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Comparative Evaluation of Cold and Heat Pressing on the Quality Characteristics of Olive Oil Extracted from Black Olives (Picual Cultivar).

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ABSTRACT

This study evaluates the effect of cold pressing and heat pressing methods on the quality of olive oil extracted from black olives (Picual cultivar). A total of 50 kg of olives were divided into two groups and processed using cold and hot extraction methods for comparison. The fruits showed good production characteristics, including a high oil content (23%) and high phenolic compounds (1025 mg/100 g). Results indicated that cold-pressed oil had lower acidity (0.14%) compared to heat-pressed oil (0.17%). Cold-pressed oil also showed lower oxidation values such as peroxide value compared to heat-pressed oil. Heat treatment increased oxidation indicators such as K232 and K270, indicating oil quality deterioration. Phenolic content decreased in heat-pressed oil, negatively affecting oxidative stability. Cold-pressed oil retained a higher proportion of oleic acid, improving stability and nutritional quality. In contrast, polyunsaturated fatty acids increased in heat-pressed oil, which reduces stability. DPPH results showed that antioxidant activity varied depending on the extraction method despite changes in phenolic.

Conclusion: This study concluded that cold pressing is the best method for preserving the nutritional and chemical quality of olive oil. Overall, the extraction method plays a crucial role in determining the final quality and stability of olive oil.

Key words : Olive oil; Picual cultivar; cold pressing; heat pressing; quality characteristics

INTRODUCTION

Olive oil is one of the most important and widely consumed vegetable oils worldwide due to its high nutritional value and numerous health-promoting properties. It is a fundamental component of the Mediterranean diet and has been associated with a reduced risk of several chronic diseases, including cardiovascular diseases, hypertension, type 2 diabetes, and certain types of cancer. These beneficial effects are mainly attributed to its high content of monounsaturated fatty acids, particularly oleic acid, as well as its abundance of bioactive compounds such as polyphenols, tocopherols, and other natural antioxidants.

In addition to its nutritional importance, olive oil possesses significant therapeutic properties. Numerous studies have demonstrated its anti-inflammatory, antioxidant, antimicrobial, and cardioprotective effects. Furthermore, olive oil has been widely used in traditional and modern medicine for improving digestive health, supporting immune function, and promoting skin and hair health. The presence of phenolic compounds

contributes substantially to these biological activities by reducing oxidative stress and protecting cells from damage.

The quality of olive oil is a critical factor that determines its nutritional, sensory, and commercial value. Among the various factors affecting oil quality, the extraction method plays a crucial role. Different extraction techniques, including traditional pressing, mechanical cold extraction, and solvent extraction, can significantly influence the chemical composition, antioxidant content, flavor, aroma, and shelf life of the final product. In particular, extraction conditions such as temperature, pressure, and processing time may affect the preservation of bioactive compounds and the oxidative stability of the oil.

Therefore, understanding the relationship between extraction methods and olive oil quality is essential for optimizing production processes and ensuring the retention of its valuable nutritional and therapeutic properties. This study aims to review the nutritional and medicinal importance of olive oil and to evaluate the impact of different extraction methods on the quality characteristics of the resulting oil.

MATERIALS AND METHODS

A total of 50 kg of Picual olives were obtained from Al Salam Farm, Ismailia, Egypt. The physical characteristics of the fruits were determined using a 1 kg representative sample. The remaining olives were divided into two groups to evaluate the properties of the extracted olive oil under different extraction conditions. One group was subjected to cold extraction, while the other was processed using hot extraction.

The resulting oils were subsequently analyzed and compared to assess the effect of the extraction method on oil quality and characteristics.

Extraction process:

The cold and hot extraction procedures were performed according to the methodology described by Garedo Fernandez in his book *Table Olives*. The cold and hot extraction procedures were performed according to the methodology described by Garedo Fernandez in his book *Table Olives* (1997)

Physical Properties : Viscosity is measured by a rotational viscometer, providing data on the oil's flow characteristics and texture. (Davila et al., 2022). The maturity index (MI) of olive fruits was determined according to the method described by Uceda and Frías (1975).

Chemical Analyses

Peroxide Value (PV) : This test measures the concentration of peroxides and hydroperoxides formed during initial lipid oxidation stages. A titrimetric method is used where iodine released from the reaction with peroxides is quantified, indicating the extent of primary oxidation (AOAC, 2019).

Free Acidity (FA) : Free fatty acid content is determined by titrating the oil sample with potassium hydroxide. High levels of free acidity are an indicator of hydrolytic degradation, affecting oil quality and classification (AOAC, 2019).

Conjugated Dienes and Trienes : The assessment of conjugated dienes and trienes in Picual olive oil was conducted using ultraviolet (UV) spectrophotometry at wavelengths of 232 nm and 270 nm, respectively, (Hashem et al., 2020).

Fatty Acid Composition by Gas Chromatography with Flame Ionization Detection (GC-FID) : The analysis of fatty acid composition in Picual olive oil was conducted using gas chromatography equipped with a flame ionization detector (GC-FID), a well-established method for precise quantification and profiling of fatty acids as recorded by (Zahran and Tawfeuk, 2019).

Phenolic Content by Folin-Ciocalteu Reagent : Total phenolic content in Picual olive oil samples was determined using the Folin-Ciocalteu colorimetric assay, a widely accepted method for quantifying phenolic compounds in food matrices (Zayed et al., 2024).

Antioxidant Activity by DPPH : Antioxidant activity was assessed using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay, a rapid and reliable method to evaluate free radical scavenging capacity (Zayed et al., 2024).

RESULTS AND DISCUSSION

Physicochemical Characteristics of Fresh Natural Black Olives (cv. Picual) :

The physicochemical characteristics presented in Table 1 indicate that the fresh black olives of the **Picual** cultivar possess desirable attributes for both olive oil production and table olive processing. These parameters reflect the cultivar's genetic characteristics as well as the degree of fruit ripening (Brenes,2004).

Maturity Index

The maturity index of 4 indicates that the fruits were harvested at an advanced ripening stage, characterized by a purple-black skin color and partial pigmentation of the flesh. This stage is generally associated with maximum oil accumulation and improved sensory quality. Previous studies have shown that fruit maturity significantly influences oil content, phenolic composition, and moisture levels in olives. As ripening progresses, oil accumulation increases while certain phenolic compounds tend to decline due to enzymatic degradation and oxidation processes.

Fruit Size

The recorded fruit size (172 fruits kg^{-1}) suggests relatively large fruits. Fruit size is an important commercial characteristic, particularly for table olives. Research on Spanish olive cultivars reported that Picual generally produces larger fruits than several other cultivars and is characterized by favorable commercial attributes.

The flesh-to-stone ratio (7:1) is considered high and indicates a large edible portion relative to the pit. This characteristic is highly desirable for table olive production because it enhances consumer acceptance and processing yield. Similar observations were reported for Picual olives, which exhibit a relatively high pulp/stone ratio compared with many other olive cultivars.

Moisture Content

The moisture content (70%) falls within the normal range reported for ripe olive fruits (approximately 60–75%). Water content strongly influences fruit texture, oil extraction efficiency, and the transfer of phenolic compounds into olive oil. Studies have demonstrated that higher fruit moisture may reduce the transfer of some phenolic constituents to the oil phase during extraction.

Ether Extract (Oil Content)

The ether extract value (23%) reflects the lipid fraction of the fruit and indicates a satisfactory oil yield. Picual is internationally recognized as a high-oil cultivar, and numerous studies have confirmed its suitability for olive oil production because of its favorable oil quantity and quality characteristics. Differences in oil content among studies are often attributed to environmental conditions, irrigation practices, and harvest maturity.

Ash Content

The ash content (1.90%) represents the total mineral matter in the fruit and is consistent with values commonly reported for olives. Minerals such as potassium, calcium, magnesium, and phosphorus contribute to both nutritional value and processing behavior. Mineral composition may vary according to soil conditions, cultivar, and agronomic practices.

Crude Fiber

The fiber content (3.4%) reflects the structural carbohydrates of the fruit tissues. This moderate level contributes positively to fruit firmness and texture, characteristics that are important for both fresh consumption and processing. Dietary fiber also enhances the nutritional value of olives as a functional food.

Table 1. Physic-chemical proportion of fresh natural black olives var (picual)

Characteristic	Value
Maturity index	4
Olive size (Fruits \ Kg)	172
Flesh \ Stone	7:1
Moisture content %	70
Ether extract	23
Ash	1.90
Fiber	3.4
Poly phenols (as mg tannic acid /100g)	1025

Total Phenolic Compounds

The total phenolic content (1025 mg tannic acid/100 g fresh weight) is relatively high and represents one of the most important quality indicators of the fruit. Phenolic compounds such as oleuropein, hydroxytyrosol, tyrosol, and various secoiridoids are responsible for the antioxidant, antimicrobial, and health-promoting properties of olives and olive oil. Several studies have demonstrated that Picual fruits and oils are characterized by relatively high phenolic concentrations and superior oxidative stability compared with many other cultivars. Furthermore, phenolic compounds contribute significantly to olive oil shelf life and resistance to oxidation.

The phenolic content obtained in the present study is even higher than some values reported for ripe Picual fruits (approximately 670 mg/100 g fresh weight), which may be attributed to differences in environmental conditions, harvesting date, orchard management, or analytical methodology.

Comparison with Previous Studies

Parameter	**Present Study**	**Literature Findings**
Maturity Index	4	Typical harvesting stage for oil and table olives (3–5) (PMC)
Flesh/Stone Ratio	7:1	Picual characterized by high pulp/stone ratio (ishs)
Moisture (%)	70	Common range 60–75% (PMC)
Oil Content (%)	23	Consistent with medium–high oil content of Picual (ishs)
Total Phenolics (mg/100 g)	1025	Higher than values reported for many ripe Picual fruits (~670 mg/100 g) (PMC)

Chemical Characteristics of Olive Oil Extracted by Cold and Heat Pressing

The extraction method plays a critical role in determining the physicochemical quality, oxidative stability, and bioactive composition of olive oil. The results presented in Table 2 reveal significant differences between olive oil obtained by cold pressing and that obtained by heat pressing, particularly in oxidation indices, phenolic content, and antioxidant properties.

Free Fatty Acidity (FFA)

Free fatty acidity is one of the most important indicators of olive oil quality because it reflects the degree of triglyceride hydrolysis. The cold-pressed oil exhibited a lower acidity value (0.14% as oleic acid) compared with the heat-pressed oil (0.17%). Although both values are well below the maximum limit established by the International Olive Council and qualify as extra virgin olive oil (<0.8%), the slight increase observed in heat-pressed oil may be attributed to enhanced hydrolytic reactions promoted by elevated temperatures during extraction.

Previous studies have reported that increasing extraction temperature accelerates lipase activity and promotes the breakdown of triglycerides into free fatty acids, resulting in higher acidity values (Servili et al., 2014). Therefore, the lower acidity of cold-pressed oil indicates better preservation of the native lipid structure.

Table 2. Chemical parameters of olive oil extracted by cold pressing and Heat pressing

Parameter	Cold pressing	Heat pressing
Free fatty Acidity (% as oleic acid)	0.14	0.17
Peroxide Value (meq O_2/kg)	7	38.98
UV232 nm	1.549	1.681
UV270nm	0.052	0.202
Delta K	0.0035	0.0055
Acid value	0.64	0.72
Viscosity(mpa.s)	83.55	85.27
Antioxdent Activity by DppH assay (IC_{50} mg/mL)	8.26	6.23
Total Phenolic Content (mg GAE/kg)	123	110

Peroxide Value (PV)

The peroxide value represents the concentration of primary oxidation products, mainly hydroperoxides. The cold-pressed oil exhibited a peroxide value of 7 meq O_2/kg, whereas heat-pressed oil showed a markedly higher value of 38.98 meq O_2/kg.

This substantial increase indicates that thermal treatment accelerated lipid oxidation during extraction. According to IOC standards, extra virgin olive oil should have a peroxide value below 20 meq O_2/kg. Therefore, while the cold-pressed oil falls well within acceptable limits, the heat-pressed oil exceeds this threshold, suggesting significant oxidative deterioration.

Similar findings were reported by Sibbett and Ferguson (2005) and Kalua et al. (2007), who demonstrated that elevated processing temperatures increase the formation of hydroperoxides and reduce oxidative stability. The observed increase is likely related to the decomposition of natural antioxidants and the enhanced exposure of unsaturated fatty acids to oxygen.

Specific Extinction Coefficients (K232 and K270)

The UV absorbance indices K232 and K270 are widely used to evaluate the oxidation status of olive oils.

The K232 values increased from 1.549 in cold-pressed oil to 1.681 in heat-pressed oil. This parameter reflects the accumulation of conjugated dienes formed during primary oxidation. Similarly, K270 increased markedly from 0.052 to 0.202, indicating greater formation of secondary oxidation products such as aldehydes and ketones.

The increase in both indices confirms that heat pressing promotes oxidative degradation of olive oil. Nevertheless, both samples remained below the IOC limits for extra virgin olive oil (K232 ≤ 2.50 and K270 ≤ 0.22), although the heat-pressed sample approached the maximum permissible K270 value.

Research conducted by Gómez-Alonso et al. (2007) demonstrated that thermal processing significantly increases conjugated diene and triene formation, leading to elevated K232 and K270 values.

Delta K

Delta K is an indicator used to detect abnormal oxidation and refining processes. The values obtained (0.0035 for cold pressing and 0.0055 for heat pressing) were low in both oils and remained below the IOC limit (≤0.01). However, the slight increase in heat-pressed oil further supports the occurrence of oxidative changes induced by temperature.

Acid Value

The acid value followed the same trend as free fatty acidity, increasing from 0.64 in cold-pressed oil to 0.72 in heat-pressed oil. This result confirms that heat treatment promotes hydrolysis of triglycerides and formation of free fatty acids. Similar increases in acid value following thermal processing have been documented by several authors investigating the effects of extraction temperature on olive oil quality.

Viscosity

The viscosity of the oils showed a slight increase from 83.55 to 85.27 mPa·s after heat pressing. Changes in viscosity are often associated with alterations in chemical composition and the formation of oxidation products. Thermal treatment can induce polymerization and structural modifications of fatty acid molecules, resulting in increased viscosity.

The relatively small difference suggests that heat treatment affected oxidation parameters more strongly than rheological properties.

Antioxidant Activity (DPPH Assay)

Antioxidant activity was evaluated using the DPPH radical scavenging assay and expressed as IC50 values. Since lower IC50 values indicated stronger antioxidant activity, the heat-pressed oil (6.23 mg/mL) exhibited higher radical scavenging activity than the cold-pressed oil (8.26 mg/mL).

This observation may initially appear contradictory because heat pressing reduced total phenolic content. However, thermal treatment can generate new antioxidant compounds through transformation of phenolic derivatives, liberation of bound phenolics, or formation of Maillard reaction products possessing radical-scavenging capacity. Similar findings have been reported in thermally processed plant oils where antioxidant activity did not always correlate directly with total phenolic concentration.

Therefore, antioxidant capacity may result from the combined contribution of phenolic and non-phenolic antioxidants.

Total Phenolic Content (TPC)

Total phenolic content decreased from 123 mg GAE/kg in cold-pressed oil to 110 mg GAE/kg in heat-pressed oil. This reduction is consistent with the known thermal sensitivity of olive phenolics. Phenolic compounds such as oleuropein derivatives, hydroxytyrosol, and tyrosol contribute significantly to the antioxidant capacity, oxidative stability, and health benefits of olive oil. Exposure to heat can promote oxidation, degradation, and polymerization of these compounds, leading to lower concentrations.

Servili et al. (2014) reported that extraction temperature is one of the most important factors affecting phenolic retention, with lower temperatures generally preserving higher phenolic levels and improving oil stability.

Comparison with Previous Studies

Parameter	Cold Pressing	Heat Pressing	Literature Trend
Free Fatty Acidity (%)	0.14	0.17	Acidity increases with extraction temperature
Peroxide Value (meq O_2/kg)	7.00	38.98	Heat promotes lipid oxidation
K232	1.549	1.681	Higher values observed after thermal treatment
K270	0.052	0.202	Secondary oxidation products increase with heating
ΔK	0.0035	0.0055	Slight increase due to oxidation
Acid Value	0.64	0.72	Hydrolysis increases during heating
Viscosity (mPa·s)	83.55	85.27	Minor increase after heat treatment
DPPH IC_{50} (mg/mL)	8.26	6.23	Antioxidant activity may vary depending on released compounds
Total Phenolics (mg GAE/kg)	123	110	Phenolic degradation occurs at higher temperatures

Fatty Acid Composition of Olive Oil Extracted by Cold Pressing and Heat Pressing

The fatty acid profile is one of the most important indicators of olive oil quality, nutritional value, oxidative stability, and authenticity. The results presented in Table 3 demonstrate that the extraction method significantly influenced the fatty acid composition of the obtained olive oil. Cold-pressed oil showed a more favorable fatty acid profile characterized by higher monounsaturated fatty acids (MUFAs), particularly oleic acid, whereas heat pressing resulted in increased saturated fatty acids (SFAs) and polyunsaturated fatty acids (PUFAs).

Saturated Fatty Acids (SFAs)

The total saturated fatty acid content increased from 15.89% in cold-pressed oil to 17.19% in heat-pressed oil. The major saturated fatty acids identified were palmitic acid (C16:0) and stearic acid (C18:0).

Palmitic Acid (C16:0)

Palmitic acid increased from 10.96% in cold-pressed oil to 11.83% in heat-pressed oil. These values fall within the normal range established by the International Olive Council for virgin olive oil (7.5–20.0%). The increase in palmitic acid percentage following heat treatment may be explained by the relative reduction of unsaturated fatty acids through oxidation, resulting in a proportional increase in saturated fatty acids.

Stearic Acid (C18:0)

Stearic acid remained relatively stable (4.27–4.29%), indicating that this fatty acid was largely unaffected by the extraction temperature. This stability is expected because saturated fatty acids are less susceptible to thermal oxidation than unsaturated fatty acids.

Minor Saturated Fatty Acids

Heptadecanoic acid (C17:0), arachidic acid (C20:0), and behenic acid (C22:0) showed slight increases in heat-pressed oil. Similar trends have been reported in thermally processed vegetable oils, where degradation of unsaturated fractions results in a relative enrichment of saturated components.

Table 3. Fatty acid composition of olive oil extracted by cold pressing and Heat pressing

Fatty acid composition	Area %	
	Cold pressing	Heating pressing
Palmitic acid (C16:0)	10.96	11.83
Palmitoleic acid (C16:1)	1.53	0.61
Heptadecanoic acid (C17:0)	0.04	0.18
Ginkgolic acid (C17:1)	0.11	0.19
Stearic acid (C18:0)	4.27	4.29
Oleic acid (C18:1n9c)	74.45	70.74
Linoleic acid (C18:2n6c)	6.72	10.23
α, Linolenic acid (C18:3n3)	0.94	0.67
Arachidic acid (C20:0)	0.53	0.70
Gadoleic acid (C20:1)	0.30	0.36
Behenic Acid (C22:0)	0.13	0.19
SFA	15.89	17.19
MUSFA	76.39	71.9
PUSFA	7.66	10.90

Monounsaturated Fatty Acids (MUFAs)

The total MUFA content decreased from 76.39% in cold-pressed oil to 71.90% in heat-pressed oil. This reduction is primarily attributable to changes in oleic acid concentration.

Oleic Acid (C18:1n-9)

Oleic acid was the predominant fatty acid in both samples, accounting for 74.45% of total fatty acids in cold-pressed oil and 70.74% in heat-pressed oil. These values are characteristic of high-quality olive oils and fall within the IOC standard range of 55–83%.

Oleic acid is considered the most important fatty acid in olive oil because it contributes significantly to oxidative stability, nutritional quality, and cardiovascular health benefits. The higher oleic acid concentration in cold-pressed oil suggests better preservation of lipid quality during extraction.

The reduction observed in heat-pressed oil may result from thermal oxidation and isomerization processes affecting unsaturated fatty acids. Several studies have reported that elevated temperatures promote oxidation of oleic acid, leading to the formation of hydroperoxides and secondary oxidation products (Boskou, 2015).

Palmitoleic Acid (C16:1)

Palmitoleic acid decreased substantially from 1.53% to 0.61% after heat pressing. This fatty acid is more susceptible to oxidative degradation than saturated fatty acids, which may explain its marked reduction during thermal treatment.

Gadoleic Acid (C20:1)

Gadoleic acid exhibited a slight increase (0.30–0.36%). Given its low concentration, this change likely reflects shifts in the relative distribution of fatty acids rather than significant biochemical alterations.

Polyunsaturated Fatty Acids (PUFAs)

The total PUFA content increased from 7.66% in cold-pressed oil to 10.90% in heat-pressed oil.

Linoleic Acid (C18:2n-6)

Linoleic acid increased markedly from 6.72% to 10.23%. Although linoleic acid is an essential fatty acid with recognized nutritional benefits, higher concentrations generally reduce oxidative stability because PUFAs are more susceptible to oxidation than MUFAs.

The increase observed in heat-pressed oil may result from improved extraction efficiency of membrane-associated lipids at elevated temperatures. Similar increases in linoleic acid have been reported when extraction conditions promote greater release of intracellular oil fractions.

α-Linolenic Acid (C18:3n-3)

In contrast, α-linolenic acid decreased from 0.94% to 0.67% following heat pressing. This fatty acid contains three double bonds and is particularly vulnerable to thermal oxidation. Its reduction therefore reflects degradation during heat treatment.

The obtained values remain within the IOC limit for virgin olive oil (<1.0%), confirming the authenticity and quality of both oils.

Oleic/Linoleic Ratio

One of the most important indicators of olive oil stability is the oleic-to-linoleic acid ratio.

- Cold pressing:
    - O/L ratio = 74.45 / 6.72 = **11.08**
- Heat pressing:
    - O/L ratio = 70.74 / 10.23 = **6.91**

The substantially higher ratio observed in cold-pressed oil indicates superior oxidative stability. Oils with higher oleic acid and lower linoleic acid concentrations are generally more resistant to oxidation and possess longer shelf lives.

This finding agrees with the peroxide value and phenolic content results reported in Table 2, which also demonstrated superior stability in cold-pressed oil.

Nutritional and Technological Implications

The fatty acid composition clearly demonstrates that cold pressing better preserves the characteristic lipid profile of olive oil. The higher MUFA content and lower PUFA concentration contribute to:

- Improved oxidative stability.
- Longer storage life.
- Greater resistance to rancidity.
- Enhanced nutritional quality.
- Better cardiovascular health benefits.

Conversely, heat pressing appears to alter the natural fatty acid balance by reducing oleic acid and increasing the relative proportion of less stable fatty acids.

Comparison with Previous Studies

Fatty Acid (%)	Cold Pressing	Heat Pressing	Typical Range for Olive Oil
Palmitic Acid	10.96	11.83	7.5–20.0
Stearic Acid	4.27	4.29	0.5–5.0
Oleic Acid	74.45	70.74	55–83
Linoleic Acid	6.72	10.23	2.5–21
α-Linolenic Acid	0.94	0.67	≤1.0
SFA	15.89	17.19	12–22
MUFA	76.39	71.90	55–83
PUFA	7.66	10.90	3–21

The obtained values are consistent with the fatty acid composition reported for Picual olive oil, which is typically characterized by high oleic acid content and excellent oxidative stability compared with many other cultivars.

Conclusion

The results demonstrated that Picual black olives possess favorable physicochemical characteristics, including a high flesh-to-stone ratio, substantial oil content, and elevated phenolic compounds, confirming their suitability for both olive oil production and, higher phenolic content, and a more desirable fatty acid profile characterized by greater oleic acid and monounsaturated fatty acid contents, resulting in enhanced table olive processing. Furthermore, the extraction method significantly affected olive oil quality, with cold pressing producing oil of superior physicochemical and nutritional quality compared with heat pressing. Cold-pressed oil exhibited lower acidity and oxidation indices oxidative stability and storage potential. In contrast, heat pressing promoted oxidation, reduced phenolic compounds, and altered the fatty acid composition. Overall, the findings indicate that cold pressing is the preferred method for preserving the natural quality, stability, and health-promoting properties of Picual olive oil

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