati et al. (2020), who showed ed that the *Pistacia khinjuk* gave higher oil yield compared to *Pistacia atlantica,* the species from natural forests in the mountains surrounding Kazerun city, Iran. Cakaloglu, et al. (2018) and Areibat and Al-Kareiwi **(**2026) mentioned the advantages of cold pressing as a natural and effective way to maintain the high-quality seed oil, especially in chemical, nutritional, and phytochemical studies, because it does not involve the use of heat or chemical solvents to extract the compounds.

3.3 Physical properties of oil

3.3.1Refractive Index and Viscosity

The refractive index (RI) of vegetable oil is a dimensionless physical constant; the RI value has a specific range for each oil, and any deviation from the these specifications may indicate oil adulteration or a chemical alteration. Typically, it is around 1.47, which measures how much the oil bends light, calculated as the ratio of the speed of light in a vacuum to its speed in the oil. It indicates the oil's purity, saturation level, and molecular density (Olaleye et al.,2019).

According to the findings in Table 3.2, the initial values of RI at 20 °C were (1.476, 1.476, 1.476, 1.476, 1.478, and 1.475) for samples from A to F, respectively. These values agree with those obtained by Mohsen (2025).

Table 3.2.The 1Refractive Index and Viscosity of Qazwan Oil During Storage

Storage	samp.	Refractive Index	viscosity in (mm^2/s)
first day	A	1.476±0.007 a	27.99±0.28 a
	B	1.476±0.007a	26.27±0.28 b
	C	1.476±0.008 a	19.45±0.28 d
	D	1.476±0.007 a	19.34±0.29 d
	E	1.478±0.01 a	19.45±0.28 d
	F	1.475±0.007a	18.37±0.28 e
after one month	A	1.482±0.09 a	24.34±0.29 c
	B	1.485±0.01 a	20.50±0.29 c
	C	1.485±0.01a	18.25±0.31 e
	D	1.477±0.007 a	16.69±0.28 f
	E	1.478±0.07 a	17.95±0.29 e
	F	1.477±0.007 a	14.28±0.28 e
after three months	A	1.486±0.01 [a]	17.90±0.29 c
	B	1.490±0.01 [a]	18.57±0.28 e
	C	1.494±0.01 [a]	15.05±0.31 f
	D	1.484±0.09 [a]	12.90±0.28 g
	E	1.485±0.01 [a]	11.25±0.29 g
	F	1.484±0.01[a]	12.20±0.28 g

Results of three (n=3) replications were expressed as mean± standard error, values with different superscript letters are significantly different ($p < 0.05$).*P. khinjukn*

(A- Erbil , B-Duhok , C-Sulaymaniyah):*P..atlantica* (D- Erbil , E-Duhok ,E-Sulaymaniyah)

Table 3.2 shows that the RI after storage increases slightly with increasing storage period. This may be attributed to the method of preservation and storage of the oils, as they were kept in opaque containers and stored in dark places away from light.

The overall increase in RI of oil samples, higher values of RI subjected to exposure to light compared with those of darkness storage, might be attributed to the elevated rate of hydrolysis and photo-oxidation as reported by(Hashem, et al.,2023).

Viscosity is an important physical indicator for vegetable oils which impact their industrial and culinary applications. Changes in viscosity during storage are commonly associated with oxidative and hydrolytic processes, which alter molecular weight distribution and intermolecular interactions. Therefore, monitoring viscosity provides valuable insight into the stability and degradation behavior of the oil.

The results indicate significant differences according to variety, and a significant decrease is observed with extended storage periods for the majority of oil samples. Sample(A), *P. khinjukn* collected from Erbil has the highest viscosity on the first day, while the lowest value was detected in *P..atlantica* from Sulaymaniyah (F) . After storage for one month, the *P..atlantica* from Sulaymaniyah (F) also showed the lowest value (14.28 mm^2/s). The *P.. khinjukn* collected from Duhok (B) has the highest value across all storage periods, while the *P.. atlantica* from the same location (E) has the lowest value. These results are consistent with those of Nirat (2012), who measured the viscosity of olive oil samples with varying storage periods, both yearly and weekly, from multiple locations, as a function of temperature. In this study, the overall results indicate that viscosity decreases with increasing storage period. Hashem et al. (2023) reported that the presence of saturated fatty acids, tocopherol, and tocotrienol in palm oil, along with storage conditions, contributes to its stability. Some chemical properties of lipids, such as the amount of unsaturation and the length of the chains of the fatty acids that make up triacylglycerols, directly affect oil viscosity. Its value goes up as the saturation level goes up, and it goes down as the temperature goes up (Diamante and Lan 2014).

3.3.2 Color Analysis

The color of edible oils is one of their most important commercial characteristics; the physical properties of deteriorated oil show clear signs that allow sensory judgment. The color parameters are illustrated in Table 3.3.

Table 3.3.Colour Analysis of Qazwan Oils During Storage

Storage	Sample	L*	a*	b*	h°	Whiteness Index
first day	A	20.24±0.62 ^{f}	-2.15± 0.24 ^{j}	8.28± 0.51^{h}	104.82±0.67 ^{a}	20.31± 0.25 ^{f}
	B	26.20± 0.28 ^{e}	-1.96± 0.12 ^{jk}	6.14± 0.22 ^{h}	107.71± 0.32 ^{a}	22.21± 0.18 ^{f}
	C	28.09 ± 0.74 ^{de}	-2.35± 0.28 ^{j}	11.58± 0.32^{g}	101.47±0.11 ^{ab}	15.99± 0.54 ^{g}
	D	31.97± 0.58 ^{d}	-2.12 ± 0.11^{j}	11.82±0.61 ^{g}	102.07± 0.38 ^{b}	33.91± 0.54 ^{d}
	E	30.65± 0.33^{d}	-3.55± 0.23 ^{j}	16.61±0.58 ^{g}	97.64± 0.17 ^{b}	29.52± 0.37^{de}
	F	34.89± 0.51 ^{d}	-1.38± 0.3 ^{k}	11.31±0.12^{h}	96.95± 0.17 ^{b}	31.71± 0.39 ^{e}
after one month	A	18.90 ± 0.60^{f}	-1.85 ± 0.20 ^{k}	7.10 ± 0.45 ^{h}	102.30 ± 0.60 ^{ab}	18.40 ± 0.22 ^{f}
	B	24.80 ± 0.25^{f}	-1.60 ± 0.10 ^{k}	5.20 ± 0.20 ^{h}	105.40 ± 0.30 ^{a}	20.10 ± 0.15^{f}
	C	26.30 ± 0.70 ^{e}	-2.05 ± 0.25 ^{k}	9.90 ± 0.30^{gh}	98.90 ± 0.10 ^{b}	14.10 ± 0.50^{g}
	D	29.80 ± 0.55^{de}	-1.75 ± 0.10^{j}	10.40 ± 0.55^{g}	99.80 ± 0.35^{b}	30.20 ± 0.50^{d}
	E	28.10 ± 0.30 ^{e}	-3.10 ± 0.20 ^{j}	14.20 ± 0.50 ^{g}	95.20 ± 0.15^{bc}	26.70 ± 0.35^{e}
	F	32.40 ± 0.50 ^{d}	-1.10 ± 0.25 ^{k}	9.80 ± 0.10 ^{h}	94.80 ± 0.15^{c}	28.60 ± 0.35^{b}
after three months	A	16.80 ± 0.55 ^{g}	-1.60 ± 0.18 ^{k}	5.90 ± 0.40 ^{b}	99.10 ± 0.55^{a}	16.20 ± 0.20^{g}
	B	22.90 ± 0.22 ^{f}	-1.40 ± 0.10 ^{k}	4.30 ± 0.18 ^{i}	102.00 ± 0.28^{b}	18.50 ± 0.12^{f}
	C	24.10 ± 0.68 ^{f}	-1.90 ± 0.22^{jk}	8.20 ± 0.28 ^{h}	96.80 ± 0.10 ^{b}	12.90 ± 0.45^{g}
	D	27.60 ± 0.50 ^{e}	-1.50 ± 0.10 ^{k}	8.70 ± 0.50 ^{h}	97.20 ± 0.30 ^{a}	27.10 ± 0.48^{e}
	E	25.30 ± 0.28 ^{ef}	-2.80 ± 0.18 ^{j}	12.50 ± 0.45 ^{g}	93.50 ± 0.12^{bc}	23.40 ± 0.30^{e}
	F	30.10 ± 0.45 ^{e}	-0.90 ± 0.20 ^{l}	8.10 ± 0.08 ^{h}	92.80 ± 0.10 ^{c}	25.90 ± 0.32^{ef}

Results of three (n=3) replications were expressed as mean± standard error, values with different superscript letters are significantly different ($p < 0.05$).*P. khinjukn* (A- Erbil , B-Duhok , C- Sulaymaniyah):*P..atlantica* (D- Erbil , E-Duhok ,E-Sulaymaniyah)

The color measurement results (L*, a*, b*, hue angle, and Whiteness Index) at first day of storage show significant differences among samples (A–F), Regarding lightness (L*), sample F recorded the highest value (34.89), followed by samples D (31.97) and E (30.65), indicating that these samples were brighter than the others. In contrast, sample A showed the lowest value (20.24), reflecting a darker appearance. These variations may be attributed to differences in the chemical composition of the fruit as showed in the Table .3.2. For the a* values, which represent the red (+) to green (−) axis, all samples exhibited negative values, indicating a tendency toward green coloration. Sample E had the most negative value (−3.55), suggesting the strongest green tone, whereas sample F had the least negative value (−1.38), making it closer to neutrality In terms of b* values, representing the yellow (+) to blue (−) axis, all samples showed positive values, indicating a shift toward yellow. Sample E recorded the highest value (16.61), indicating a more intense yellow coloration, while sample B had the lowest value (6.14), suggesting it was the least yellow among the samples.The hue angle (h°) ranged from 96.95 to 107.71. Sample B exhibited the highest value (107.71), indicating a stronger yellow-green hue, whereas sample F showed the lowest value (96.95), reflecting a slight shift toward a more yellow tone.

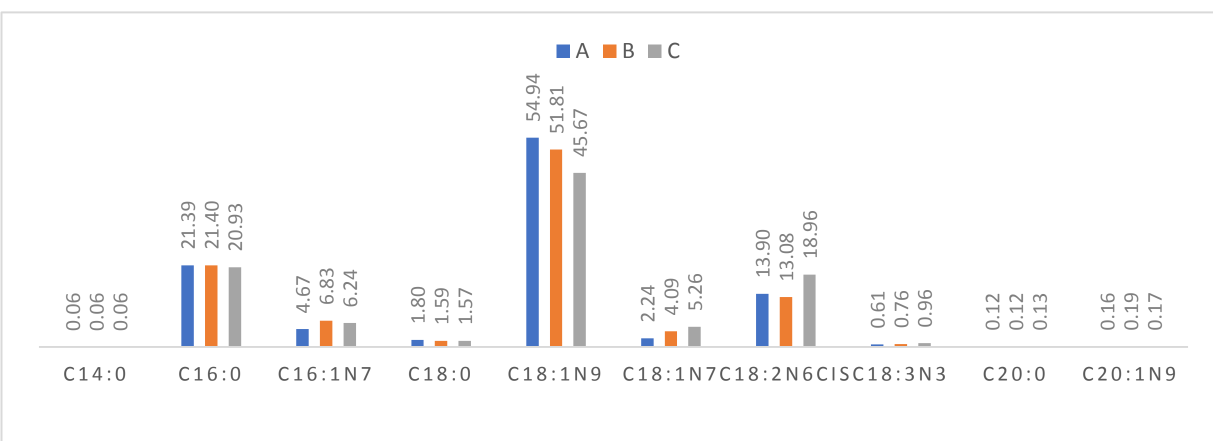
Regarding the Whiteness Index, sample D recorded the highest value (33.91), followed by samples F (31.71) and E (29.52), indicating higher perceived whiteness. In contrast, sample C showed the lowest value (15.99), reflecting reduced whiteness. In general, the Whiteness Index values were consistent with the L* results, as samples with higher lightness tended to exhibit higher whiteness.

Data presented in the table above indicate that the color index of oils decreased with increased storage time. After one month of storage, a general decrease in L*, b*, h°, and whiteness index values was observed, indicating progressive darkening and loss of color purity. This behavior can be attributed to oxidative degradation of pigments such as carotenoids and chlorophylls. Meanwhile, a slight increase in a* values suggests a shift toward red hues, likely due to the formation of secondary oxidation products. Bellomo et al.(2009) observed at 37 °C with a degradation of about 62% for chl a, 44% for chl b and 57.5% for lutein of pistachio oil . At 10 and 25 °C , the samples showed slight differences; the pigment degradations were about 46% for chl a, 33% for chl b and 37% for lutein.

After three months of storage, a more pronounced deterioration in color parameters was observed, characterized by a significant decrease in L*, b*, h°, and whiteness index values. This indicates progressive darkening of the oil and substantial loss of pigment stability. The observed changes are mainly attributed to advanced oxidative degradation of minor oil components like tocopherol, carotenoids, chlorophylls, and other pigments that give them their color and leading to the formation of secondary brown-colored oxidation products (Abdellah and Ishag, 2012). The increase in a* values further suggests a gradual shift toward reddish tones associated with oxidative by-products (Jusman and Handayani, 2021). These findings are consistent with those of Abdellah and Ishag, *(2012) and Hashem* et al.2023).

3.4. Fatty acids contain of Qazwan Samples

Fatty acids are the major constituents of oils and fats, and their composition plays a crucial role in determining their nutritional value, stability, and functional properties.



.**Figure3.3 a: Fatty acids composition of *P. khinjuk fruit* oils (A- Erbil, B-Duhok, C-Sulaymaniyah)**

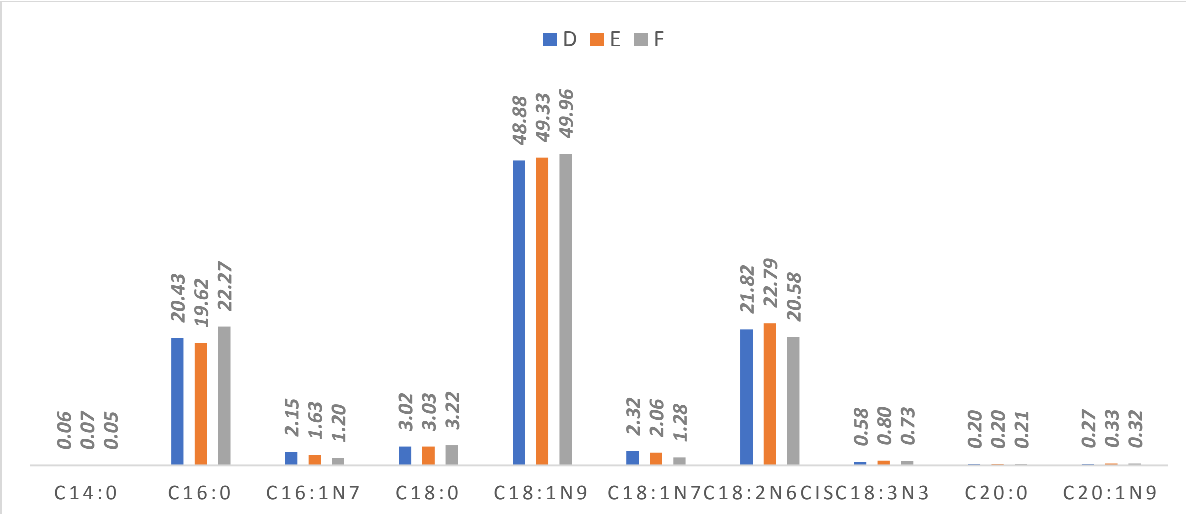


Figure 3.3b: Fatty acids composition of *P..atlantica* fruit oils (D- Erbil, E-Duhok, E-Sulaymaniyah)

Gas chromatography analysis of fatty acids in fruit oil from the two *Pistacia* species at different locations is shown in Figure3. 3.a and b. Although there were slight differences in fatty acid content among the samples, these differences may be due to maturation and environmental and growing conditions that affect the fatty acid composition of fruits, as reported by Benhassaini (2007). The two species were similar in that both contained high levels of oleic acid, a monounsaturated fatty acid (MUFA), with the highest level in sample A (54.94%) and the lowest in sample C (45.67%). In contrast, polyunsaturated fatty acids (PUFAs) were present in lower amounts. Linoleic acid was the most abundant PUFA, with the highest level in sample E (22.79%) and the lowest in sample B (13.08%). The α-linolenic acid (omega-3) percentage was very low, ranging from 0.58% to 0.96%. Regarding saturated fatty acid (SFA) content, palmitic acid was the most abundant fatty acid, with amounts of 22.27% in sample F and 19.62% in sample E. The samples also contained a low percentage of stearic acid, ranging from 3.02% to 6.83%. The results showed that unsaturated fatty acids comprised around 75% of the total fatty acid content, which improved nutritional value but may reduce stability. These variations highlight the relationship between nutritional quality and oxidative stability, which is critical in determining the intended application and shelf life of the oil. These results were similar to other researchers' data

(Benhassaini, 2007; Dorehgirae and Pourabdollah, 2015; Hazrati et al., 2020; Ahmad et al., 2023) for *Pistacia* from Iranian, Turkey Algerian and Halabja.

3.5 Quality Indices of the Oil

3.5.1 Acid Value

Table 3.4 shows some chemical constants of Qazwan fruits oil from different location stored at room temperature for three months to test the storage stability of samples.

Table 3 .4The Quality Indices of Qazwan Oil During Storage

Storage	samples	Acid value mg KOH /g Oil	Peroxide value meq/kg	Iodin value g/100g
first day	A	3.54 ± 0.31^{c}	0.66 ± 0.05^{d}	87.91 ± 6.23^{a}
	B	3.41 ± 0.56^{c}	0.69 ± 0.06^{d}	89.23 ± 4.98^{a}
	C	3.87 ± 0.31^{bc}	0.69 ± 0.07^{d}	79.83 ± 3.58^{bc}
	D	3.65 ± 0.62^{c}	$0.64\pm0.0\ 7^{d}$	88.8 ± 0.68^{a}
	E	3.82 ± 0.38^{bc}	0.68 ± 0.06	83.75 ± 2.69^{ab}
	F	3.99 ± 0.15^{bc}	0.68 ± 0.09^{d}	78.23 ± 1.98^{bc}
after one month	A	4.09 ± 0.22^{bc}	0.75 ± 0.06^{c}	75.72 ± 1.33^{cd}
	B	4.30 ± 0.41^{b}	0.79 ± 0.04^{c}	75.57 ± 2.43^{cd}
	C	4.11 ± 0.41^{bc}	0.71 ± 0.09^{cd}	76.25 ± 2.45^{cd}
	D	4.17 ± 0.89^{bc}	0.74 ± 0.06^{cd}	77.80 ± 1.62^{bc}
	E	4.47 ± 0.80^{b}	0.77 ± 0.04^{c}	79.20 ± 5.62^{bc}
	F	4.54 ± 0.86^{b}	0.72 ± 0.06^{cd}	77.90 ± 3.62^{bc}
after three months	A	5.14 ± 0.75^{ab}	0.91 ± 0.52^{bc}	71.82 ± 4.67^{e}
	B	4.98 ± 0.81^{ab}	0.85 ± 0.07^{bc}	72.86 ± 4.87^{de}
	C	5.570 ± 1.13^{a}	1.24 ± 0.06^{ab}	71.95 ± 3.68^{e}
	D	5.65 ± 0.65^{a}	0.98 ± 0.09^{b}	72.41 ± 2.15^{de}
	E	5.52 ± 0.74^{a}	1.60 ± 0.12^{a}	72.24 ± 4.55^{de}
	F	5.88 ± 0.98^{a}	1.29 ± 0.09^{ab}	71.3 ± 0.45^{e}

Results of three (n=3) replications were expressed as mean± standard error, values with different superscript letters are significantly different ($p < 0.05$).*P. khinjukn*

(A- Erbil , B-Duhok , C- Sulaymaniyah):*P..atlantica* (D- Erbil , E-Duhok ,E-Sulaymaniyah)

Acid value (AV) is an indicative index of oil quality and a key chemical constant for maintaining the quality of edible fats and vegetable oils. It serves as a reliable indicator of the degree of hydrolysis occurring in these fats before, during, and after extraction, processing, and storage. However, controlling the acidity of edible oils is essential because excessive free fatty acid concentrations render them unfit for human consumption (Enyoh et al., 2017). The acid values of Qazwan oil samples are given in Table 3.4. The results indicate that although there are minor differences in acid values among oils from two species and three different locations, these variations were not statistically significant across the oil samples. The differences might be due to parameters that influence the fatty acid composition of oil, including the processes employed for oil extraction, cultivar, fruit maturity, altitude, climate, and storage conditions (Nierat, 2012). The results showed a gradual increase in the measured parameter as storage duration increased. The differences were significant when comparing values on the first day and after three months of storage. The data show the lowest and highest acid values of 3.41 and 3.99 mg KOH/g oil, which rise to 4.98 and 5.88 mg KOH/g oil for Erbil P. khinjukn and Sulaymaniyah P. atlantica, respectively. The results obtained (AVs) from this study were within the limits of acid value reported for cold-pressed and virgin oils in the Codex Standard for named vegetable oils (Hanafy et al., 2023). Many researchers have reported changes in the AV of fresh pistachio samples during the storage period. FFA values increased over time in all samples of *P. kernels* and *P. vera* L. (Bellomo et al., 2009; Şahan and Bozkurt, 2025).

3.5.2 Peroxide Value

The peroxide value(PV) indicates the stability of oil against oxidative degradation. It is widely used to measure peroxides and hydroperoxide forms resulting from oxidation in oils (Bellomo et al., 2009).

The peroxide values of fresh pistachio samples ranged from 0.64±0.07 meq O_2/kg to 0.69±0.07 meq O_2/kg with non-significant differences at the beginning of storage. After three months of storage, these values increased significantly and reached levels between 0.85±0.07 meq O_2/kg and 01.60 ±0.12meq O_2/kg as seen in Table 3.4, indicating an increase in oxidative rancidity which be contributed to the several prooxidants, including light, initial oxygen concentration, permeability of oxygen through the packaging materials and temperature(Kucuk & Caner, 2005)., which accelerated the reaction rate. It is noticeable that the lowest values of peroxides were recorded in the oil of Erbil *P. khinjukn* , while the highest values were obtained in *Pistacia atlantica* oil from Sulaymaniyah. This may be attributed to the differences in natural antioxidants and fatty acids levels in the samples, as it is clear that the higher the concentration of unsaturated fatty acids, the greater their oxidation capacity. Specifically, the oxidation rates of fatty acids are approximately 1:10:100:200 for stearic, oleic, linoleic, and linolenic acids, respectively (O'Keefe et al., 1993).Bellomo et al., (2009) (and ¸Sahan and Bozkurt (2025) recorded an increase in PV from 1.7 ± 0.000 meq O_2/kg to 4.1 ± 0.76meq O_2/kg and from 0.33 ± 0.03meq O_2/kg to 0.995 ± 0.05meq O_2/kg, respectively, of pistachio oil with increasing storage time from 0 to three months. The obtained results (AVs) from this study were within the accepted range, which is considered suitable for human consumption, as recommended by the regulation (<10 meq O_2/kg oil) (Ramli et al., 2021).

3.5.3 Iodine Value

Fats and oils, for example, have an iodine value (IV), which measures how much iodine is taken up by the unsaturated fatty acids in oil samples IV is a measure of the degree of unsaturation of an oil. The higher the IV, the more unsaturation is present. Edible oils with high IV are desired by oil processors, while oils having lower IV are suggestive of lower quality (Tesfaye and Abebaw, 2016). Besides, IV reflects the reactivity of the oil and is useful for detecting adulteration in oils.it was deduced that the oils with low IV might have contributed to their greater oxidative storage stability, as reported by (Chigbogu et al., 2015). The analysis of IV on two species and three different locations during three months storage of Qazwan oil samples is given in Table 3.4, which indicates that the samples had IVs ranging from 71.3g/100 g to 89.23 to 71.3g/100 g at the first day of storage, the lowest values were recorded in the oil of *P. atlantica* from Sulaymaniyah while the highest values were obtained in Erbil *P. khinjukn* , the differences in IV of samples oil may be attributed to variations in amount and degree of unsaturation of fatty acid, IV of 92.70 ± 1.06 gI_2/100g to 96.65 ± 0.40gI_2/100g and 88.000 ± 0.010 gI_2/100g was reported by Yıldız et al,1998 and Acheheb et al. 2012 in Algeria and Turkish pistachio fruit oil, they stated that, the high iodine value indicated a high nutritional value confers a less stable with a longer shelf-life. The same table showed a gradual decrease in iodine value with increasing storage duration, which may be refer to the fact that the oils were susceptible to oxidation (Chigbogu et al., 2015).

3.6 Screening Antimicrobial Activity of oils

The antimicrobial effect results of the qazwan oils was illustreated in Table 3.5 and Figure 3.4.

Table3.5. Inhibitory activity of the *Pistacia khinjuk* and *Pistacia atlantica.*oil extracts on the growth of some pathogenic bacteria

Oil types	Diameter of inhibition zone (mm)	
	Pseudomonas aeruginosa	***Staphylococcus aureus***
A	-	-
B	21	16
C	15	15
D	-	-
E	-	-
F	15	-

Results of three (n=3) replications were expressed as mean± standard error, values with different superscript letters are significantly different (p < 0.05).*P. khinjukn*

(A- Erbil , B-Duhok , C- Sulaymaniyah):*P..atlantica* (D- Erbil , E-Duhok ,E-Sulaymaniyah)

Figur.3.4 antibacterial activity of oil extracts

The antibacterial activity of oil extracts derived from *Pistacia khinjuk* and *Pistacia atlantica* collected from different regions of Kurdistan (Erbil, Duhok, and Sulaymaniyah) was evaluated against multidrug-resistant clinical isolates of *Pseudomonas aeruginosa*

and *Staphylococcus aureus* using the agar well diffusion method.
Among the tested samples, *Pistacia khinjuk* oil from Duhok exhibited the highest antibacterial activity, producing inhibition zones of 21 mm against *P. aeruginosa* and 16 mm against *S. aureus*.

Moderate activity was observed for *P. khinjuk* oil from Sulaymaniyah (15 mm against both organisms) and *P. atlantica* oil from Sulaymaniyah (15 mm against *P. aeruginosa* only). Similar findings have been reported previously for *Pistacia* species. A study by Kamel et al. (2017) showed that *P. khinjuk* extracts inhibited the growth of *S. aureus*, *Escherichia coli*, and *P. aeruginosa*, supporting the antibacterial potential observed in the current study. The authors attributed this activity to the presence of flavonoids, fatty acids, and phenolic compounds. Likewise, resinous extracts of *P. khinjuk* demonstrated antibacterial activity against *S. aureus*, although lower activity was observed against *P. aeruginosa*, likely due to the intrinsic resistance mechanisms of Gram-negative bacteria(Al-jaff, 2003). This agrees with the present findings, where *P. aeruginosa* showed lower susceptibility compared with *S. aureus*.
For *Pistacia atlantica*, previous investigations reported that the essential oil of *P. atlantica* subsp. *kurdica* exhibited stronger antibacterial activity against Gram-positive bacteria than Gram-negative bacteria. Major compounds identified included α-pinene, limonene, and β-pinene, which are known antimicrobial terpenoids(Fathollahi et al., 2019). These compounds may contribute to membrane disruption and inhibition of bacterial growth.

In contrast, *P. khinjuk* oil from Erbil and *P. atlantica* oils from both Erbil and Duhok showed no detectable antibacterial activity.

The differences observed among oils collected from Erbil, Duhok, and Sulaymaniyah may be related to environmental and geographical factors affecting phytochemical composition. Similar regional variability in chemical composition and antibacterial activity has also been reported in wild *Pistacia* populations(Pulaj et al., 2016).

Although the agar well diffusion method provides useful preliminary screening data, it remains qualitative. Therefore, further quantitative assays such as minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) are recommended to validate these findings.

Overall, the results demonstrate that *Pistacia khinjuk*, particularly from Duhok, shows promising antibacterial activity against MDR pathogens and may serve as a potential source of natural antimicrobial agents. These findings support the growing interest in plant-derived compounds as alternative strategies to combat antimicrobial resistance.

Conclusion

This study highlights the physicochemical characteristics of fruit oil from Pistacia species extracted by cold pressing, along with oil quality indices such as acid value, peroxide value, and iodine value over three months of storage. The high oil yield, as well as low peroxide values during storage, indicate good oxidative stability. The oils also showed an appreciable nutritional profile and a high proportion of essential unsaturated fatty acids, suggesting their importance as a natural source of edible vegetable oil and in food applications, given that wild pistachios are a major agricultural product in the Iraqi Kurdistan Region.

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تقييم بعض الخصائص الفيزيائية والكيميائية لزيت ثمار القزوان (أنواع الفستق) من مناطق مختلفة في كردستان – العراق

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الخلاصة

يُعدّ كلٌّ من الفستق الخنجوكي والفستق الأطلسي، المعروفان باسم قزوان باللغة الكردية، من الأنواع البرية المهمة واسعة الانتشار في إقليم كردستان شمال العراق. هدفت هذه الدراسة إلى بحث تأثير مدة الخزن على مؤشرات الجودة والخصائص الفيزيائية للزيت المستخلص من ثمار قزوان. كما قيمت الدراسة تركيب الأحماض الدهنية، والنشاط المضاد للبكتيريا للزيوت المستخلصة، والتركيب الكيميائي التقريبي لثمار القزوان. تم تقييم التركيب الكيميائي التقريبي لعينات الثمار من خلال تحديد محتوى الرطوبة والزيت والبروتين والألياف والرماد. تتميز الثمار بمحتوها العالي من الزيت، حيث تتزاوح بين 21.60% و38.47%، وكان محتوى الألياف مرتفعا نسبيا، حيث تراوح الغذائيةبين 19.95% و27.19%، مما يشير إلى أن الثمار قد تكون مصدرا جيدا للألياف الغذائية، مما يدل على وجود عناصر معدنية أساسية. تراوحت نسبة الرطوبة بين 11.37% و14.02%، وتراوح البروتين الخام بين 7.61% و9.01%. كانت الأحماض الدهنية الرئيسية هي الأوليك واللينوليك والبالميتيك، والتي شكلت 48.88-54.93%، و13.89-22.78%، و19.61-22.26% على التوالي .

تم تقييم تأثير مدة التخزين على مؤشرات الجودة والخصائص الفيزيائية للزيت ، مثل اللزوجة وشدة اللون ومعامل الانكسار للزيوت المستخلصة من ثمار القزوان. كما تم قياس مؤشرات الجودة، بما في ذلك قيمة الحموضة وقيمة البيروكسيد والرقم اليودي ، خلال فترات الخزن لمدة يوم واحد وشهر واحد وثلاثة أشهر. أظهرت النتائج أن مدة التخزين أثرت بشكل ملحوظ على جودة الزيت بعد فترة التخزين التي استمرت ثلاثة أشهر. تراوحت قيم الحموضة في الزيت الطازج بين 3.41 و3.99 ملغم هيدروكسيد البوتاسيوم/غرام، ثم ارتفعت إلى ما بين 4.98 و5.88 ملغم هيدروكسيد البوتاسيوم/غرام بعد ثلاثة أشهر من التخزين. كما ارتفعت قيم البيروكسيد من 0.64-0.69 ملي مكافئ أكسجين/كغم إلى 0.85-1.60 ملي مكافئ أكسجين/كغم، بينما انخفضت قيم اليود من 78.23-89.23 غرام/100 غرام إلى 71.30-72.86 غرام/100 غرام. وعلى الرغم من هذه التغيرات التي طرأت في نهاية فترة الخزن ، إلا أن هذه القيم ظلت ضمن حدود المواصفات القياسية. وكشفت الدراسة أن عينات الفاكهة تتمتع بخصائص غذائية قيّمة، ويمكن اعتبارها مصادر للزيوت الصالحة للأكل والألياف الغذائية وغيرها من العناصر الغذائية.

اظهر زيت الفستق الخنجوكي من دهوك اعلى نشاط مضاد للبكتيريا حيث أحدث مناطق تثبيط بلغت 21 ملم ضد بكتيريا P. aeruginosaو16 ملم ضد بكتيريا S. aureus في حين اظهر زيت الفستق الكنجوكي الموخوذ من سليماتية 15ملم ضد بكتيرياP. aeruginosa

الكلمات المفتاحية: قزوان، الفستق الأطلسي، الفستق الخنجوك، الزيوت ، مدة التخزين