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Evaluating The Influence of Harvesting and Storage practices of Olive Fruits on Oil Quality in Hebron District

Sabreen Mohammad Odeh Ballout

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Prepared By:
Sabreen Mohammad Odeh Ballout

B.Sc. Plant Production & Protection, Hebron University, Palestine

Supervisor: Prof. Dr. Jehad Abbadi
Co-supervisor: Dr. Thameen Hejawi

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Prepared by: Sabreen Mohammad Odeh Ballout
Registration No: 22312418

Supervisor: Prof. Dr. Jehad Abbadi
Co-supervisor: Dr. Thameen Hejawi

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The names and signatures on the examining committee members are as follows:

1. Head of Committee: Prof. Dr. Jihad Abbadi Signature
2. Co-supervisor: Dr. Thameen Hejawi Signature
3. Internal Examiner: Prof. Dr. Foad Al Rimawi Signature
4. External Examiner: Dr. Mohammed Hmidat Signature

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Dedication

To my beloved mother, the warmth of my heart and source of strength, and to my father, who has always been my support and refuge, granting me a love unlike any other, and whose sincere prayers have been the light guiding my steps. To my dear husband, Emad Ahmed, my companion on this journey, whose patience and support have made this path possible. To my precious daughters, Maha and Hamsa, the pulse of my soul and the greatest gifts of my life. To my beloved sisters—Yasmin, Hamsa, and Shorouq—my pillars through all stages of life. And to my mother-in-law, my second mother, who gave me motherly love and a warm heart, I dedicate this thesis with all my gratitude and love.

And to the farmers, those who plant the seeds of life in the earth and sow hope in the face of hardships, you have my utmost respect and appreciation. You are the salt of the earth and the source of blessing and generosity.

Declaration

I certify that the thesis submitted for the degree of master is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not be submitted for a higher degree to any other university or institution.

Signed:

Sabreen Mohammad Odeh Ballout

Date: 16/08/2025

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Sabreen Mohammad Odeh Ballout August, 2025

Abstract

Olive oil, renowned for its nutritional, medicinal, and sensory properties, is a vital product in the Mediterranean region, particularly in Palestine. The quality of extra virgin olive oil (EVOO) is profoundly influenced by pre- and post-harvest factors, including harvesting techniques, storage conditions, and environmental variables specific to the region. This study investigates how these factors interact to affect the chemical and nutritional properties of Extracted olive oil, focusing on three representative Palestinian olive-producing areas: Idna, Kharas, and Yatta in the Hebron district. The research examines the impact of four harvesting methods -manual hand-picking, manual combing, mechanical harvesting using electric combs, and traditional stick-beating- and two types of post-harvest storage (ventilated boxes and non-ventilated plastic bags) over varying durations (0, 3, and 5 days) on key quality indicators of olive oil, including oil content, acidity, peroxide value, UV absorption (K_{232} and K_{270}), and total phenolic content.

The results show that harvesting methods significantly influence oil quality. Manual harvesting and the use of combs yielded oil with lower acidity, peroxide values, and UV absorption (K_{232} and K_{270}), alongside higher phenolic content—attributes associated with freshness, stability, and health benefits. In contrast, stick-beating and mechanical harvesting methods, which cause more physical damage to the olives, led to increased oxidative degradation reflected in higher acidity, peroxide, K_{232}, and K_{270}, resulting in reduced oil quality. These trends were consistent across all locations, confirming that harvesting practices that preserve fruit integrity help minimize enzymatic oxidation and preserve valuable bioactive compounds.

Post-harvest storage conditions also played a critical role in determining oil quality. Prolonged storage, especially in non-ventilated plastic bags, led to significant increases in acidity, peroxide values, and UV absorption (K_{232} and K_{232}), while decreasing phenolic content. Conversely, olives stored in ventilated boxes exhibited less oxidative deterioration, especially when storage duration did not exceed three days. These findings reinforce the need for prompt processing and the use of suitable containers to minimize the biochemical changes that degrade oil quality.

All tested oils met the international EVOO standards for acidity and peroxide value and K_{232} and K_{232} values. Moreover, elevated phenolic content is considered a positive indicator of oil quality due to its role in enhancing oxidative stability and offering greater health benefits, which emphasizes the importance of proper harvesting and storage techniques.

Regional variations among Idna, Kharas, and Yatta also had a notable effect. Olives from Yatta consistently exhibited higher oil yield and phenolic content, suggesting favorable environmental conditions such as altitude, soil type, and microclimate. Meanwhile, Kharas olives showed lower oil content but also maintained relatively low acidity. These regional differences underscore the importance of considering local environmental and cultivar-specific factors in optimizing harvesting and post-harvest practices.

This study highlights the crucial role of harvesting techniques and storage conditions of olive fruits in determining the quality of olive oil, with implications for both producers and consumers. By optimizing harvesting practices, minimizing olive fruits storage durations, and considering regional factors, the olive oil industry can significantly enhance its product quality. The findings provide valuable insights for improving industry standards and offer a foundation for further research aimed at maximizing the health benefits and market value of olive oil globally.

Importantly, the research demonstrates that no single factor operates in isolation; rather, olive oil quality is the result of a complex interaction among harvesting methods, storage conditions, and environmental variables. Traditional harvesting methods such as stick-beating were associated with reduced oil quality, as indicated by higher acidity, peroxide values, K_{232} and K_{232} values, and phenolic content. Likewise, inappropriate olive fruits storage—particularly for extended periods in plastic bags—accelerated oxidative reactions that compromise both sensory and nutritional attributes of the oil. On the other hand, shorter olive fruits storage durations and ventilated containers helped maintain oil integrity, preserving key health-related compounds and overall quality.

Moreover, regional agroecological conditions were shown to influence oil characteristics, emphasizing the need for region-specific best practices. Variations in soil, climate, and olive cultivar significantly contributed to differences in oil yield and composition. This reinforces the importance of tailoring olive oil production strategies to local contexts.

Ultimately, maintaining high-quality olive oil requires an integrated approach that addresses every stage of production. Such an approach is particularly crucial in traditional farming systems like those in Palestine, where low-input agricultural practices and limited mechanization are common.

Keywords: Olive oil, Harvesting techniques, Storage methods, Quality control, Chemical composition.

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List of Abbreviations

Abbreviation	Full Term
EVOO	Extra Virgin Olive Oil
MUFA	Monounsaturated Fatty Acids
PUFA	Polyunsaturated Fatty Acids
IOC	International Olive Council
K232	UV Absorption Index at 232 nm
K270	UV Absorption Index at 270 nm
PEF	Pulsed Electric Fields
HPUS	High Power Ultrasound
TPC	Total Phenolic Content
CVDs	Cardiovascular Diseases
FA	Fatty Acids
RH	Relative Humidity
PDO	Protected Designation of Origin
RDI	Regulated Deficit Irrigation
SDI	Sustained Deficit Irrigation
ISO	International Organization for Standardization
AOAC	Association of Official Analytical Chemists
SAS	Statistical Analysis System

`Chapter One:

Introduction

1.1 General Introduction

Olive oil, derived from the olive tree (*Olea europaea*), is globally esteemed for its exceptional nutritional, sensory, and medicinal attributes (Jimenez-Lopez et al., 2020; Fernandes et al., 2018; Jiménez-Sánchez et al., 2022). It holds a unique place in culinary traditions (Dancausa-Millán et al., 2022) and Mediterranean landscapes (Dancausa Millán et al., 2023). With over 750 million olive trees worldwide, 95% of which thrive in the Mediterranean, olive oil production forms a cornerstone of agricultural economies and cultural identities (United Nations; IOC, 2001).

The Middle East, including Palestine, plays a pivotal role in the history and cultivation of olives, as domestication began in this region over 6,500 years ago (Barazani et al., 2023; Galili et al., 1997; Langgut and Garfinkel, 2022; Langgut et al., 2019). Traditional rain-fed olive orchards in Palestine predominantly grow the Improved Nabali variety (Barazani et al., 2014; Lavee et al., 2008). These systems, characterized by low-density plantings, Mountain Orchards, minimal agrochemical use, and reliance on manual harvesting methods, face challenges such as low productivity and high labor costs (Beaufoy et al., 1994; Duarte et al., 2008; Sola-Guirado et al., 2014). Such practices, coupled with extended delays between harvest and milling, often compromise fruit and oil quality (Vossen, 2007).

Olive oil is more than a culinary ingredient; it is a superior dietary fat recognized for its balanced composition of saturated, monounsaturated (MUFA), and polyunsaturated fatty acids (PUFA), as well as its minor bioactive components like sterols, chlorophyll, polyphenols, and tocopherols (Cercaci et al., 2007; Lazzez et al., 2008). These components not only enhance the oil's nutritional value but also contribute to its stability and health benefits, including the prevention of cardiovascular diseases and degenerative conditions (Fedeli and Testolin, 1991; Hill and Giacosa, 1991; Martin-Moreno et al., 1994; Roche et al., 2000; Visioli & Galli, 2002).

Extra virgin olive oil (EVOO), the highest grade, must meet strict organoleptic and chemical criteria, such as free fatty Acids below 0.8% and a peroxide value under 20 milliequivalent O2 per kg oil (IOC, 2003). Its quality and characteristics vary based on cultivar, fruit maturity, cultivation practices, and extraction methods (Lopez-Feria et al., 2008; Koprivnjak et al., 2009). Sensory traits like color, aroma, and taste further define olive oil grades, reflecting its unique composition and the growing consumer preference for less processed foods (Gutiérrez and Fernández, 2002; Salvador et al., 1999).

The quality of virgin olive oil depends on triglycerides (over 98%) and minor components, including antioxidants, pigments, and sterols, which are influenced by factors such as species, climate, harvesting methods, and storage conditions (Canabate-Diaz et al., 2007). These factors impact not only the oil's stability and sensory appeal but also its nutritional properties, enhancing its market value and health benefits (Ibanez et al., 2002). However, only about half of the global olive oil production meets the EVOO standards due to suboptimal practices (Bongartz and Oberg, 2011).

The properties of olive oil, particularly its health-promoting components and favorable fat profile, are intricately influenced by well-coordinated harvesting and storage practices (Demirag & Konuskan, 2021). Empirical evidence has substantiated that judiciously timed harvesting coupled with appropriate storage conditions significantly bolsters the health benefits and market value of extra virgin olive oil (Dwaik, 2016). The distinct olive varieties and agricultural frameworks present in Hebron serve as a pertinent model for the application of these strategies (Sharkawi, 2019).

Harvesting methods significantly affect oil quality. Manual techniques, including handpicking, preserve fruit integrity, minimizing bruising and oxidative damage (Hill and Giacosa, 1991). Mechanical methods, although efficient for large-scale production, may cause damage to the fruit, leading to enzymatic and oxidative processes that degrade oil quality (Martin-Moreno et al., 1994; Roche et al., 2000). Traditional harvesting in Palestinian orchards involves long poles or sticks, often leading to delays in milling and affecting oil quality (Sola-Guirado et al., 2014; Vossen, 2007).

Post-harvest storage plays a critical role in shaping olive oil quality. Prolonged storage before milling can trigger biochemical reactions such as lipid oxidation , enzymatic activity and microbial growth, altering the oil's sensory and chemical properties (Vacca et al., 2006; Selvaggini et al., 2014). The choice of storage containers further impacts oil composition, with materials influencing acidity, peroxide values, and antioxidant content (Caponio et al., 2005; Guillaume et al., 2000). Optimal storage conditions, including temperature and duration control, are essential to preserve fruit quality and oil integrity (Kalua et al., 2007). To address logistical challenges in processing large quantities of fruit, cold storage has been explored as a method to maintain fruit quality. Studies suggest that storage conditions can modify bitterness and polyphenol content, affecting oil characteristics (Plasquy et al., 2021). However, inadequate storage practices during transportation or prolonged fruit storage before milling can lead to quality deterioration, including rancidity and loss of health-beneficial compounds (Manna et al., 1997; Velasco and Dobarganes, 2002).

The quality and sensory characteristics of extra virgin olive oil are directly related to the integrity of the harvested olives and the conditions under which the oil is extracted, harvesting at high temperatures and bulk transportation can negatively affect the quality of the olives and lead to undesirable changes in the extracted oil (Plasquy et al., 2021).

The environment also plays a key role. Variations in climate can significantly affect how much oil we can produce and its quality (Mafrica et al., 2021). Higher temperatures, especially during the ripening stage, can alter the oil's healthy fats and stability (Kaniewski et al., 2023). To tackle these challenges, farmers may need to adjust their irrigation methods and the timing of harvests (Taha & Khalifa, 2024).

New technologies like pulsed electric fields and high-power ultrasound are changing how olive oil is processed, helping with efficiency and the preservation of important compounds (Navarro et al., 2022). However, these improvements depend heavily on the quality of the olives used; if they're damaged or overly ripe, it could limit the benefits (Nardella et al., 2021).

Though not always highlighted, how we fertilize and water the trees plays a big role in oil quality and yield. Too much nitrogen can harm beneficial substances in the olives (Zipori et al., 2023). To achieve both good production and better oil quality, it's crucial to align nutrient management with postharvest practices (Conde-Innamorato et al., 2022). Additionally, combining traditional methods with scientific advances can help strengthen Palestinian olive farming (Salim, 2022).

Managing how we store the oil after harvesting is just as important. Studies have shown that temperature, light exposure, and the material used for packaging can significantly impact the quality of the oil (Plasquy et al., 2021). Keeping the oil at around 20°C can slow down degradation, while higher temperatures can speed up harmful processes (Caipo et al., 2021). Additional risks to olive integrity arise from traditional harvesting methods, which may involve dragging nets along the ground or stepping on fallen fruit. The storage of harvested olives might also be postponed for several days to accumulate an adequate quantity for processing (Famiani et al., 2020). Although traditional orchards can yield premium quality extra virgin olive oil, suboptimal handling during the processing stages—from harvesting through pressing—exerts a detrimental effect on the overall oil quality (Dag et al., 2024).

In the Hebron Governorate, producing olive oil is more than just farming; it's a whole system shaped by factors like the environment, technology, and the economy (Sharkawi, 2019). Although olive growing has deep roots, modern issues such as climate change and market competition make it crucial to understand how different farming practices impact both the quantity and quality of the oil produced (Salim, 2022). To achieve this effectively, we require a scientific approach that combines research with local farmers' existing knowledge (Qassis, 2024).

Therefore, This study takes a close look at how olives are harvested and stored in the Hebron Governorate, contributing to the larger conversation about olive oil production in the Mediterranean. It aims to uncover the best methods suited for local farming and environmental conditions. The goal is to offer helpful advice to farmers who want to improve the quality of their oil, reach more customers, and take better care of the land. The approach is systematic, recognizing that every step from managing the olive trees to handling the oil after harvest plays a role in determining both the quality of the oil and how well it sells.

1.2 Study Objectives:

This study evaluates the impact of harvesting methods (manual, comb, stick, and machine) and olive fruit storage practices (duration and container types) on the quality of virgin olive oil produced in traditional Palestinian orchards. Key parameters assessed include acidity, peroxide value, UV absorption indices (K_{232} and K_{270}), and polyphenol content. The research aims to identify practices that optimize oil quality, ensuring the production of premium-grade olive oil while supporting the economic sustainability of traditional olive cultivation.

Chapter Two:

Literature Review

2.1 Overview of Olive Oil Production in Mediterranean and Palestinian Contexts

The cultivation of olives is one of the oldest farming practices in the Mediterranean, stretching back over six thousand years to the Levant (Sharkawi, 2019). This tree has adapted wonderfully to dry and semi-arid areas, thriving in different landscapes and becoming essential for both food and trade. In Palestine, olive trees hold a deep meaning beyond just crops; they are part of the nation's heritage, local identity, and connection to the land (Qassis, 2024). This deep-rooted cultural importance shines through in yearly traditions like communal harvests, family oil pressing, and networks for sharing oil, which go beyond mere economic exchanges (Sharkawi, 2019).

In recent years, Palestinian olive oil production has faced significant hurdles due to climate shifts, land restrictions, and issues with infrastructure (Qassis, 2024). These challenges have led to changes in how much oil is produced and its quality, especially in places like the Hebron District, where access to water, storage, and modern processing might not be equal (Salim, 2022). Therefore, many production methods still depend on traditional techniques, with oil mainly extracted using local mills, whether mechanical or stone, often lacking standard quality checks (Sharkawi, 2019). This inconsistency impacts how the oil is categorized and its market value, which can limit opportunities for export.

Even with these difficulties, Palestinian olive oil is highly sought after in local and diaspora markets due to its unique taste and authenticity (Qassis, 2024). Oils from regions like Hebron, Nablus, and Jenin are known for their strong bitterness and sharpness, qualities linked to early harvesting and cultivation reliant on rainfall (Khatib et al., 2009). However, these traits might not match international grading standards that prefer oils with low acidity and balanced flavors, which puts Palestinian oils at a disadvantage when it comes to global certification (Salim, 2022).

To improve this situation, several cooperatives and NGOs are working to enhance production by creating systems for tracking quality, monitoring standards, and establishing fair trade or organic certification (Salim, 2022). These efforts strive to standardize practices while respecting cultural traditions and helping farmers tap into more lucrative export markets. However, the complete rollout of these initiatives is still limited due to knowledge gaps, financial challenges, and the need for research that fits the local conditions, including crop varieties, soil types, and climate changes (Qassis, 2024).

The way olive oil is produced in Palestine also shows how agriculture and adaptation to the environment can vary across regions. For example, the climate diversity in the Hebron area affects how trees are cared for, such as how often they are pruned and how much fertilizer they are given. These factors alter oil production and phenolic content in different ways (Zipori et al., 2023). Traditional ecological knowledge of farmers is also crucial to maintaining the characteristics of local varieties and ensuring stable oil quality even with changing weather (Kaniewski et al., 2023).

Foreign customer preferences are also increasingly influencing domestic production targets. According to marketing research, global demand often focuses on chemical purity, low acidity, and traceable production methods. On the other hand, Palestinian oils are traditionally valued for their strong flavor and artisanal quality (Qassis, 2024). To bridge this gap, small farmers who want to sell their produce outside their local markets must make strategic post-harvest changes and follow certification rules (Saleem, 2022).

Recent research has shown that the interval between harvest and milling is important in influencing oil quality. Delays in processing, often caused by the lack of modern mills in some locations, have been shown to raise free Fatty Acids levels and degrade antioxidant components (Snouber, 2016). These chemical changes are directly linked to the loss of sensory properties, which means that investment in a decentralized and modern infrastructure may be necessary to maintain high product quality and increase the company's competitiveness (Kaibo et al., 2021).

Meanwhile, research in different parts of the world continues to investigate how choosing the right variety affects agriculture. Evidence suggests that local Palestinian varieties, such as Nabali Baladi, react differently to the same agronomic treatments than imported varieties, especially in cases of adverse weather conditions, such as heat waves or irregular irrigation (Radwan et al., 2022). This reinforces the importance of providing local agricultural recommendations that consider genetic diversity and environmental resilience when setting best practice standards (Grillo et al., 2021).

In many rural areas, promoting knowledge among local consumers remains a lower priority. However, educating local buyers about oil quality indicators and how to use them properly can bring about changes in the supply chain. Researchers have found that more knowledgeable consumers are more likely to pay more for better oils. This gives farmers reasons to improve how they harvest and store their crops (Minley, 2014). This demonstrates the importance of having integrated policy frameworks that help improve quality on both the supply and demand sides (Qassis, 2024).

Finally, more and more people are realizing that moving toward climate-smart agriculture is a vital step for long-term adaptation. Controlled irrigation management, coordination of tree canopy structure, and the use of organic plants are among the methods that have proven effective in reducing environmental stress on trees, increasing production stability, and improving the quality of chemicals used in oils (Siako et al., 2021).

2.2 Harvesting Methods and Timing

The timing of the olive harvest plays a big role in how much oil we get and its quality. As olives grow, they go through changes in moisture, enzyme activity, and the creation of beneficial compounds that impact the final oil's characteristics (Farayeh et al., 2017).

When olives are picked early, while they are still green or yellow green, we may get less oil, but it tends to have more antioxidants and better resistance to spoilage because of the higher phenolic content (Flamminii et al., 2021). These early oils often taste more bitter and pungent, which reflects the higher levels of certain compounds like hydroxytyrosol and oleuropein that are present during early ripening (Dwaik, 2016).

Fruit weight, maturity index, and oil content increased with the progress of harvest date, while color, moisture content and total phenolics decreased at the last harvest date (Şen & Esen, 2021).

On the flip side, when olives are harvested at later stages—after they turn purple or black—the oil yield generally increases. However, this is often accompanied by lower levels of beneficial polyphenols and a simpler flavor profile (Radwan et al., 2022). With fewer antioxidants, the shelf life of the oil decreases, and its nutritional value may decline, making it more difficult to meet the criteria for extra virgin classification (Farayeh et al., 2017). Additionally, as olives ripen, linoleic acid content tends to rise, partially due to the enzymatic conversion of oleic acid via oleate desaturase. Although oleic acid typically increases during the early to mid-stages of ripening, it may decline slightly at advanced ripening stages. This shift in free fatty acid composition can reduce the oxidative stability of the oil (Flamminii et al., 2021).

Oils made from early-harvest Nabali Baladi olives contain much more hydroxytyrosol and have a better balance of oleic and linoleic acids compared to those from later-harvested olives (Radwan et al., 2022). This indicates that finding the best times to harvest is essential, balancing market needs for oil quantity with quality indicators. The struggle between getting more oil and keeping healthy compounds is especially important for small farmers, who may delay their harvest to get that extra volume (Dwaik, 2016).

How we harvest the olives also matters for keeping the fruit in good condition and reducing the chances of oxidation before we process them. Hand-harvesting, despite being more work, typically causes less damage to the fruit and keeps enzymatic reactions slower compared to mechanical methods like shaking branches (Farayeh et al., 2017). In Palestinian areas, hand-picking is still common, especially in hilly or uneven land, but challenges like staffing issues and logistics can extend the harvesting period. This may lead to over-ripening and physical damage to some olives (Radwan et al., 2022). These factors can influence the acidity and peroxide levels of the oil, sometimes exceeding international quality standards if processing is delayed (Flamminii et al., 2021).

Given how the stage of ripeness affects beneficial compounds, fatty acids, and flavor, it's vital to think about the timing in the broader planning of production. This is especially true when facing climate challenges, where temperature changes can unpredictably speed up or slow down how fruits mature (Dwaik, 2016). It is essential to understand how local varieties like Nabali and Souri respond in these situations to create effective harvest schedules that prioritize both yield and quality (Radwan et al., 2022).

Recent research indicates that the optimal timing of olive harvesting should consider not only the apparent ripeness of the fruit, but also the prevailing climatic conditions that influence the balance of chemical compounds within the fruit (Kaniewski et al., 2023). In areas such as the Hebron Governorate, it is observed that the variation in daytime and nighttime temperatures during the harvest season directly affects the levels of saturated and unsaturated fatty acids, which requires adjusting the harvest timing from year to year (Ben-Ari et al., 2021).

Locally grown varieties such as 'Nabali Baladi' and 'Suri' also show marked variation in their response to different harvest dates. While Nabali Baladi is best harvested at early maturity to obtain the highest concentration of hydroxytyrosol, Souri can maintain stable levels of antioxidants for a longer period (Radwan et al., 2022). This genetic variability imposes the need to develop customized harvesting schedules for each variety according to environmental conditions and soil type (Grilo et al., 2021).

Regarding harvesting methods, manual methods are more suitable for maintaining fruit quality in Palestinian contexts, especially in mountainous areas where mechanization is difficult (Qassis, 2024). However, the high cost of labor and the difficulty of securing it in a timely manner led to an extended harvest period, which increases the likelihood of the resulting oil being affected by high levels of peroxide or acidity (Flamminii et al., 2021).

Therefore, it is suggested to invest in lightweight and portable tools that can reduce harvesting time and limit mechanical damage without sacrificing fruit quality (Farayeh et al., 2017).

Palestinian studies have also shown that delaying the transfer of fruits to the press, even for just a few hours, increases enzymatic and oxidative activity, which accelerates the damage of oil cells within the fruit (Snouber, 2016). Therefore, advance planning of transportation and processing operations is crucial to maintain international oil quality standards (Caipo et al., 2021).

In the same context, agricultural extension programs still suffer from a lack of awareness among farmers about the precise relationship between harvest timing and method and international classification standards for olive oil, such as acidity and oxidative stability index (Meneley, 2014). Integrating these criteria into training programs will contribute to improving harvesting decisions at the farm level.

Mechanical damage index and acidity were lower in olive fruits harvested by branch shakers compared to those dropped down by stick (Şen & Esen, 2021).

Finally, some studies recommend the introduction of ripeness prediction techniques such as color analysis, moisture content measurement, and ripeness-related enzyme indices as effective tools for determining the optimal harvest date (Dwaik, 2016). Implementing these methods across agricultural communities in Hebron could make a significant difference in improving quality output and reducing waste.

2.3 Olive Storage Conditions

The conditions under which olives are stored represent a significant determinant of the chemical composition and sensory attributes of olive oil. Research indicates that when olives remain in plastic bags for over 48 hours post-harvest, the quality of the resultant oil deteriorates markedly. This degradation is primarily attributed to enhanced microbial activity and enzymatic degradation occurring within the fruit (Dag, 2024). Numerous studies have demonstrated that traditional orchards that can yield high-quality extra virgin olive oil (EVOO) frequently fail to satisfy quality benchmarks. This failure is predominantly linked to inadequate handling practices after harvest, especially during the storage phase (Barazani et al., 2023). The use of conventional methods, such as employing sticks to dislodge olives from branches and postponing the milling process, exacerbates fruit damage and heightens susceptibility to microbial spoilage, thereby adversely affecting oil quality (Vossen, 2007).

The advent of mechanical harvesting systems, particularly designed for super-intensive orchards, presents another dimension to the challenges associated with olive quality. While these systems facilitate rapid harvesting, they often inflict internal damage to the olives, resulting in accelerated quality deterioration unless swift processing is ensured or optimal storage conditions are maintained (Dag et al., 2008). Empirical evidence suggests that early harvesting and mechanical handling, when complemented by effective postharvest management strategies, can enhance oil quality and diminish losses related to storage (Camposeo et al., 2013). However, without stringent temperature regulation and minimal intervals between collection and processing, the advantages offered by mechanical systems are frequently undermined by subsequent oxidation and fermentation phenomena occurring in stored olives (Morales-Sillero & García, 2015). In stark contrast, olives harvested by hand, despite requiring more time for collection, often exhibit reduced bruising rates. This mechanical integrity contributes to diminished oxidation rates if the oil is processed expeditiously (Yousfi et al., 2012).

Evidence from a study conducted in Turkey indicates that olives harvested manually and processed within a 36-hour timeframe produce oil that retains its freshness for more extended periods, attributable to lowered oxidation rates and limited enzymatic activity (Aktas, 2019). Conversely, olives subjected to delayed processing-extending over several days-demonstrate elevated peroxide values alongside diminished sensory profiles (Olive Oil Times, 2020). Comparative experiments examining six harvesting methods corroborate that the duration between olive collection and milling correlates negatively with oxidation rates in the final oil product, establishing a clear expectation that expedited processing mitigates the risks associated with harmful microbial proliferation and rancidity (Aktas, 2019).

The Middle East, renowned as one of the most ancient olive-growing regions, contends with distinctive challenges in reconciling traditional practices with stringent quality control measures (Langgut & Garfinkel, 2022). Many small-scale producers experience limitations in accessing appropriate transportation and storage facilities, thereby necessitating the retention of harvested olives in local storage or under shaded conditions for several days.

Such practices lead to increased moisture retention and an elevated risk of fungal growth (Famiani et al., 2020). The dependency on familial labor and minimal mechanization prolongs the harvesting period, resulting in inconsistent collection profiles and extended on-farm storage durations (Serrano et al., 2012). These circumstances create a recursive problem whereby olives harvested earliest endure the longest delays before milling, culminating in the accumulation of defects that impair oil stability (García & Yousfi, 2006). In traditional olive production, the practice of gathering olives that have naturally fallen or have been dislodged during storm events often leads to the storage of these fruits for multiple days until sufficient volume is obtained for pressing (Barazani et al., 2023). However, the olives that have reached the ground are especially susceptible to sensorial and microbial contamination and fermentative processes; such prolonged storage further exacerbates oil acidity and peroxide concentrations (Vossen, 2007). While this method of collection may be driven by economic considerations, substantial data reveal that the resultant negative effects on oil quality significantly diminish the market value and consumer acceptance of the final product (Sola-Guirado et al., 2014). Consequently, enhancements in storage logistics, even within small-scale farms, represent a viable strategy to bolster profitability and improve product reputation (Langgut et al., 2019).

The utilization of modern intensive systems, characterized by the employment of automated shakers and over-the-row harvesters, has been identified as a mechanism for reducing labor expenses. However, these systems simultaneously introduce novel challenges related to storage management (Arbonés et al., 2014). Empirical evidence suggests that mechanically harvested olives, when stored in large aggregates or plastic bags lacking proper ventilation, are prone to rapid increases in temperature. Such conditions ultimately lead to quality deterioration that can prove difficult, if not impossible, to rectify (Morales-Sillero & García, 2015). The implementation of best practices, particularly rapid transportation, limited storage duration, and appropriate cooling measures, has been shown to result in significant improvements in the quality of extra virgin olive oil (EVOO), especially in cultivars that exhibit heightened sensitivity to bruising and mechanical stress (Dag et al., 2008; Camposeo et al., 2013).

In addition to these storage considerations, producers operating under semi-arid climates, such as those prevalent in Mediterranean regions, are faced with irrigation strategies that have profound impacts on fruit composition and storability (Arbonés et al., 2014). Specific irrigation techniques may lead to the production of fruit characterized by thinner skins or augmented water content, thereby increasing susceptibility to spoilage during storage. Research focusing on the interplay between irrigation and harvesting strategies has highlighted the necessity for integrated management approaches to optimize both fruit health and postharvest efficacy (Dag, 2024).

Moreover, the marketing environment imposes additional challenges on producers. Adherence to stringent quality standards required for products certified under PDO (Protected Designation of Origin) schemes necessitates careful postharvest handling, with criteria such as low acidity and elevated sensory scores being critical (Barazani et al., 2023). In the absence of investments in superior storage solutions and expedited processing, many producers encounter difficulties in meeting these certification standards, thereby restricting their access to premium markets and undermining the economic viability of their operations

(Langgut & Garfinkel, 2022). This scenario underscores the critical role of optimal storage conditions, not only in terms of technical quality but also in the long-term sustainability of producers within the industry (Famiani et al., 2020).

2.4 Oil Extraction Techniques and Processing Variables

The processing methods employed in the production of olive oil are critical determinants of the resultant quality, flavor profile, and associated health benefits. In numerous regions of Palestine, with a particular focus on the Hebron District, the conventional technique of cold pressing remains prevalent. This method is influenced by various factors, including the duration of processing, temperature control, and the extent of air incorporation, as articulated by (Sharkawi, 2019). Despite the cultural significance inherent in these traditional practices and their general cost-effectiveness, it has been observed that improper execution can lead to suboptimal oil quality and diminished retention of healthful properties, as noted (Salim, 2022). Thus, the balance between preserving cultural heritage and achieving optimal oil characteristics necessitates careful consideration.

On the other hand, new technologies in extraction are helping to boost oil yield and keep more beneficial ingredients intact. One innovation is called the pulsed electric field (PEF) method. It sends high-voltage pulses to break open the olive cells before mixing, which helps release more oil and keeps important health-promoting compounds like oleacein and oleocanthal (Navarro et al., 2022). Tests with this method have shown that more oil can come out when the mixing is done at lower temperatures, and minimal malaxation time along with better taste and antioxidant levels (Navarro et al., 2022).

Another promising technique is high-power ultrasound-assisted extraction (HPU). This method uses sound waves to make olive paste less thick and break down cells during mixing. It helps to get more beneficial compounds out while keeping low peroxide levels and increasing tocopherols, all without needing high heat (Nardella et al., 2021). However, both HPU and PEF methods require a good amount of money and expertise, which can be a challenge in places like Hebron, where older mills are more common and upgrades are limited (Salim, 2022).

Mixing the olive paste, known as malaxation, is vital in all extraction processes. How long and at what temperature this happens, plus how much air is involved, can change the yield and quality of the oil. If the mixing takes too long or the temperature rises above 27°C, it might make the oil droplets join, but it can also lead to oxidation and loss of fresh aromas (Navarro et al., 2022). Managing air exposure is also important; too much can speed up the breakdown of healthy compounds and affect how the oil tastes (Nardella et al., 2021).

In many mills in Palestine, mixing conditions aren’t always well-regulated because of outdated tools or a lack of monitoring systems (Sharkawi, 2019). This inconsistency can lead to different results in each batch, making it hard to meet international standards for extra virgin oil. Additionally, not being able to control the speed of the decanter or having inefficient separation techniques can further reduce quality during processing (Salim, 2022).

Research indicates that the way oil is extracted also plays a role in how well pigments like chlorophylls and carotenoids are kept. These pigments can affect the color and health properties of the oil. For instance, oils made using the PEF method often have more green pigments because of the careful temperature management and quicker processing time, making them look better and healthier (Navarro et al., 2022). Likewise, oils made with ultrasound retain more tocopherols and sterols, which help with stability and longevity (Nardella et al., 2021).

Even with the advantages of modern extraction methods for improving both yield and oil quality, they aren't widely adopted in Hebron due to challenges related to costs, logistics, and knowledge. Many producers depend on cooperative or family-operated mills that often focus on quantity and speed during busy harvest times, which can mean less careful monitoring of the process (Sharkawi, 2019). Overcoming these challenges would need tailored training programs, financial help for upgrading equipment, and expert assistance that fits the needs of smaller producers (Salim, 2022).

The quality of the oil extracted from the press depends largely on the raw materials used in it. For example, humidity, soil type, and fruit condition affect how the paste reacts to mechanical extraction processes (Demirag & Konuskan, 2021). Studies have shown that olives stressed by heat or water shortage during the season produce lower quality oil in terms of taste and aroma (Siakou et al., 2021).

The quality of the oil is also affected by how the olive fruits stored before pressing. If the olive fruits is stored for a longer period without refrigeration, it becomes more acidic and accelerates the auto-oxidation process, which impairs the final classification of the oil (Plasquy et al., 2021). According to scientific research, the period between olive picking and pressing should be less than 24 hours to preserve its phenolic content and make the product safer for microbes (Caipo et al., 2021).

It is important to control the centrifugal speed during the separation process to ensure less moisture and stability of the final product. Studies have shown that using different speeds based on dough density is better than using the same speed all the time (Zipori et al., 2023). However, many of the older presses in Hebron lack these modern technical features, meaning that the quality of the oil may vary even during the same growing season (Sharkawi, 2019).

Researchers have also shown that using adjuvants such as talcum powder or natural enzymes during squeezing speeds up the extraction process, especially when the paste is sticky or contains a lot of water (García-Garví et al., 2022). However, these additives must be carefully monitored, as excessive use may alter the sensory properties of the oil or affect standard quality indicators (Grilo et al., 2021).

Scientific studies also show that using methods such as pressure filtration or vacuum centrifugation to clean the oil after separation may help reduce the number of fine particles and water, extend shelf life, and not alter the flavor (Mavrika et al., 2021). There is still controversy about whether this step reduces the phenolic content, which needs further research in the context of the local Palestinian situation (Kanievsky et al., 2023).

One of the things that indirectly affects the quality of the final product is the level of familiarity of workers with the technologies on the production lines. Due to lack of training, people often make mistakes during manual processing, including stirring the dough too much or not cleaning the machines between cycles. This changes the chemical stability of the oil and its sensory properties (Saleem, 2022). Therefore, adding vocational training modules to agricultural cooperatives in Hebron could be a major step forward in ensuring that they meet international standards and are of high quality (Navarro et al., 2022).

2.5 Environmental and Climatic Influences

The development of olive trees and the composition of olive oil are significantly influenced by environmental factors such as temperature, precipitation, and elevation. Moderate winter temperatures are necessary for the induction of flowering, while stable weather conditions in spring facilitate pollination and fruit set. Research indicates that optimal production of olive oil corresponds with annual mean temperatures of approximately 16.9°C and annual precipitation nearing 575 mm, conditions that bolster both yield and oil quality (Kaniewski et al., 2023). However, when temperatures exceed this optimal limit, essential physiological processes, including flowering, fertilization, and oil biosynthesis, are adversely affected. This disruption frequently results in diminished fruit set and modified oil profiles (Ben-Ari et al., 2021).

Such climatic alterations not only diminish productivity but also negatively impact oil composition. For example, increased temperatures during the growing season correlate with reduced levels of oleic acid and polyphenols, both of which are crucial for maintaining oxidative stability and nutritional quality (Ben-Ari et al., 2021). Conversely, heat stress is associated with heightened concentrations of linoleic acid, which decreases shelf life and compromises the oil's resistance to degradation (Mafrica et al., 2021).

Elevation also emerges as a vital factor influencing the characteristics of olive oil. In higher-altitude locations, cooler temperatures can prolong the ripening period and encourage the accumulation of oleic acid, resulting in oils that exhibit a more advantageous fatty acid profile (Mafrica et al., 2021). These elevated conditions contribute to the preservation of tocopherols, carotenoids, and total phenol compounds linked to health benefits and antioxidant properties. In contrast, olive oils produced in lower-altitude orchards, which are subjected to more intense heat, generally experience quicker ripening, a reduction in oleic acid content, and decreased phenolic retention (Ben-Ari et al., 2021).

Drought conditions further exacerbate challenges associated with oil production, as diminished rainfall and extended dry periods negatively affect both vegetative growth and fruit development. Under drought stress, olive trees often reallocate resources from oil accumulation to survival, consequently reducing yield and altering the proportions of volatile and phenolic compounds within the oil (Kaniewski et al., 2023). where olive cultivation is primarily reliant on rainwater and exists with limited irrigation infrastructure. In these contexts, even slight variations in rainfall during critical developmental phases-such as flowering and oil biosynthesis, yield substantial effects on both oil volume and quality (Ben-Ari et al., 2021).

Moreover, climate variability contributes to inconsistencies in oil characteristics from year to year. Such variability poses complications for market positioning, quality control, and adherence to international grading standards, especially for producers who depend on traditional cultivation practices devoid of climate monitoring tools (Mafrica et al., 2021). As climate projections suggest ongoing warming trends and decreased precipitation throughout the eastern Mediterranean, the long-term sustainability of traditional olive cultivars in their existing geographical locations faces increasing uncertainty (Kaniewski et al., 2023).

The outcomes of this research indicate a pressing need for the development of strategies tailored to specific regional conditions, with a focus on regions such as Hebron. Suggested interventions may encompass the adoption of heat-tolerant olive cultivars and alterations to harvesting schedules aimed at aligning with modified ripening patterns. Additionally, the application of effective irrigation techniques is recommended to maintain consistency in yield and quality. Moreover, the implementation of systematic monitoring of climate indicators, along with an analysis of their relationship with production decisions, has the potential to enable smallholder farmers to reduce risks and remain competitive in markets that prioritize quality.

Studies of the environment show that olive oil quality indicators change a lot from one season to the next in agricultural areas where the climate changes a lot. This is because the temperature and humidity levels change a lot while the fruit is growing (Mafrica et al., 2021). This change in climate lowers the number of polyphenols, which makes the oil less resistant to oxidation. This hurts the oil's commercial classification in worldwide markets (Ben-Ari et al., 2021).

Dry winds during the flowering time can also make pollination less effective, especially in agricultural settings that don't get enough water. This can lead to less fruit set, which means less fruit and oil supply each year (Kaniewski et al., 2023). Climate models show that these events are likely to get worse as the world gets warmer. This means that farmers need to use climate prediction tools and link them to when they plant and harvest (Ben-Ari et al., 2021).

Scientific research shows that the difference in temperature between day and night has a direct effect on how olives grow. Low temperatures at night cause oleic acid to build up, whereas high temperatures during the day cause linoleic acid to build up. This could change the oil's taste and nutritional value (Mafrica et al., 2021). So, choosing planting places that keep a strong thermal contrast will help the oil's fatty acid balance (Kaniewski et al., 2023).

On the other side, not enough rain during important times like flowering and cell fixation has a bigger effect on oil quality dependent on the soil and the type of variety planted. Water stress affects local types like Nabali Baladi. It lowers the number of phenolic compounds and makes antioxidant chemicals less efficient (Ben-Ari et al., 2021). This means that we need to use strategies that make plants more resistant to drought and change the dates of harvests based on the weather in each season.

Some studies suggest that planting olive trees alongside other drought-resistant crops can help keep the soil moist and lower evaporation rates, which is good for the environment in the long term (Kaniewski et al., 2023). Permanent plants between trees can also help keep soil surface temperatures stable and shield roots from heat stress. This makes oil quality better during very hot or very cold seasons (Mafrica et al., 2021).

According to agroclimatic studies, one of the most important things we can do to deal with the effects of climate change is to understand how periods of active olive growth and annual rainfall are related to each other (Ben-Ari et al., 2021). When droughts happen at the same time as flowering or fruit-filling, the plants don't take in as many nutrients, which makes the oil's chemical makeup bad (Kaniewski et al., 2023). This is especially true in places with big seasonal changes, like the highlands of the southern West Bank, where production records suggest that quality dropped significantly during years when hydrological patterns changed suddenly.

From an environmental point of view, periods of very hot weather with very low humidity speed up the breakdown of volatile compounds and natural essential oils. This makes the oil taste less unique and makes it less popular in export markets (Mafrica et al., 2021). The timing of spring also changes the flowering time, which means that flowering and pollinating insects are not always present at the same time. This is very important for rainfed agriculture (Kaniewski et al., 2023).

The quality of the soil and the way it is spread out across the land also have a big effect on how much stress trees can handle from the environment. Clay soils are less likely to dry out than light, sandy soils. This causes moisture to leave quickly, which affects oil production and acidity (Ben-Ari et al., 2021). Steep hills also make soil erosion more likely, especially when it rains heavily. This makes the topsoil less fertile and makes output less stable.

Recent suggestions include using bio-coverage methods, windbreaks, and planting hedgerows in olive groves to lessen the direct effects of hot winds and heavy rains (Kaniewski et al., 2023). Drip irrigation systems with moisture sensors make better use of water and cut down on waste in locations with limited resources (Mafrica et al., 2021).

Olive oils of good quality (free acidity, fatty acid composition, antioxidant components and oxidative stability were obtained in the site with lower temperatures and higher rainfall (Mafrica et al., 2021).

2.6 Irrigation and Fertilization Practices

The factors influencing water availability and nutrient management hold substantial significance in the agronomy of olive oil, where their interplay directly affects both the quantity and quality of the product. In Mediterranean regions, such as Palestine, the predominant reliance on rainfed cultivation of olive trees renders these trees susceptible to drought stress, which adversely impacts fruit development and oil biosynthesis. To address water scarcity, regulated deficit irrigation (RDI) and sustained deficit irrigation (SDI) have been employed; these strategies aim to optimize water usage by applying limited irrigation during critical phenological stages while maintaining yield levels (Siakou et al., 2021).

Field trials involving the ‘Koroneiki’ cultivar have demonstrated that the implementation of RDI can preserve oil production levels while significantly enhancing the total phenolic content, which, in turn, contributes positively to the nutritional and oxidative stability of the oil (Siakou et al., 2021). Similarly, the use of SDI in Spain's super-high-density plantations has yielded comparable outcomes. Oils extracted under these water-efficient regimes have exhibited increased concentrations of oleic acid, alongside a heightened intensity of green aroma volatiles such as trans-2-hexenal. These improvements directly correlate with enhanced shelf life and consumer acceptance (García-Garví et al., 2022).

Moreover, under conditions of water stress, significant enrichment of phenolic compounds, including oleracea and oleuropein aglycone, has been observed, suggesting that moderate drought conditions may promote the accumulation of secondary metabolites that are advantageous for oil quality (García-Garví et al., 2022).

Research conducted in sandy soils of Egypt provides further confirmation of the advantages associated with optimized irrigation practices. Trials focusing on the Cortina cultivar revealed that an irrigation reduction to 80% of the evapotranspiration demand can sustain high oil yields and content, all the while improving water productivity and minimizing energy inputs (Taha & Khalifa, 2024). The same investigation highlighted that excessive irrigation, often practiced by commercial growers, results in elevated costs and compromised oil quality due to the dilution of phenolic and volatile compounds (Taha & Khalifa, 2024). Such findings carry significant implications for water-scarce regions, like Hebron, where the efficiency of resource utilization is of utmost importance.

In addition to water management, nutrient management-particularly about nitrogen (N), phosphorus (P), and potassium (K), is critical in determining the composition of olive oil. Long-term field studies have indicated that excessive nitrogen application may lead to diminished phenolic content and adverse alterations in the fatty acid profile, including a reduction in oleic acid and an increase in linoleic acid, consequently reducing oxidative stability (Zipori et al., 2023). In these trials, oils derived from high-nitrogen-treated trees exhibited increased free fatty acid, potentially disqualifying them from extra virgin status (Zipori et al., 2023). These observations emphasize the necessity of calibrated nitrogen management, informed by leaf nutrient analysis and anticipated crop load.

Conversely, phosphorus was observed to have minimal impact on oil composition throughout the duration of the study, contingent upon the maintenance of minimum soil levels (Zipori et al., 2023). Likewise, potassium deficiency did not present a significant limitation under Mediterranean climatic circumstances, as soil reserves and established fertilization practices effectively maintained leaf potassium levels within optimal thresholds (Zipori et al., 2023). These findings suggest that while a balanced supply of macronutrients is essential for overall tree health, nitrogen remains the predominant element influencing oil chemistry in intensive cultivation systems. Additional evidence gathered from high-density plantations reinforces the notion of cultivar-specific responses to fertilization .

Field studies in mountainous areas where olives are grown show that irrigation timing can affect the chemical balance of the extracted oil. Irrigation during the later stages of fruit ripening can reduce levels of volatile chemicals that give fruits their taste and aroma (Siako et al., 2021). So, improving irrigation schedules not only improves water use, but also improves the taste and aroma of the oil.

Experimental results from Nablus and Hebron fields show that growing plants in water-limited areas, using soil moisture assessment techniques and plant water stress indices, made the oil more stable when exposed to oxygen (Taha and Khalifa, 2024). This effect results from the accumulation of more phenolic compounds when water is scarce, reducing the likelihood of oil spoilage.

Experiments have shown that using organic fertilizer and animal waste in controlled amounts can help improve soil structure and provide more micronutrients such as boron and zinc. This is beneficial for photosynthesis and fruit development (Zipori et al., 2023). These results support the move towards eliminating chemical fertilizers and adopting environmentally friendly agricultural methods.

Studies conducted on Spanish farms have shown that excessive nitrogen application in the early stages of growth accelerates leaf growth and reduces flower production, which affects the amount of fruit formed and reduces oil production (Zipori et al., 2023). This demonstrates the importance of selecting the right amount of nitrogen fertilizer to achieve the desired vegetative and reproductive growth.

Studies on the Nabali variety have shown that adding micronutrients, especially iron and manganese, to the leaves in mid-season increases the amount of chlorophyll in them. This improves photosynthesis and facilitates oil extraction (García-Garví et al., 2022).

Soil tests and leaf analysis can help you determine how to adjust fertilizer inputs to suit the weather. This data-driven method helps reduce the adverse effects of over-application of fertilizers and ensures that production meets international quality requirements (Siakou et al., 2021).

2.7 Olive Oil Storage and Post-Extraction Handling

The stability of olive oil following extraction is significantly influenced by various storage conditions, which subsequently affect oxidation rates, sensory properties, and the preservation of health-promoting compounds. Among the primary determinants are temperature, light exposure, oxygen availability, and the type of container utilized for storage. Empirical studies have demonstrated that elevated temperatures can accelerate the degradation of phenolic compounds, augment peroxide values, and promote rancidity (Caipo et al., 2021). For instance, controlled experiments indicated that storing Arbequina extra virgin olive oil at a temperature of 40°C led to considerable reductions in hydroxytyrosol, tocopherols, and carotenoids within six months, with these losses surpassing acceptable free acidity and oxidative stability thresholds (Caipo et al., 2021). In addition to temperature, light exposure represents another critical factor contributing to oxidative deterioration .

Research has shown that oils stored at ambient temperatures under direct light exhibit more rapid declines in antioxidant activity, accompanied by elevated levels of oxidation products, including hexanal and trans-2-nonenal, which contribute to sensory defects (Caipo et al., 2021). The presence of these volatile compounds can adversely affect consumer perceptions, thereby impacting oil classification. Consequently, the utilization of light-protective containers and the implementation of dark storage environments emerge as essential practices for maintaining product quality. Furthermore, fluorescence spectroscopy has emerged as a valuable tool for identifying chemical changes correlating with suboptimal storage conditions. One study revealed that reduced fluorescence intensity at specific wavelengths during the analysis of oils subjected to prolonged storage indicated the degradation of pigments, such as chlorophyll and carotenoids, as well as reductions in tocopherol levels (Snouber, 2016).

These indicative markers serve as early warning signs of quality degradation, enabling producers to monitor product stability throughout its shelf life. Oils that experienced extended exposure to heat and oxygen demonstrated marked deviations from the expected spectral profiles characteristic of fresh, high-quality olive oil (Snouber, 2016). In addition to fluorescence techniques, non-invasive optical methods have proven effective in evaluating pigment degradation and identifying adulteration. The analysis of oils sourced from diverse regions in the West Bank through UV-Vis and photoluminescence spectroscopy revealed distinct profiles of chlorophyll and carotenoids, which altered significantly under oxidative storage conditions (Musa, 2024). Notably, these changes were found to be correlated with increased K232 and K270 absorbance values, thereby confirming that spectral data can reliably indicate compositional modifications resulting from heat, oxygen, and light exposure (Musa, 2024).

This approach offers a viable quality control mechanism for small-scale producers who may lack access to advanced chemical laboratory facilities. Additionally, the effects of storage conditions on peroxide values and fatty acid composition warrant consideration. Even oils that initially adhere to extra virgin standards may experience elevated peroxide levels within several months of improper storage, surpassing International Olive Council (IOC) thresholds (Caipo et al., 2021). Long-term evaluations utilizing fluorescence-based methodologies revealed that oxidized oils exhibited diminished chlorophyll fluorescence alongside increased signals corresponding to secondary oxidation products (Guzmán et al., 2015).

The type of container employed for storage also significantly influences post-extraction quality. Transparency in plastic or glass bottles that lack UV protection facilitates light penetration, while improperly sealed metal containers may permit oxygen ingress. Both scenarios contribute to swift oxidative deterioration. Sound storage practices advocate the use of dark glass or stainless-steel containers maintained at temperatures between 15-20°C in sealed, light-free conditions to preserve both sensory attributes and chemical integrity (Caipo et al., 2021). However, in rural Palestinian contexts, adherence to these optimal storage conditions is often challenged by limited financial resources, infrastructural deficiencies, and unreliable electricity supply.

Olive Oil Storage conditions are critical factors affecting the quality of extra virgin olive oil, especially under local Palestinian conditions where oil is consumed and stored for long periods. Palestinian households commonly use high-density polyethylene (HDPE) containers for oil storage at home, alongside dark glass bottles and traditional pottery, which is still used in some areas. Studies have shown that dark glass containers offer better protection against oxidation compared to plastic and pottery containers, preserving the chemical and sensory properties of the oil for longer periods (Saramah & Stiban, 2020). On the other hand, HDPE containers are more permeable to oxygen and light, which accelerates oxidation and deteriorates oil quality. Another study indicated that glass and PET containers better reduce the loss of important phenolic compounds that contribute to the oil's health benefits, while pottery containers were the least effective in this regard (Abbadi et al., 2014). These findings highlight the importance of selecting suitable packaging types and proper storage conditions to maintain olive oil quality, especially considering Palestinian societal habits that require long-term oil storage.

Producers located in Hebron are increasingly recognizing that the improvement of methods for post-extraction handling serves as a strategically advantageous approach to augmenting the quality of oil. Empirical evidence suggests that the regulation of temperature and control of light exposure during the oil storage phase, independent of alterations to harvesting or processing methodologies, can significantly prolong the shelf life of the product and ensure adherence to export regulations. In this framework, the execution of educational campaigns and the collaborative investment in appropriate storage infrastructures are proposed as measures to reduce losses post-extraction, while concurrently enhancing consumer satisfaction across both local and international markets.

2.8 Impact of Olive Fruit Fly Infestation

The olive fruit fly*(Bactrocera oleae*) is the most dangerous insect pest that affects olive trees in the Mediterranean region, including Palestine (Hamdan & Al-Qurna, 2017).
Olive fruit fly infestation is one of the factors affecting olive oil quality. The larvae feed on the olive pulp, leading to a reduction in oil content and an increase in acidity and peroxide levels, which negatively impacts the quality of the product. In addition, the exit holes created by the fly facilitate the entry of oxygen and microorganisms into the fruit, accelerating oxidation and hydrolytic degradation processes (Qrinawi, 2023).
The activity of the olive fruit fly is influenced by climatic changes, particularly temperature and humidity. These factors are crucial in determining the onset of flight activity, which increases at moderate temperatures (20–25°C) and decreases significantly during cold conditions or periods of rainfall (Hamdan & Al-Qurna, 2017).

2.9 Summary and Comparison of Previous Studies

Table 2.1.a : It presents a summary of a collection of studies related to olive oil, detailing the title and authors of each study, its objective, results, and how it relates to the current study

#	Study Title and Authors	Objective	Results	Relevance to Current Study
1	Dag, 2024 :Factors that Affect the Quality of Olive Oil Produced Using Olives from Traditional Orchards in the Middle East	To evaluate the actual and potential quality of olive oil from traditional orchards and identify harmful practices in the production chain.	Traditional farming practices negatively affect olive oil quality. Using stick beating for harvesting increases fruit injury and mold, reduces polyphenol content, and raises free fatty acid levels compared to manual picking. Additionally, storing the fruit in plastic bags for more than 48 hours after harvest significantly deteriorates the oil quality.	This study agrees with mine that traditional harvesting, especially stick-beating, increases fruit damage, raises acidity, and reduces antioxidants in the oil, thereby lowering its quality. It also confirms that storing olives in plastic bags for extended periods accelerates oil deterioration, while storing them in ventilated boxes preserves its quality—findings that my study supports with a deeper analysis of different harvesting methods.

Table 2.2.b : It presents a summary of a collection of studies related to olive oil, detailing the title and authors of each study, its objective, results, and how it relates to the current study

#	Study Title and Authors	Objective	Results	Relevance to Current Study
3	Taha & Khalifa, 2024: Productivity of olive oil (Coratina variety) in response to irrigation treatments in sandy soil	To evaluate the effect of five irrigation treatments (120%, 100%, 80%, 60% of reference crop evapotranspiration, and farmer practice) on water consumption, olive fruit and oil production, fruit quality, water use efficiency, energy consumption, and farm income in drip-irrigated olive orchards grown in sandy soil.	The amounts of water used varied among the treatments, with the highest fruit and oil yields and quality recorded under the 120% ETo treatment. Local crop coefficients were calculated at 0.75, and the crop yield response factor at 0.83. It was also shown that olive oil production from Coratina variety trees in sandy soil is possible using 80% or 60% of ETo water without significant losses in yield.	In my study, it was observed that areas with higher irrigation volumes produced lower oil percentages, which aligns with the findings of the Coratina study that showed reducing irrigation to 80% or 60% of crop water requirements can improve oil yield compared to excessive irrigation.
4	Plasquy et al., 2021: Cold Storage and Temperature Management of Olive Fruit: The Impact on Fruit Physiology and Olive Oil Quality—A Review	To provide a comprehensive review of research on cold storage of olive fruits, and to evaluate the impact of post-harvest temperatures on the physiological response of the fruits and the quality of the extracted oil.	Studies indicate that storing olive fruits at low temperatures significantly affects the physiological response of the fruits and the quality of the extracted oil. Proper management of fruit temperature throughout the postharvest stages up to the oil extraction process is essential to maintain and improve oil quality.	This study aligns with the focus of my research, which examines the impact of harvesting methods, types of containers, and storage duration on the quality of olive fruits. The study emphasizes the importance of controlling fruit temperature after harvest, which supports my understanding of how storage conditions affect maintaining and improving oil quality.

Chapter Three:

Materials and Methods

Three aspects were studied during the current study: the effect of general orchard management; the effect of the harvesting method; and the effect of fruit storage practices.

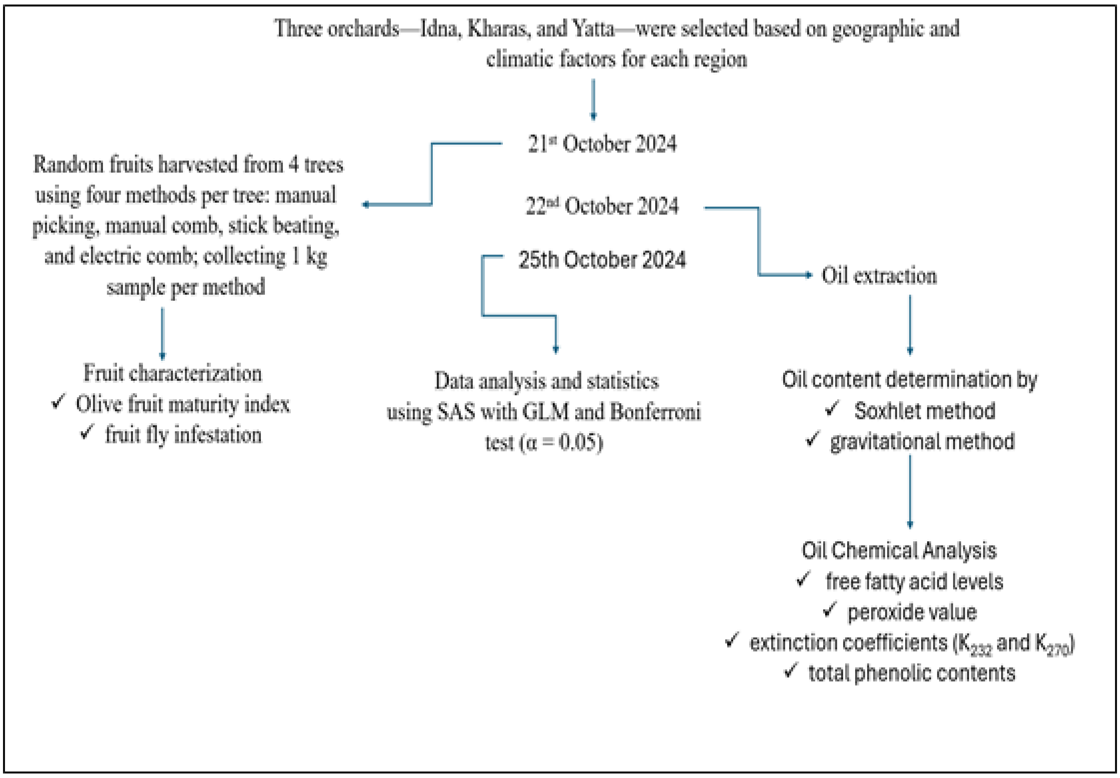

Figure 3.1: Experimental Plan for Evaluating the Effect of Harvesting Methods on Olive Oil Quality

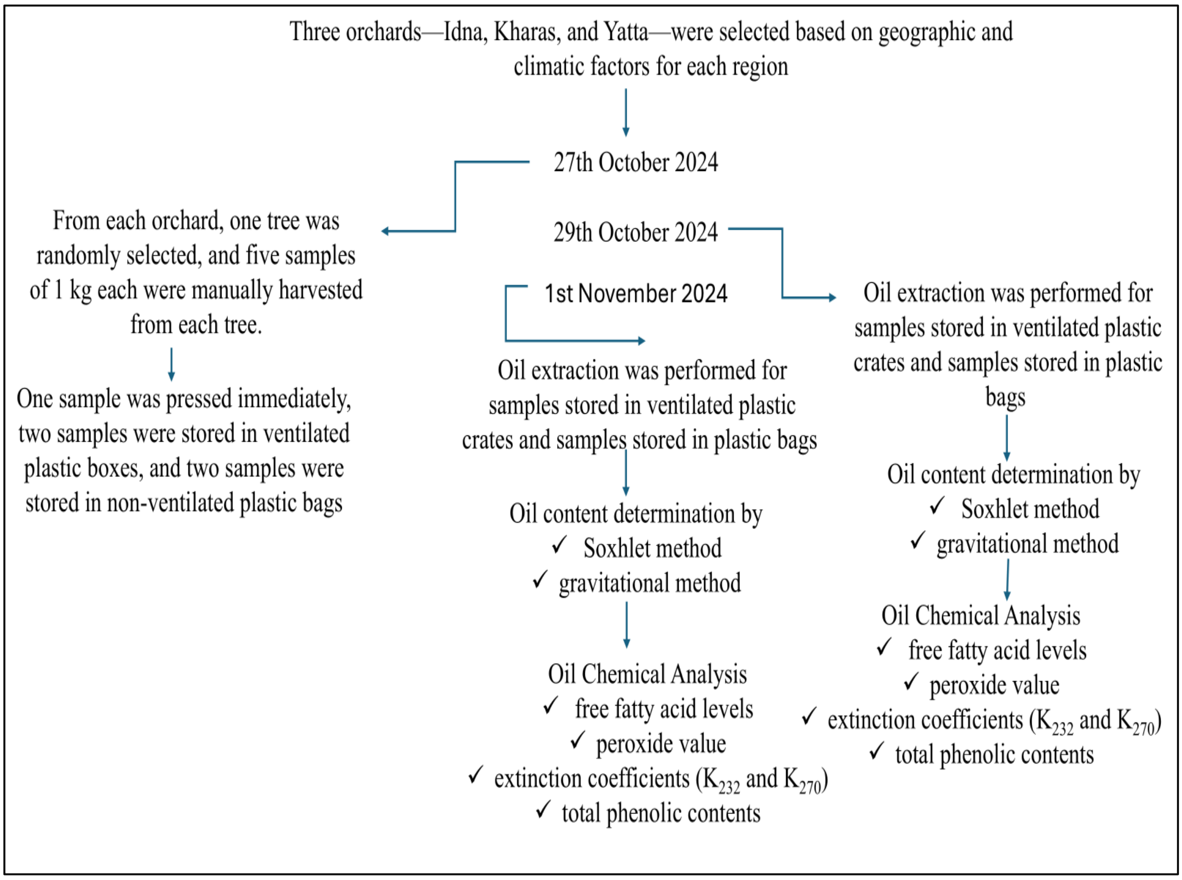

Figure 3.2: Experimental Plan for Evaluating the Effect of Storage Methods on Olive Oil Quality

3.1 Orchard locations and characteristics

Three representative, traditional rain-fed olive orchards of different ages were selected in the southern part of the West Bank – Palestine, during the summer of 2024. The orchard locations were chosen based on diverse geographical and climatic conditions to ensure the inclusion of varying environmental factors. Specifically, orchards were selected from Yatta in the east, Idna in the west, and Kharas in the north of Hebron district. This geographic distribution allowed for covering clear differences in altitude, rainfall, average temperature, and soil type, which enhances the representativeness and reliability of the study results.

In each orchard, four fruit-bearing trees (replicates) with medium to high yields were selected. All trees belonged to the local olive cultivar Nabali Baladi, one of the most common and traditional varieties in the region. The morphological, geographical, and climatic characteristics of each orchard were recorded, including location, altitude, annual rainfall, average temperature, soil type, trunk diameter, and tree age, as presented in Table 3.1. The orchards' altitudes ranged from 422 to 753 meters above sea level. In all locations, the soil type was brown Rendzina with medium to heavy texture, and annual temperatures ranged from 18°C to 19.2°C.

Table 3.1 :Olive trees orchards location, altitude, annual rainfall, average temperature, soil type, trees morphological characteristics (stalk width), and tree age

Location	Altitude M	Annual Rainfall mm	Temperature rate **°C**	Soil type	Tree Stalk Width Up (cm)	Tree Stalk Width Middle (cm)	Tree Stalk Width Down (cm)	Tree Age (years)
Kharas	493	432	18.2	Brown Rendzina	9.5	10.5	14	4
Idna	422	403	19.2	Brown Rendzina	25	28	30	25
Yatta	753	459	18	Brown Rendzina	22	25	27	20

A flexible measuring tape was used to measure the trunk circumference of the tree at three different points: the upper part near the beginning of the trunk where the branches diverge, the middle section between the upper and lower parts, and the lower part near the base of the trunk close to the ground. The trunk circumference represents the distance around the trunk, and this measurement allows for assessing the trunk size and identifying growth differences between the different measurement points on the same tree. This distribution aims to evaluate longitudinal variations in trunk size and ensure accuracy and comprehensiveness of the data, as illustrated in (Fig. 3.3).

Figure 3.3: Measurement of Tree Stalk Width Middle (cm)

3.2 Fruit sampling

3.2.1 Effect of the Harvest Method

In three selected orchards, simultaneous with the grower's harvest between mid- October and mid-November, four harvest methods were tested using four trees (replicates). Harvesting methods include: manual picking, using manual comb, using stick; the traditional harvest method, i.e., beating the canopy with a stick to detach the fruit and collecting them on nets extended on the ground; and the use of electric combs or machines (Pellenc, Pertuis, France) to detach the fruit and collect them on nets extended on the ground. In each orchard, a 1-kg subsample of olives was taken from each tree and for each harvest method, reaching four samples per orchard. All harvest methods were tested using the same tree. First, a 1-kg representative sample was hand-picked. Then, the manual comb was used for some branches, then the electric machine was used for other canopies, the stick-beating method was applied for some branches until enough fruits were available for the 1-kg sample required for each harvesting method.

(a) Manual Picking

(b) Harvesting by Manual comb

(C) Harvesting by Stick

(d) Harvesting by Electric Combs

Figure 3.4: Harvesting methods include: manual picking, using manual comb, using stick and the use of electric combs or machines

Figure 3.5: Sample weighing process

Figure 3.6: Samples with a weight of 1 kg

3.2.2 Effect of Fruit Storage

In three of the previously mentioned orchards, I hand-picked 5 kilograms of olives from the same tree in each orchard, then divided this amount into five equal groups, with each group containing 1 kilogram of olives. These groups were stored using two types of containers: ventilated 20-kilogram boxes and non-ventilated 20-kilogram plastic bags, simulating common practices among some growers. Two storage durations were tested for each container type, three days and five days, in addition to a fresh sample that was pressed directly from the same tree without any storage as a control.

Figure 3.7: Samples storage process

3.3 Fruit characterization

1. Olive Fruit Maturity index

I randomly selected a sample of 100 olive fruits from each study site to accurately evaluate fruit maturity. The maturity level was determined based on the color of the fruit pulp, which changes from green to black as ripening progresses.

I classified the fruits on a scale from 0 to 10, where 0 represents completely unripe fruits with light green color, and 10 represents fully ripe fruits with completely black color. For each fruit, I recorded the appropriate maturity score based on pulp color. Then, I calculated the maturity index for each sample using the following formula: multiplying the number of fruits at each maturity score by the score value, summing these results, and dividing by the total number of fruits (100), yielding an average value that quantitatively reflects the sample's maturity level.

2. Fruit Fly Infestation

Using the same sample of 100 olive fruits from each site, I examined each fruit to determine the level of infestation by fruit flies, based on visible signs such as holes or external damage. I rated the infestation level on a scale from 0 to 10, where 0 indicates no infestation and 10 indicates severe and obvious infestation. For each fruit, I recorded the infestation score according to the severity of damage.
The infestation index was calculated similarly to the maturity index: by multiplying the number of fruits at each infestation score by the score value, summing these values, and dividing by the total number of fruits to obtain an average representing the infestation level in the sample. The following fruit parameters of a subsample of 100 fruit were measured: fruit maturity index and fruit fly infestation. Both indexes were measured using a scale of 0 to 10, with 0 indicating no maturity or infestation and 10 indicating heavy maturity or infestation.

3.4 Laboratory oil extraction and oil content determination

Laboratory oil extraction of all olive samples was conducted using a laboratory scale olive mill (Abencor; mc2 Ingenieriay Sistemas, Seville, Spain). After extraction, the oil was filtered using filtering paper. A subsample from the olive paste was taken to determine oil content using Soxhlet method and water contents using gravitational method.

(a) Olive crushing process

(b) Olive paste malaxation process

(c) Centrifugal separation process

(d) Oil filling process

Figure 3.8: The stages of the olive oil extraction process are as follows: crushing, malaxation, centrifugal separation, and bottling.

3.5 Oil Chemical Analysis

An olive oil sample representing commercial harvesting and oil extraction processes was collected from the olive mill at each orchard. This sample was filtered and analyzed alongside samples obtained from laboratory extraction. Chemical analyses were performed to assess oil quality indicators, including acidity (free fatty acid levels), peroxide value, extinction coefficients (K_{232} and K_{270}), and total phenolic contents.
Acidity in olive oil, which reflects the concentration of free fatty acids. To determine the acidity level of the oil samples, the procedure was based on the AOAC official method 940.28, in accordance with ISO 660 standards. Approximately 7 grams of the oil sample were placed in a clean, dry 250 mL Erlenmeyer flask. A volume of 50 mL of 96% ethanol was first neutralized using 0.1 N sodium hydroxide (NaOH) solution in the presence of 2

mL of phenolphthalein indicator until a faint pink color appeared and remained. The neutralized ethanol was then added to the oil sample in the flask, and the mixture was shaken thoroughly. The flask was gently heated on a hot plate for about two minutes. Finally, the mixture was titrated with 0.1 N NaOH until a persistent faint pink color was observed for at least one minute. The acidity was then calculated and expressed as a percentage of oleic acid.

Peroxide value, which reflects the primary oxidation state of fats and oils, was determined according to AOAC official method 965.33 and aligned with ISO 3960. Approximately 5 grams of the oil sample were accurately weighed into a 250 mL glass-stoppered conical flask. To dissolve the oil completely, 30 mL of a glacial acetic acid–chloroform solution (3:1 v/v) were added with gentle swirling. Then, 1 mL of a saturated potassium iodide solution was added. The flask was immediately stoppered and allowed to stand in the dark for one minute with occasional shaking to prevent iodine volatilization.

After that, 30 mL of freshly boiled and cooled distilled water were added, and the mixture was titrated with 0.01 N sodium thiosulfate solution while shaking vigorously. When the yellow color had nearly disappeared, 0.5 mL of starch indicator solution was added. The titration was continued with constant shaking until the blue color just disappeared, indicating the end point.

Ultraviolet light absorption indices (K_{232} and K_{270}) were determined following the International Olive Council (IOC) method (IOOC COI/T20/Doc. No. 19/Rev.1, 2001). Materials used included cyclohexane and a UV-Vis spectrophotometer. A 1% solution of the oil sample was prepared by dissolving 0.25 g of oil in 25 mL of cyclohexane at room temperature (approximately 27°C). The absorbance of this solution was measured at wavelengths of 232 nm and 270 nm using a UV-Vis spectrophotometer with a 1 cm path length cuvette.

The total phenolic content was determined spectrophotometrically using the Folin–Ciocalteu reagent. Materials used included Folin–Ciocalteu reagent, distilled water, sodium bicarbonate, gallic acid, and a UV-Vis spectrophotometer. A 100 µL aliquot of the oil extract was mixed with 1.8 mL of tenfold diluted Folin–Ciocalteu reagent and left for 5 minutes. Then, 1.2 mL of 7.5% sodium bicarbonate solution was added. The mixture was allowed to stand for 60 minutes, after which absorbance was measured at 735 or 765 nm, depending on the protocol used, against a distilled water blank. Calibration was carried out using gallic acid solutions ranging from 100 to 500 ppm. Phenolic compounds were extracted from oil dissolved in hexane by double extraction with methanol–water (60:40, v/v). Results were expressed as gallic acid equivalents (mg GAE/kg oil) or tyrosol equivalents (mg/kg oil).

3.6 Data analysis and statistics

All statistical analyses were carried out using SAS (SA Institute Inc., Cary, USA, Release 8.02, 2001). Comparisons of means between different treatments (harvesting techniques or storage conditions (containers and duration) were carried out using the GLM procedure considering a fully randomized design. With multiple t-test, the Bonferoni procedure was employed in order to maintain an experiment-wise α of 5%

Chapter Four:

Results and Discussion

4.1 EFFECT OF THE HARVEST METHOD

4.1.1 Fruit maturity index

The fruit maturity index Fig.(4.1) showed csistency across the various harvesting methods but differed among orchard locations. Kharas recorded the highest maturity index at 3.8, whereas Yatta had the lowest at 1.2. The maturity index for the other locations followed an ascending trend: Yatta < Idna < Kharas.

The variation in fruit maturity index across different locations indicates the influence of local environmental and climatic factors on the growth and development of the olives. This aligns with studies on the impact of climatic conditions and irrigation practices on oil quality and fruit composition (Siakou et al., 2021). For example, in irrigated areas, it is possible to control the ripening stages to enhance oil quality and increase the concentration of beneficial phenolic compounds. This suggests that variations in irrigation practices or water availability among locations may directly or indirectly affect the maturity index.

Moreover, (Taha & Khalifa, 2024) confirm that irrigation management in sandy soils affects fruit development and productivity, supporting the idea that differences in soil characteristics and climatic conditions among these locations contribute to variation in fruit ripening stages. Additionally, fertilization practices—especially the regulation of nitrogen levels—can influence fruit growth and ripening rates. As (Zipori et al., 2023) noted, excessive fertilization can alter oil composition and thereby impact the apparent ripeness of the fruit.

In higher-altitude locations, cooler temperatures can prolong the ripening period, resulting in a lower maturity index at harvest time (Mafrica et al., 2021). This aligns with the case of Yatta, which may experience more moderate temperatures compared to lower-altitude locations like Kharas, leading to delayed fruit development and hence a lower ripening index at harvest.

Therefore, the variation in fruit maturity index between locations can be attributed to the complex interaction of irrigation, soil type, elevation, climate, and agricultural practices. This is consistent with what has been stated in the literature regarding the impact of these factors on final crop quality.

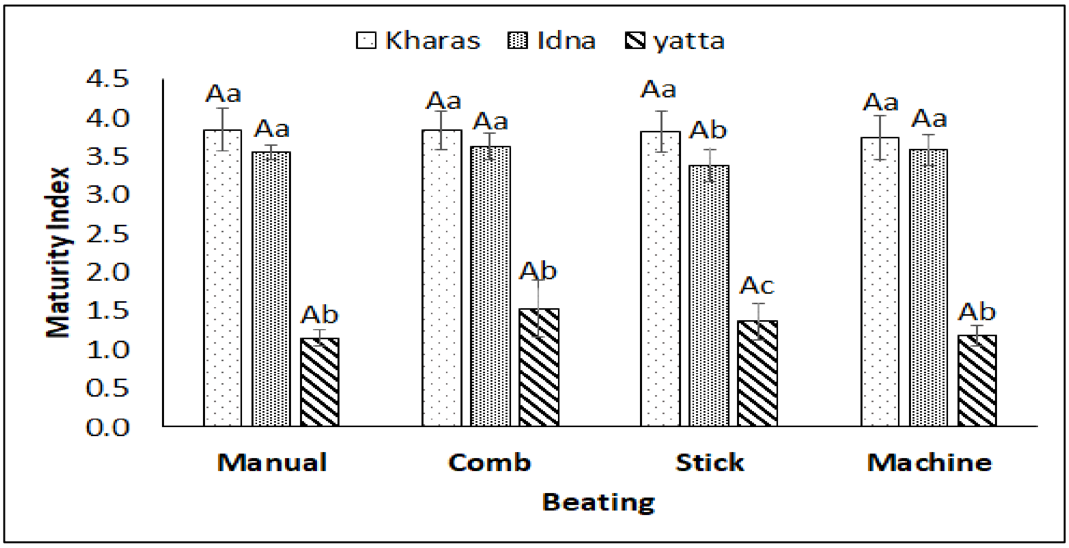

Figure 4.1: Maturity index of olive fruits collected from different Palestinian locations (Kharas, Idna, and Yatta).

As affected by different harvesting methods (manual picking by hand, picking using manual comb, picking using wooden stick, and picking using electric harvesting machine) before pressing. For a given location and different harvesting treatment, means followed by the same capital letter are not significantly different, means of the same treatment within locations followed by the same small letter are not significantly different. $P < 0.05$, $n=4$.

4.1.2 Olive Fly Infestation

Olive fruit infestation by the olive fly Fig.(4.2) showed no significant differences among samples from various locations or between different harvesting methods within the same orchard. However, samples collected from Yatta using the machine exhibited a higher percentage of olive fly infestation compared to other locations.

These results are consistent with previous studies, as the higher infestation rate in Yatta during mechanical harvesting can be explained by the increased exposure of the fruits to damage or wounds caused by mechanical handling, which facilitates the entry of the insect (Qrinawi, 2023).

The high infestation rate in Yatta aligns with the literature regarding the impact of e**nvironmental and activity factors on the olive fruit fly's behavior and spread. Climatic conditions such as temperature and humidity significantly affect the fly's activity, which increases at moderate temperatures (20–25°C) and decreases during cold weather or rainfall (Hamdan & Al-Qurna, 2017).

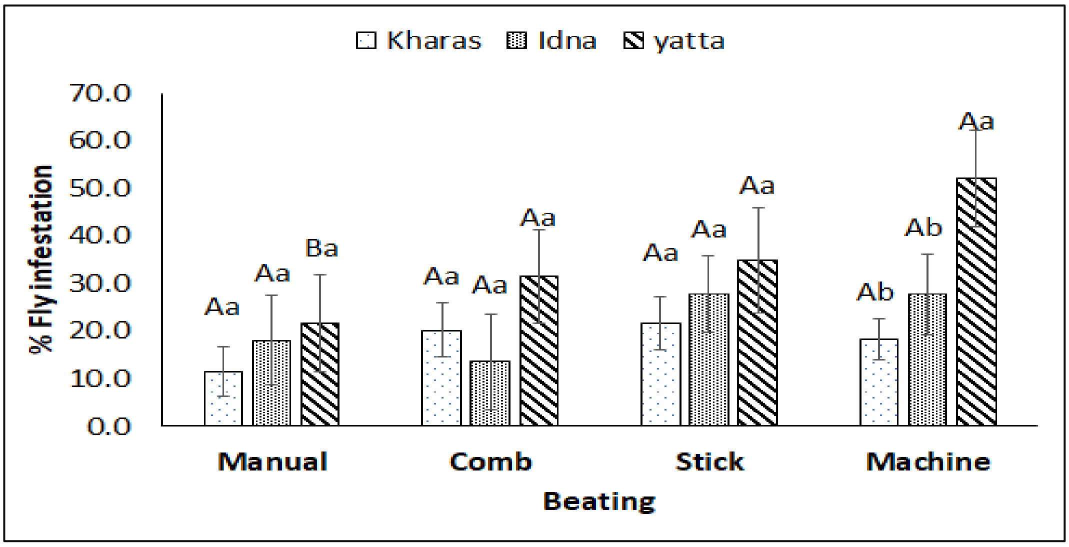

Figure 4.2: Olive fruits fly infestation (%) in fruits collected from different Palestinian locations (Kharas, Idna, Yatta)

As affected by different harvesting methods (manual picking by hand, picking using manual comb, picking using wooden stick, and picking using electric harvesting machine) before pressing. For a given location and different harvesting treatment, means followed by the same capital letter are not significantly different, means of the same treatment within locations followed by the same small letter are not significantly different. $P< 0.05$, $n=4$.

4.1.3 Oil Content (%)

Oil content in olive fruits was determined using two methods. The first method (Method A) involved pressing olive fruits with a laboratory pressing machine Fig .(4.3) and calculating the oil content as mg oil per 100g of olive fruits based on the oil weight obtained from the fruit weight processed. The second method (Method B) measured oil content (mg oil per 100g of olive paste) by extracting oil from paste samples using an organic solvent with the Soxhlet apparatus Fig. (4.4). In both extraction methods, oil contents were interpreted as percentage.

In Method A, oil content remained consistent within the same orchard across different harvesting methods. Olives from Yatta yielded significantly higher oil content compared to those from Kharas and Idna, with the latter two locations showing statistically similar oil content values.

Similarly, in Method B, oil content measured from paste samples using the Soxhlet extraction method remained stable within the same orchard across different harvesting methods. Consistent with the results from the pressing method, Yatta olives exhibited significantly higher oil content compared to Kharas and Idna, where no statistical difference was observed between the two locations.

This variation in oil content between locations can be explained by multiple environmental and climatic factors, as temperature, rainfall levels, and elevation above sea level directly affect photosynthesis processes and oil accumulation in the fruit. Studies have shown that optimal environmental conditions for high-quality olive oil production correspond to an annual mean temperature of approximately 16.9°C and annual rainfall near 575 mm—conditions that enhance both yield and oil quality (Kaniewski et al., 2023; Ben-Ari et al., 2021).

Furthermore, the relatively higher elevation of Yatta may contribute to a slower fruit ripening process and greater accumulation of oleic acid, resulting in oils with higher content and better quality (Mafrica et al., 2021).

In addition, the limited irrigation practices in dry areas such as Yatta may lead to increased accumulation of secondary metabolites such as phenolic compounds, which are directly associated with oil quality and higher oil content (Siakou et al., 2021).

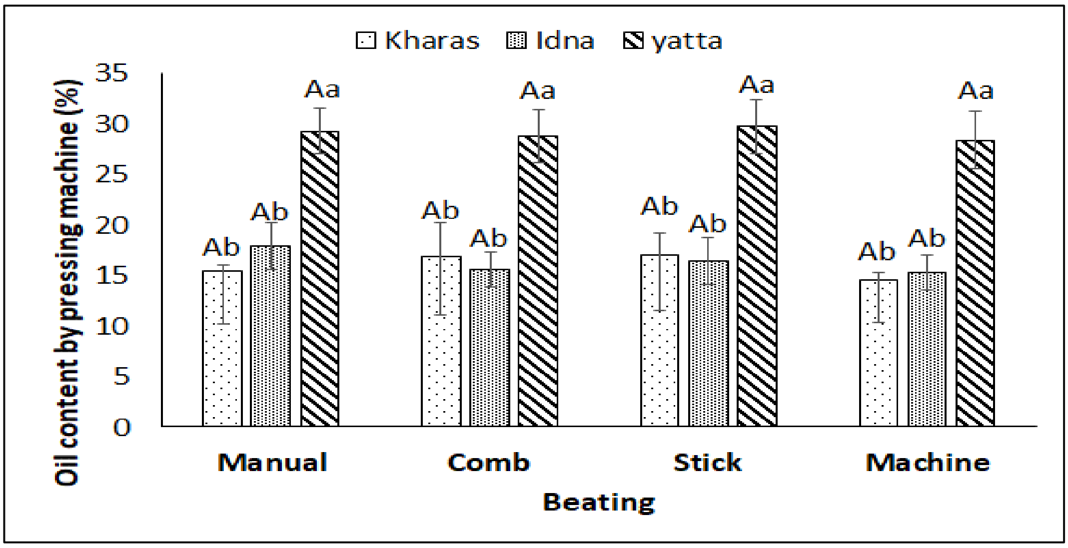

Figure 4.3: Olive oil content by laboratory pressing machine (%) in fruits collected from different Palestinian locations (Kharas, Idna, and Yatta).

As affected by different harvesting methods (manual picking by hand, picking using manual comb, picking using wooden stick, and picking using electric harvesting machine) before pressing. For a given location and different harvesting treatment, means followed by the same capital letter are not significantly different, means of the same treatment within locations followed by the same small letter are not significantly different. $P < 0.05$, n=4.

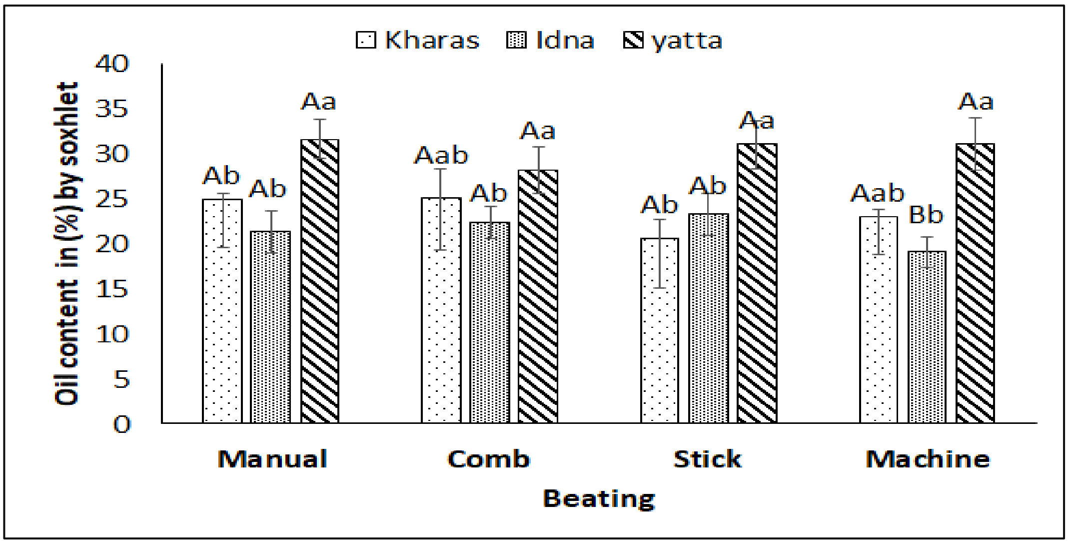

Figure 4.4: Olive oil content (%) using Soxhlet method in fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

Aas affected by different harvesting methods (manual picking by hand, picking using manual comb, picking using wooden stick, and picking using electric harvesting machine) before pressing. For a given location and different harvesting treatment, means followed by the same capital letter are not significantly different, means of the same treatment within locations followed by the same small letter are not significantly different. $P < 0.05$, $n=4$.

4.1.4 Water content

Olives harvested using different methods within the same location showed similar water content. Water content in Kharas and Idna remained comparable across all harvesting methods, while olives from Yatta consistently exhibited significantly lower water content across all methods.

The lower water content observed in olive fruits from Yatta, compared to Kharas and Idna, can be explained by several environmental and climatic factors that directly influence moisture loss and water balance in the fruits. According to (Ben-Ari et al., 2021), regions exposed to higher temperatures and lower relative humidity are more prone to water loss through evaporation and transpiration, leading to reduced moisture content in the fruits.

Yatta is also characterized by a relatively higher elevation and a drier environment, which enhances moisture loss compared to the other locations. Previous studies have confirmed that arid climatic conditions, such as those in parts of the southern West Bank, contribute to faster ripening and greater water loss from the fruits (Kaniewski et al., 2023; Mafrica et al., 2021).

Moreover, the absence of irrigation in Yatta increases the trees' exposure to water stress, resulting in reduced fruit water content due to limited water availability during critical growth stages (Siakou et al., 2021). This factor also contributes to a higher concentration of oil, due to the decrease in water proportion.

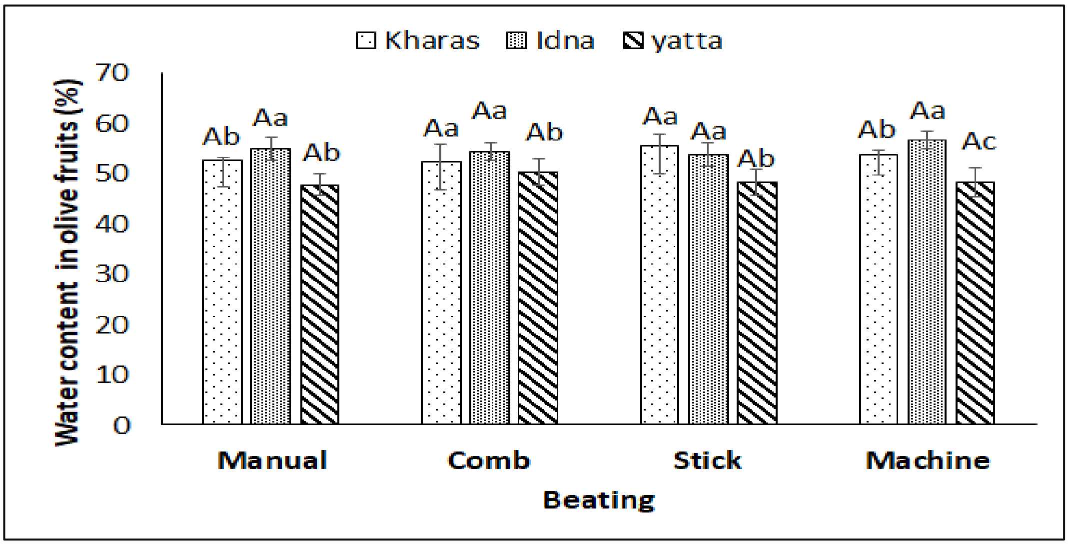

Figure 4.5: Water content (%) in fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different harvesting methods (manual picking by hand, picking using manual comb, picking using wooden stick, and picking using electric harvesting machine) before pressing. For a given location and different harvesting treatment, means followed by the same capital letter are not significantly different, means of the same treatment within locations followed by the same small letter are not significantly different. $P< 0.05$, $n=4$.

4.1.5 Acidity

Acidity, measured as the percentage of free fatty acids expressed as oleic acid, is a key indicator of olive oil quality. A significant finding Fig .(4.6) was that the traditional method of striking branches with a stick resulted in the highest acidity levels across all locations. Similarly, olives harvested using the machine also produced oil with significantly higher acidity compared to the manual and comb methods, though slightly lower than the stick method and statistically similar to it. The lowest acidity was observed in oil from Idna, harvested either manually or with the comb, which was significantly lower than the acidity of oils from Kharas and Yatta. The latter two locations showed statistically similar acidity levels when harvested manually or with the comb. Despite these variations, all locations and harvesting techniques yielded oils that met the extra virgin quality standard (<0.8% oleic acid).

These results are consistent with what the literature has reported regarding the impact of mechanical damage caused by harvesting methods on oil quality. Practices that cause mechanical injuries, such as shaking branches or using mechanical harvesters, can lead to increased enzymatic activity and the breakdown of free fatty acids, thereby raising the acidity level (Farayeh et al., 2017).

This result is consistent with the findings of (Şen and Esen ,2021), whose study showed that the mechanical damage index and acidity were lower in olive fruits harvested using branch shakers compared to those dropped by stick

The differences between locations—such as the lower acidity observed in oil from Idna compared to Kharas and Yatta—can be explained by environmental and climatic factors that influence the composition of fatty acids in olives. Studies have shown that climatic conditions, including high temperatures and water stress, negatively affect the chemical stability of the oil and tend to increase acidity levels (Ben-Ari et al., 2021; Mafrica et al., 2021; Siakou et al., 2021).

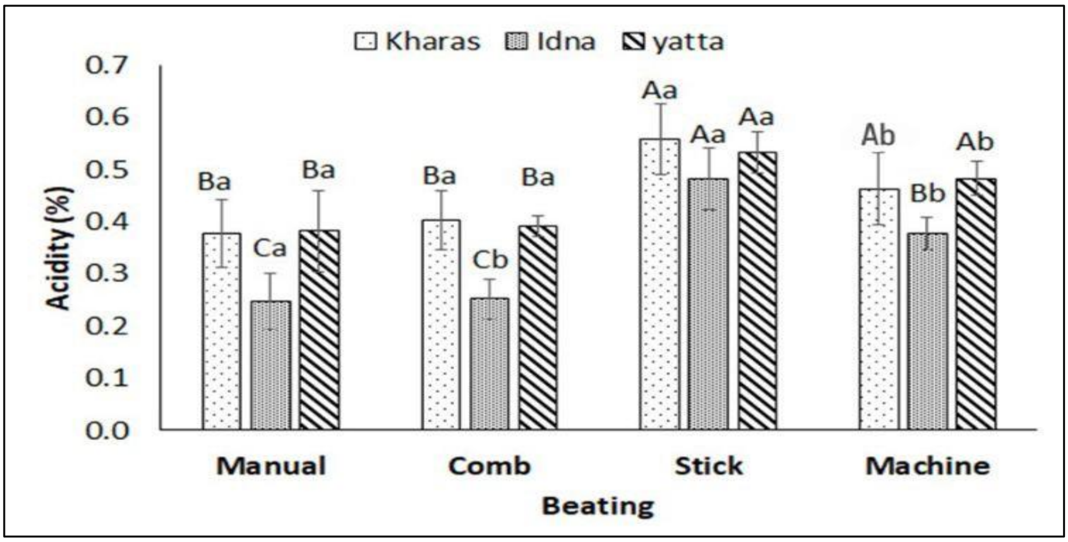

Figure 4.6: Acidity (% oleic acid) of oil obtained from fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different harvesting methods (manual picking by hand, picking using manual comb, picking using wooden stick, and picking using electric harvesting machine) before pressing. For a given location and different harvesting treatment, means followed by the same capital letter are not significantly different, means of the same treatment within locations followed by the same small letter are not significantly different. $P< 0.05$, $n=4$.

4.1.6 Peroxide value

The peroxide value Fig.(4.7), measured in mill equivalents of O_2 per kilogram of oil, is a crucial indicator of olive oil quality. Similar to acidity, the traditional stick beating method and the harvesting machine resulted in the highest peroxide values, with statistically similar results between the two methods across all locations. These values were significantly higher than those observed with manual and comb harvesting methods. Peroxide values in oil from Yatta were comparable to those from Idna across all harvesting methods and significantly lower than those from Kharas for each respective harvesting technique. Despite these differences, all locations and harvesting methods met the extra virgin olive oil standard (<20 mill equivalents of O_2 per kilogram of oil).

In previous studies, similar findings to those of the current study were reported. The literature confirmed that harvesting methods causing mechanical damage to the fruit—such as stick beating or mechanical harvesting—lead to a significant increase in peroxide values due to enhanced primary oxidation. This has been attributed to cell damage in the fruit and the activation of oxidative enzymatic activity, which accelerates fat degradation reactions and compromises oil quality (Kaniewski et al., 2023).

Differences between locations may be attributed to climatic and environmental variations among these regions. Climatic factors such as temperature, humidity, and elevation directly affect the balance between oxidizing and antioxidant compounds during fruit ripening and storage (Ben-Ari et al., 2021; Mafrica et al., 2021). It has been observed that high-quality olive oils (in terms of free acidity, fatty acid composition, antioxidant components, and oxidative stability) were obtained from sites characterized by lower temperatures and higher rainfall (Mafrica et al., 2021). Additionally, agricultural management practices, such as irrigation and soil type, contribute to the fruit's oxidative resistance by increasing its content of phenolic compounds and natural antioxidants (Siakou et al., 2021).

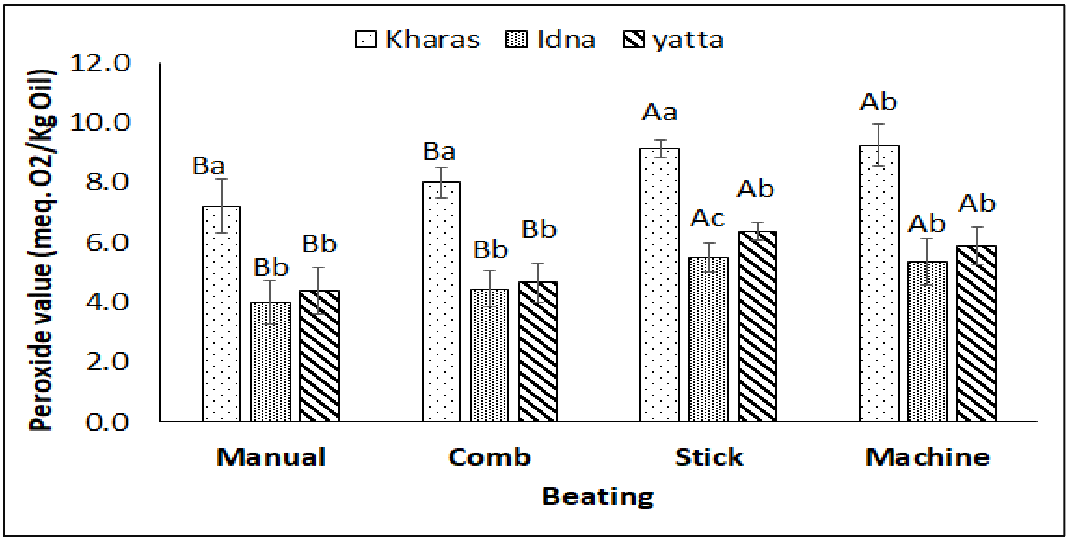

Figure 4.7: Peroxide value (milli-equivalents O2/ Kg oil) of oil obtained from fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different harvesting methods (manual picking by hand, picking using manual comb, picking using wooden stick, and picking using electric harvesting machine) before pressing. For a given location and different harvesting treatment, means followed by the same capital letter are not significantly different, means of the same treatment within locations followed by the same small letter are not significantly different. $P < 0.05$, $n=4$.

4.1.7 Phenolic compounds contents

Consistent with the trends observed for acidity and peroxide value, harvesting olives by beating branches with a stick negatively impacted oil quality by reducing phenolic content due to oxidation across all locations Fig.(4.8). This method resulted in lower phenolic content compared to manual and comb harvesting methods. Similarly, olives collected using the harvesting machine produced oil with lower phenolic content than the manual and comb methods. Oil from Idna exhibited significantly lower phenolic content compared to Kharas and Yatta, which showed similar values across all harvesting methods, except for the stick method, where Idna and Kharas had comparable phenolic levels.

These results are consistent with previous literature regarding the negative impact of harsh harvesting methods on the phenolic content of olive oil, which is one of the most important indicators of olive oil quality and its health value. Studies have shown that harvesting using sticks or machinery causes mechanical bruising to the fruit, which stimulates early oxidation processes and contributes to the degradation of sensitive phenolic compounds, leading to a decrease in their concentration in the extracted oil (Farayeh et al., 2017).

Moreover, the differences between locations—such as the lower phenolic content in the olive oil from Idna compared to Yatta and Kharas—can be attributed to environmental and climatic factors related to geographic location. Studies have shown that areas with higher temperatures and lower rainfall tend to experience a reduction in the accumulation of phenolic compounds in the fruit, which negatively affects the final oil quality. In contrast, high-altitude regions characterized by cooler temperatures and greater rainfall promote the accumulation of phenolics, thereby enhancing the antioxidant properties of the oil (Mafrica et al., 2021; Ben-Ari et al., 2021).

Previous studies have observed that high-quality olive oil — in terms of fatty acid composition, phenolic content, and oxidative stability — was obtained from regions with lower temperatures and higher rainfall, which promotes the stability of bioactive compounds during ripening and storage (Mafrica et al., 2021).

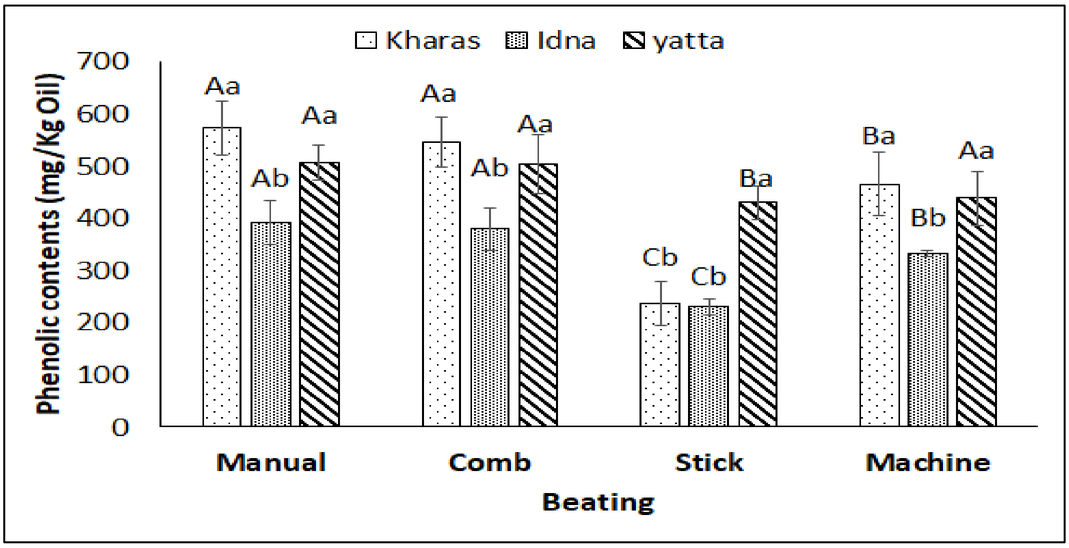

Figure 4.8: Phenolic contents (mg/ Kg oil) of oil obtained from fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different harvesting methods (manual picking by hand, picking using manual comb, picking using wooden stick, and picking using electric harvesting machine) before pressing. For a given location and different harvesting treatment, means followed by the same capital letter are not significantly different, means of the same treatment within locations followed by the same small letter are not significantly different. $P < 0.05$, $n=4$.

4.1.8 Absorption coefficient at 232nm (K_{232})

The highest K_{232} value Fig .(4.9) was recorded in olives harvested using the stick whipping method across all studied locations. In contrast, this quality parameter remained consistently similar across all locations for the other harvesting methods, including manual handpicking, comb, and machine harvesting.

Olives collected using either the stick whipping method or the harvesting machine produced oils with statistically similar K_{232} values, both significantly higher than those obtained from manual and comb harvesting methods. K_{232} values were comparable between oils from Idna and Yatta across all harvesting methods, while oils from Kharas exhibited significantly lower K_{232} values than Idna and Yatta for all methods, except for machine harvesting, where the difference was not significant.

These results are consistent with previous studies, which have shown that harvesting methods causing mechanical bruising to the fruit—such as stick beating or mechanical harvesting—accelerate primary oxidation processes. This is clearly reflected in the elevated K_{232} values, which are indicative of the accumulation of aldehydes and peroxides resulting from the degradation of unsaturated fatty acids (Farayeh et al., 2017). The study demonstrated that the stick beating and mechanical harvesting methods produced the highest values for this parameter, indicating a decline in oil quality compared to manual handpicking and comb harvesting methods.

Regarding the differences between locations, oils from "Kharas" recorded the lowest K_{232} values compared to those from "Idna" and "Yatta." This can be explained by environmental and climatic factors, such as high temperatures and water stress, which negatively affect oil stability and accelerate its degradation (Ben-Ari et al., 2021; Mafrica et al., 2021). Studies also indicate that high-altitude regions with moderate climates and higher rainfall promote the stability of bioactive compounds in the oil, which is reflected in lower oxidation indicators like K_{232} (Mafrica et al., 2021).

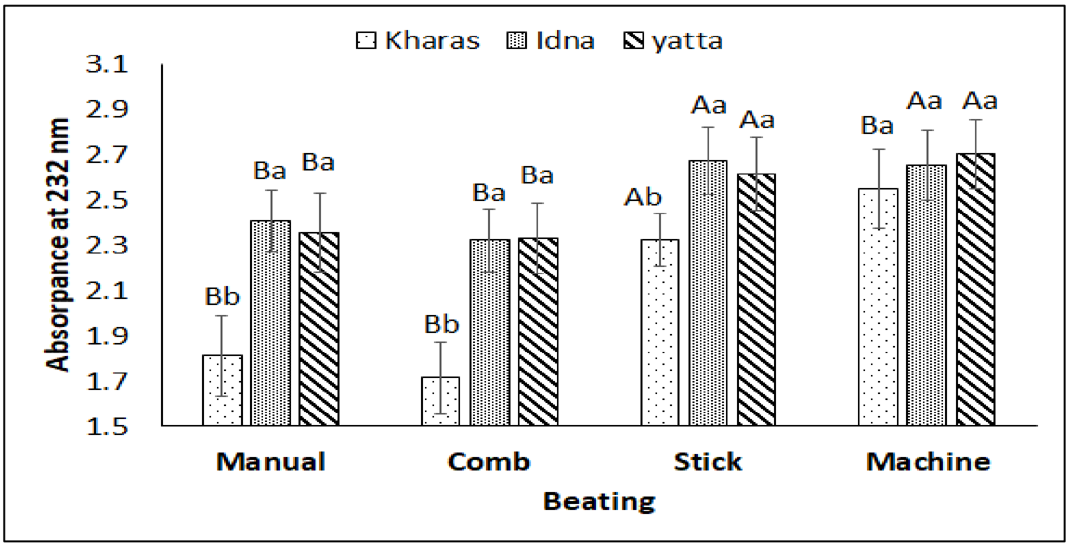

Figure 4.9: Absorption coefficient K232 (absorbance at 232 nm) of oil obtained from fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different harvesting methods (manual picking by hand, picking using manual comb, picking using wooden stick, and picking using electric harvesting machine) before pressing. For a given location and different harvesting treatment, means followed by the same capital letter are not significantly different, means of the same treatment within locations followed by the same small letter are not significantly different. $P< 0.05$, n=4.

4.1.9 Absorption coefficient at 270nm (K_{270})

Similar to the K_{232} results, K_{270} values Fig. (4.10) were higher in most locations when olives were harvested using the stick method or the machine compared to manual and comb harvesting practices. Once again, oil from Kharas exhibited lower K_{270} values than Idna and Yatta across all respective harvesting methods.

These results are consistent with previous studies, which have shown that harvesting methods causing mechanical bruising to the fruit—such as stick beating or mechanical harvesting—accelerate primary oxidation processes. This is clearly reflected in the elevated

K_{270} values, which are indicative of the accumulation of aldehydes and peroxides resulting from the degradation of unsaturated fatty acids (Farayeh et al., 2017). The study demonstrated that the stick beating and mechanical harvesting methods produced the highest values for this parameter, indicating a decline in oil quality compared to manual handpicking and comb harvesting methods.

Regarding the differences between locations, oils from "Kharas" recorded the lowest K_{270} values compared to those from "Idna" and "Yatta." This can be explained by environmental and climatic factors, such as high temperatures and water stress, which negatively affect oil stability and accelerate its degradation (Ben-Ari et al., 2021; Mafrica et al., 2021). Studies also indicate that high-altitude regions with moderate climates and higher rainfall promote the stability of bioactive compounds in the oil, which is reflected in lower oxidation indicators like K_{270} (Mafrica et al., 2021).

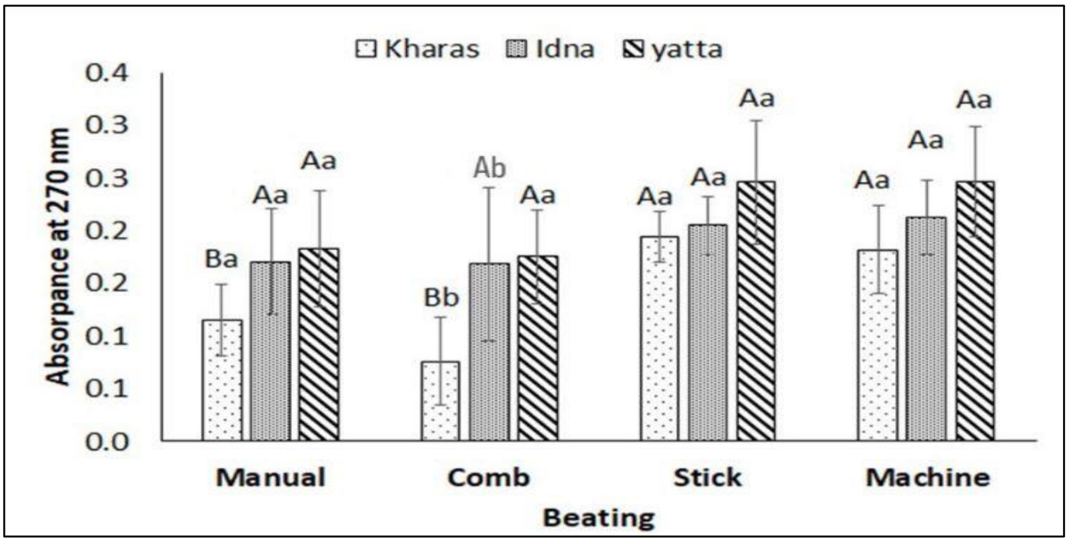

Figure 4.10: Absorption coefficient K270 (absorbance at 270 nm) of oil obtained from fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different harvesting methods (manual picking by hand, picking using manual comb, picking using wooden stick, and picking using electric harvesting machine) before pressing. For a given location and different harvesting treatment, means followed by the same capital letter are not significantly different, means of the same treatment within locations followed by the same small letter are not significantly different. $P < 0.05$, n=4.

4.2 Effect of Fruit Storage

The impact of various storage conditions and durations of olive fruits from different locations before pressing on selected oil quality indicators (acidity, peroxide value, extinction coefficients K_{232} and K_{270}, and total phenolic content) was evaluated in comparison to freshly pressed fruits using a laboratory presser.

The results of the different treatments on oil quality parameters are presented as mean values with standard deviations, along with significance letters ($p<0.05$). Statistical analysis was conducted to assess variations in mean values within treatments from the same location and among locations under the same storage treatment.

4.2.1 Oil content

The oil content in olive fruits varied across treatments and locations, with some differences being statistically significant. Olives harvested from Kharas and Idna consistently exhibited similar oil content, both higher than that of Yatta across all treatments, except when stored for 5 days in plastic containers. Under this condition, Kharas showed the lowest oil content, followed by Yatta, and then Idna with the highest.

Storage in aerated boxes did not affect oil content in any of the three locations, as values remained consistent when comparing freshly extracted oil with samples stored for 3 and 5 days in aerated boxes. However, when olives were stored in plastic bags, oil content in Kharas decreased with longer storage durations, while the opposite trend was observed in Idna and Yatta, with significant differences between the locations.

These results are consistent with the literature indicating that storing olives in a closed, humid environment such as plastic bags enhances microbial and enzymatic activity within the fruit, accelerating its degradation and reducing the quality of the extracted oil (Dag, 2024). In contrast, ventilated boxes provide continuous airflow that reduces moisture and heat accumulation, helping to preserve tissue integrity and limit oil loss (Barazani et al., 2023; Vossen, 2007).

The variation between regions may be attributed to climatic and physiological differences affecting the fruit's resistance to deterioration during storage. For example, higher temperatures and humidity in Kharas may have exacerbated fruit degradation inside plastic bags, reflected by a decrease in oil content. Conversely, olives from Idna and Yatta may possess thicker skins or more resilient tissue structures, which could explain the slight increase in oil content despite storage under the same conditions.

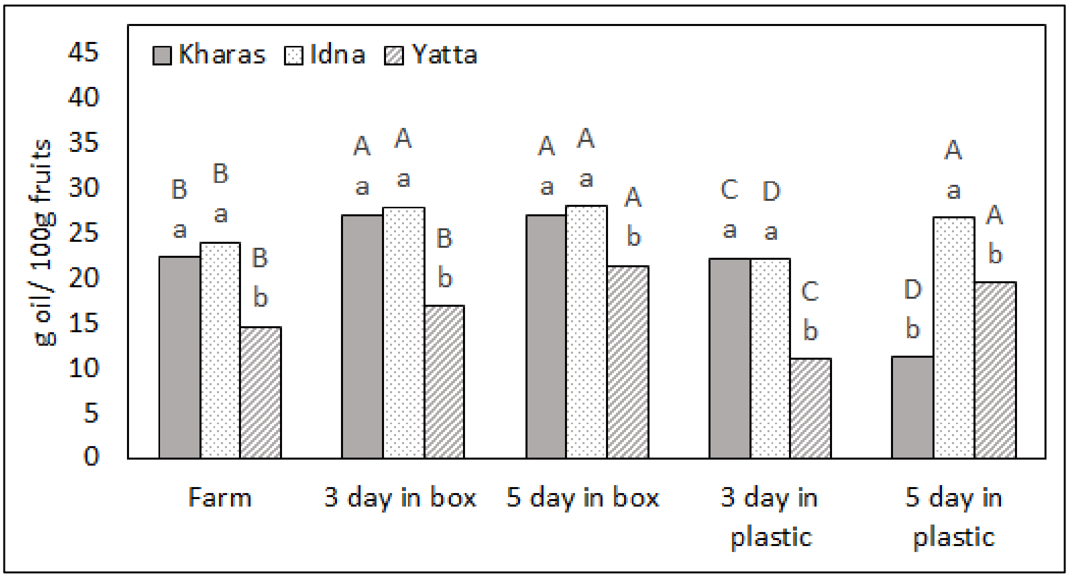

Figure 0.11: Oil content (%) of olive fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different storage duration (3 and 5 days) and condition (box and plastic sacs) before pressing. For a given district and different storage treatment, means followed by the same capital letter are not significantly different, means of the same treatment within district followed by the same small letter are not significantly different. $P < 0.05$, n=3.

4.2.2 Extinction coefficient K_{232}

The K_{232} value of extracted olive oil was similar across olives collected from the three locations when oil was extracted directly from the farms as a baseline. However, when olives were stored for short (3 days) or long (5 days) periods, this value varied significantly within locations. Generally, storage for both short and long durations increased the K_{232} value in both types of storage containers.

For olives collected from Kharas, the K_{232} values remained similar whether stored in boxes for short or long periods. In contrast, olives from Idna and Yatta produced oil with higher K_{232} values when stored for longer periods in both types of storage containers, with the values being significantly higher when stored in plastic bags.

This result is consistent with studies indicating that delaying the milling of olives after harvest increases the oxidation rates in the resulting oil, due to enhanced microbial activity and enzymatic degradation in the stored fruits—particularly under suboptimal storage conditions such as sealed plastic bags (Dag, 2024; Morales-Sillero & García, 2015). Aktas (2019) also demonstrated that processing delays beyond 36 hours lead to increases in oxidative values, including K232.

The observed variation between regions may be attributed to differing climatic or environmental conditions, or to the inherent characteristics of the olives themselves. For example, studies have shown that olives with thinner skins or higher moisture content are more susceptible to damage during storage (Arbonés et al., 2014).

Additionally, storing the olives in sealed containers increases the internal temperature, which in turn accelerates oxidation reactions (Morales-Sillero & García, 2015).

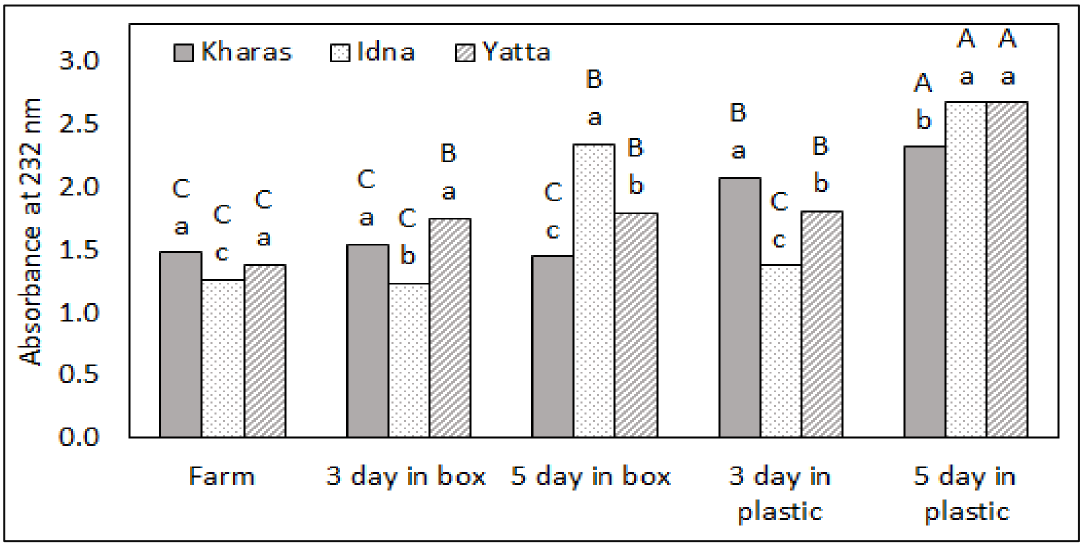

Figure 4.12: Absorption coefficient K232 (absorbance) of olive fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different storage duration (3 and 5 days) and containers (box and plastic sacs) before pressing. For a given district and different storage treatment, means followed by the same capital letter are not significantly different, means of the same treatment within district followed by the same small letter are not significantly different. $P < 0.05$, $n=3$.

4.2.3 Extinction coefficient K_{270}

The K_{270} values of extracted olive oil varied across locations under similar treatments, as well as within the same location depending on storage time and containers. K_{270} values increased when olives were stored for three days in aerated boxes, and remained consistent when the storage period was extended to five days in the same containers. A similar trend was observed when olives were stored in plastic bags, though the values were significantly higher. The highest K_{270} values were observed in oil from Idna, followed by Kharas, and then Yatta.

This finding is consistent with what was indicated by (Morales-Sillero & García, 2015) and, namely that poor storage conditions—especially in non-ventilated containers—lead to the accumulation of secondary oxidation products, which raises the K_{270} value. (Aktas, 2019) also confirmed the direct relationship between extended storage duration and the increase in K_{270} value.
It is noted that the highest values were recorded in oil extracted from olives grown in the Idna region, followed by Kharas, then Yatta. This variation can be explained by climatic or environmental differences between the regions, in addition to differences in the fruit's

structure and chemical composition. This aligns with the findings of (Arbonés et al., 2014), who stated that olives with thinner skins and higher moisture content are more susceptible to oxidative degradation.

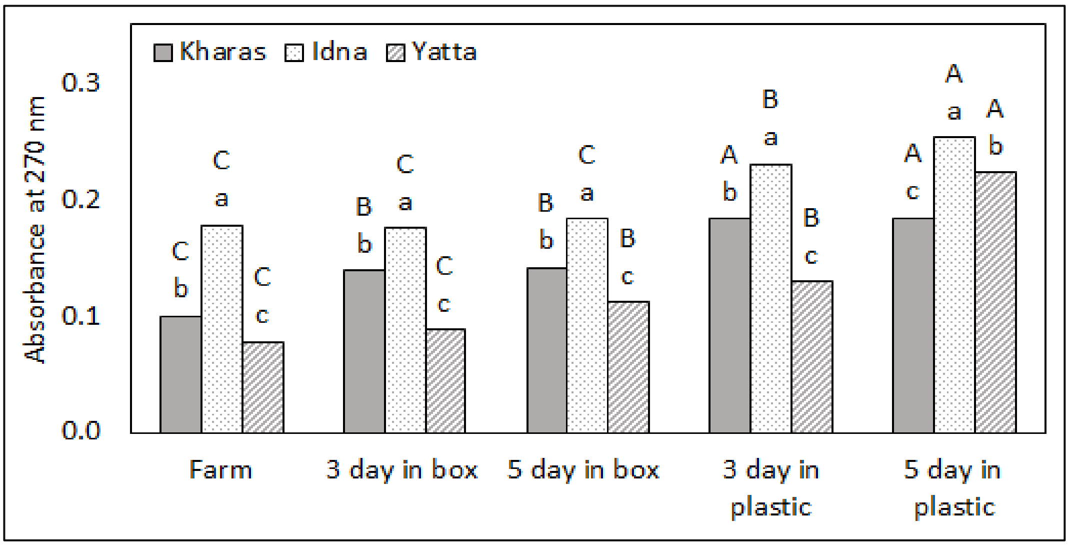

Figure 4.13: Absorption coefficient K270 (absorbance) of olive fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different storage duration (3 and 5 days) and containers (box and plastic sacs) before pressing. For a given district and different storage treatment, means followed by the same capital letter are not significantly different, means of the same treatment within district followed by the same small letter are not significantly different. $P< 0.05$, $n=3$.

4.2.4 Acidity

The acidity of oil produced from olives collected from all locations was similar across the districts when olives were directly extracted from the farm without any storage.
Notably, longer storage durations in both boxes and plastic bags consistently resulted in higher acidity levels compared to shorter storage periods across all locations. The acidity of oil from olives collected in Kharas remained lower than that from the other two locations across all storage methods and durations. After five days of storage in plastic bags, the highest acidity was found in oil extracted from olives collected in Yatta, followed by Idna, and then Kharas. Despite these variations, all oils, whether pressed fresh or after short or extended storage in boxes or plastic bags, remained within the acidity limits for extra virgin olive oil (EVOO).
This result is consistent with previous studies, which indicate that delays in processing after harvest are among the critical factors contributing to increased acidity and the deterioration of olive oil quality (Vossen, 2007). This is attributed to the fact that fresh olives, when processed immediately after harvest, retain low levels of free fatty acids due to reduced

microbial and enzymatic activity within the fruit at this early stage of handling(Aktas, 2019).
The increase in acidity resulting from storage in plastic bags has been documented in numerous previous studies. The literature confirms that prolonged storage—particularly under poorly ventilated conditions such as plastic bags—leads to elevated temperatures, increased microbial activity, and enzymatic degradation. These factors collectively contribute to a higher concentration of free fatty acids in the oil (Morales-Sillero & García, 2015; Dag, 2024).

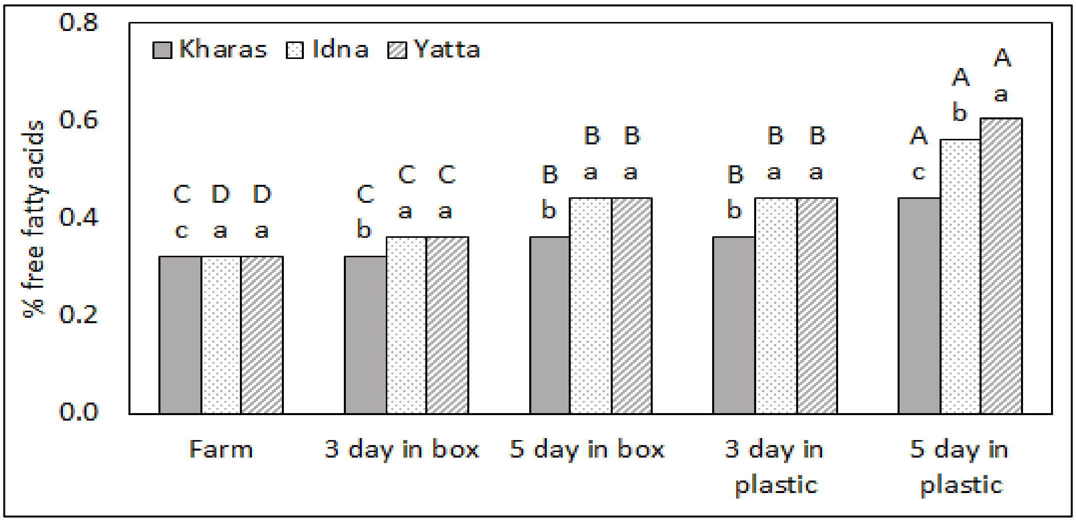

Figure 4.14: Acidity (% free fatty acids) of olive fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different storage duration (3 and 5 days) and containers (box and plastic sacs) before pressing. For a given district and different storage treatment, means followed by the same capital letter are not significantly different, means of the same treatment within district followed by the same small letter are not significantly different. P< 0.05, n=3.

4.2.5 Peroxide value

The peroxide values of olives varied across locations and different storage conditions. In freshly milled olives, peroxide levels were significantly higher in Idna compared to the other two locations.

Peroxide levels in the extracted oil increased with longer storage durations in both boxes and plastic bags for each location. All differences within the same location and across different storage durations were statistically significant, with a more pronounced increase observed in plastic containers.
The peroxide value of oil extracted from olives collected from Idna, stored in different containers and for varying durations, was higher than that from Kharas and Yatta, with significant differences observed after longer storage in both types of containers.

These results are consistent with previous studies, as (Morales-Sillero & García, 2015) indicated that improper storage conditions—especially in poorly ventilated environments such as plastic bags—lead to increased temperatures and heightened microbial and enzymatic activity within the olive fruit. This stimulates the initiation of primary lipid oxidation processes, which is reflected in a significant increase in the peroxide value of the extracted oil.

(Olive Oil Times, 2020) also pointed out that this pattern of chemical degradation is common when processing is delayed for several days after harvest. Such delays accelerate the production of primary oxidation compounds, leading to elevated peroxide values and, consequently, a decline in both the sensory and chemical quality of the olive oil.

On the other hand, (Aktas, 2019) points out that olives harvested manually and processed within 36 hours produce oil that retains its freshness for longer periods, due to lower rates of oxidation and limited enzymatic activity.

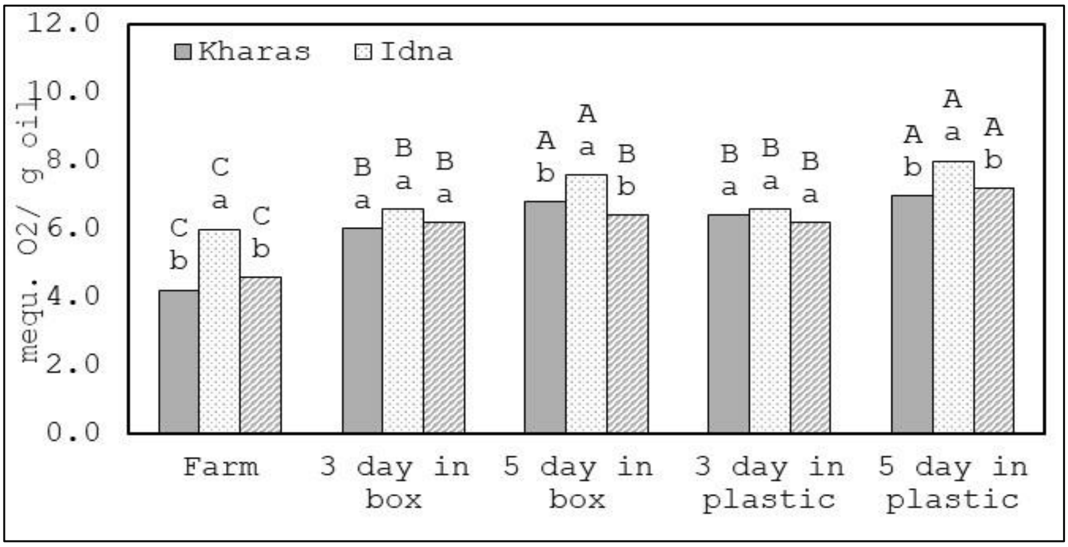

Figure 4.15: Peroxide value (mill equivalent O2/ kg oil)) of olive fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different storage duration (3 and 5 days) and containers (box and plastic sacs) before pressing. For a given district and different storage treatment, means followed by the same capital letter are not significantly different, means of the same treatment within district followed by the same small letter are not significantly different. $P < 0.05$, $n=3$.

4.2.6 Phenolic compounds

Phenolic content varied both within locations and across storage conditions (container type and duration). In all treatments, the highest phenolic compound content was found in olives from Yatta, followed by Kharas, and then Idna.

Storing olives for three to five days in both types of containers significantly reduced the phenolic content of the extracted oil across all locations. After three or five days of storage, whether in boxes or plastic containers, oil from Yatta retained the highest phenolic content, while oil from Idna had the lowest.

The higher phenolic content in olives from Yatta, despite their lower ripeness, can be explained by the chemical changes occurring during maturation. A study by (Şen & Esen ,2021) showed that early harvesting of olives, which is associated with lower ripeness stages, leads to oils with higher levels of phenolic compounds. This is because early ripening preserves higher levels of antioxidants, which decrease as the fruit matures (Flamminii et al., 2021; Dwaik, 2016).

Regarding the effect of storage conditions, the results align with many researchers who indicated that prolonged storage enhances the activity of oxidative enzymes and microbes that cause the breakdown of phenolic compounds and deterioration of oil quality (Vossen, 2007; Snouber, 2016). Studies have also shown that storage in plastic containers may increase the risks of moisture retention and elevated temperatures, which accelerate oxidation and oil degradation (Dag, 2024; Morales-Sillero & García, 2015).

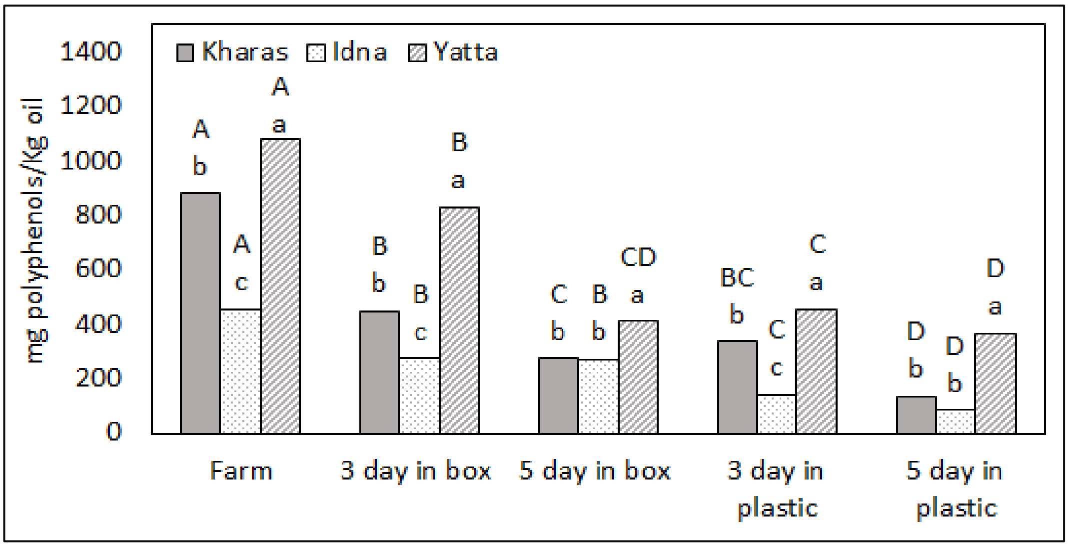

Figure 4.16: Polyphenolic compound content (mg/L) of olive fruits collected from different Palestinian locations (Kharas, Idna, and Yatta)

As affected by different storage duration (3 and 5 days) and containers (box and plastic sacs) before pressing. For a given district and different storage treatment, means followed by the same capital letter are not significantly different, means of the same treatment within district followed by the same small letter are not significantly different. $P < 0.05$, $n=3$.

Chapter Five:

Conclusion and Recommendations

The results of this study align with the growing body of literature that emphasizes the significance of various factors in determining the quality of olive oil, including harvesting methods, storage conditions, and regional differences. Olive oil's health benefits, which are largely attributed to its rich content of phenolic compounds, antioxidants, and favorable fatty acid composition (Cercaci et al., 2007; Lazzez et al., 2008), are closely tied to the conditions under which olives are harvested and stored. In particular, the interplay between these factors significantly influences oil attributes such as acidity, peroxide values, and phenolic compounds, which are crucial indicators of oil quality and stability.

The study's findings on the impact of harvesting methods corroborate existing literature highlighting the importance of fruit integrity in oil quality. Manual harvesting, which is known to minimize mechanical damage to the olives, resulted in lower acidity, peroxide values, and higher phenolic content compared to more abrasive methods like stick and machine harvesting (Vacca et al., 2006; Martin-Moreno et al., 1994). This supports previous research that underscores the role of harvesting techniques in preserving olive fruit quality and minimizing enzymatic oxidation, which can degrade oil quality (Sola-Guirado et al., 2014). Manual methods, though labor-intensive, are essential for producing higher-quality olive oil, as they help avoid the oxidative damage that is more common in mechanical harvesting (Jiménez-Sánchez et al., 2022). The negative impact of stick and machine harvesting on oil quality was observed across all three locations in the present study, further emphasizing the value of gentle harvesting techniques in preserving oil integrity.

The influence of storage conditions, particularly the type of container and duration of storage, was another critical finding of this study. Prolonged storage, especially in plastic containers, led to increased oxidative degradation of the olives, resulting in higher acidity and peroxide values and reduced phenolic content. This mirrors findings from Caponio et al. (2005) and Guillaume et al. (2000), which highlighted the role of storage conditions in accelerating lipid oxidation and hydrolytic degradation, ultimately compromising oil quality (Kalua et al., 2007). The study found that olives stored for longer periods, regardless of container type, showed a decrease in oil quality, consistent with previous research that suggests the storage time before milling is a critical factor in preserving olive oil's chemical and sensory attributes (Vacca et al., 2006; Selvaggini et al., 2014).

Regional differences also played a significant role in oil quality. Olives from Yatta consistently exhibited higher phenolic content across all treatments, which may be attributed to the specific climatic conditions and soil compositions of the region (Barazani et al., 2014). This supports findings from research on regional variability in olive oil production, where climate, soil, and cultivar differences are known to significantly affect oil quality (Baccouri et al., 2007; Dag et al., 2009). Yatta's superior oil quality may be linked to a more favorable growing environment for olive cultivation, emphasizing the importance of region-specific practices in optimizing oil production.

These results underscore the necessity of adopting region-specific approaches to improve olive oil quality, particularly in traditional, low-intensity farming systems such as those found in Palestine. As demonstrated in this study, manual harvesting and optimized storage conditions are essential for preserving oil quality and enhancing the nutritional, sensory, and medicinal properties of the oil (Jiménez-Lopez et al., 2020; Jiménez-Sánchez et al., 2022). However, the challenge remains in balancing these traditional methods with the need for increased productivity and economic sustainability in olive orchards, particularly in marginal areas where low yields and high labor costs are prevalent (Lavee, 2009). Further research is needed to explore innovative methods that can enhance olive oil quality while addressing the economic challenges faced by small-scale producers (Duarte et al., 2008; Barazani et al., 2023).

This study highlights the crucial role of harvesting techniques and storage conditions in determining the quality of olive oil, with implications for both producers and consumers. By optimizing harvesting practices, minimizing storage durations, and considering regional factors, the olive oil industry can significantly enhance its product quality. The findings provide valuable insights for improving industry standards and offer a foundation for further research aimed at maximizing the health benefits and market value of olive oil globally.

No single factor operates in isolation; rather, olive oil quality is determined by a combination of these elements, each contributing in unique ways to the final product. Traditional harvesting methods, such as the use of sticks, were found to result in lower oil quality, characterized by higher acidity, peroxide values, and reduced phenolic compounds, which are crucial for the oil's health benefits. Storage conditions also played a pivotal role, with prolonged storage, especially in plastic bags, leading to increased oxidative damage and deterioration of oil quality. On the other hand, shorter storage durations helped to preserve oil integrity, reducing the formation of undesirable compounds. These findings emphasize the necessity of minimizing storage time and employing protective storage methods to safeguard olive oil quality.

Furthermore, regional variations such as climate, soil composition, and olive variety, were shown to significantly affect oil yield and quality. The study underscores the importance of adopting region-specific strategies that account for these local factors, as well as integrating optimal harvesting and storage practices. Ultimately, maintaining high-quality olive oil requires a comprehensive management approach that addresses each of these variables, from harvesting through to storage and extraction. This understanding can guide best practices for olive growers, especially in regions like Palestine, where traditional methods coexist with modern practices, to ensure the production of superior olive oil.

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تقييم تأثير ممارسات الحصاد والتخزين لثمار الزيتون على جودة الزيت في محافظة الخليل

اعداد: صابرين محمد عوده بلوط

اشراف: البروفيسور جهاد عبادي

ملخص:

يُعد زيت الزيتون، المعروف بخصائصه الغذائية والطبية والحسية، منتجًا أساسيًا في منطقة البحر الأبيض المتوسط، وخصوصًا في فلسطين. وتتأثر جودة زيت الزيتون البكر الممتاز (EVOO) بشكل كبير بعوامل ما قبل الحصاد وما بعده، بما في ذلك تقنيات الحصاد، وظروف التخزين، والمتغيرات البيئية الخاصة بكل منطقة. تهدف هذه الدراسة إلى استكشاف كيفية تفاعل هذه العوامل وتأثيرها على الخصائص الكيميائية والغذائية لزيت الزيتون المستخلص، مع التركيز على ثلاث مناطق فلسطينية تمثيلية لإنتاج الزيتون: إذنا وخُرّاس وبيطّا في محافظة الخليل. وتتناول الدراسة تأثير أربع طرق للحصاد – القطاف اليدوي، التمشيط اليدوي، الحصاد الآلي باستخدام الأمشاط الكهربائية، والطريقة التقليدية المتمثلة بضرب الأغصان بالعصي – إلى جانب نوعين من طرق التخزين بعد الحصاد (الصناديق المهواة والأكياس البلاستيكية غير المهواة) لفترات زمنية مختلفة (0، 3، و5 أيام)، على مؤشرات جودة رئيسية تشمل محتوى الزيت، الحموضة، قيمة البيروكسيد، الامتصاص بالأشعة فوق البنفسجية K_{232} وK_{270}، ومحتوى المركبات الفينولية الكلية.

أظهرت النتائج أن طرق الحصاد تؤثر بشكل كبير على جودة الزيت؛ حيث أدت الطرق اليدوية واستخدام الأمشاط إلى إنتاج زيت بحموضة وقيم بيروكسيد وامتصاص بالأشعة K_{232} و K_{270}أقل، ومحتوى فينولي أعلى – وهي صفات مرتبطة بالانتعاش والثبات والفوائد الصحية. في المقابل، أدت طريقتا الضرب بالعصا والحصاد الآلي، اللتان تُسببان ضررًا أكبر للثمار، إلى تدهور أكسدي أعلى، كما انعكس ذلك في زيادة الحموضة، والبيروكسيد، وقيمK ، وانخفاض جودة الزيت. وكانت هذه الاتجاهات ثابتة في جميع المناطق، مما يُؤكد أن ممارسات الحصاد التي تحافظ على سلامة الثمار تُقلل من الأكسدة الإنزيمية وتحافظ على المركبات الحيوية القيمة.

كما لعبت ظروف التخزين بعد الحصاد دورًا حاسمًا في تحديد جودة الزيت. فقد أدى التخزين المطوّل، خاصة في الأكياس البلاستيكية غير المهوّاة، إلى زيادة ملحوظة في الحموضة، وقيم البيروكسيد، وقيم K_{232} وK_{270}، مع انخفاض في محتوى الفينولات. في المقابل، أظهرت الثمار المخزنة في صناديق مهوّاة تدهورًا أكسديًا أقل، خاصة إذا لم تتجاوز مدة التخزين

ثلاثة أيام. تؤكد هذه النتائج على أهمية المعالجة السريعة واستخدام أوعية مناسبة لتقليل التغيرات الكيميائية الحيوية التي تضعف جودة الزيت.

جميع الزيوت التي تم تحليلها تطابقت مع معايير زيت الزيتون البكر الممتاز الدولية من حيث الحموضة وقيم البيروكسيد و K_{232}و K_{270}علاوة على ذلك، يُعتبر ارتفاع محتوى الفينولات مؤشرًا إيجابيًا على جودة الزيت لما له من دور في تعزيز الثبات الأكسدي وتوفير فوائد صحية أكبر، مما يؤكد أهمية اتباع ممارسات الحصاد والتخزين المثلى.

كما كان للتباين الإقليمي بين إذنا وخُرّاس ويطّا تأثير ملحوظ. فقد أظهرت ثمار يطّا باستمرار محتوى أعلى من الزيت والمركبات الفينولية، مما يشير إلى ظروف بيئية ملائمة مثل الارتفاع، ونوع التربة، والمناخ المحلي. في المقابل، أظهرت ثمار خُرّاس محتوى أقل من الزيت، لكنها حافظت على مستويات حموضة منخفضة نسبيًا. وتؤكد هذه الفروقات الإقليمية أهمية مراعاة الظروف البيئية والمحاصيل المحلية عند تحسين ممارسات الحصاد والتخزين.

تسلط هذه الدراسة الضوء على الدور المحوري لتقنيات الحصاد وظروف التخزين في تحديد جودة زيت الزيتون، بما له من تأثيرات على كل من المنتجين والمستهلكين. ومن خلال تحسين ممارسات الحصاد، وتقليل فترات التخزين، ومراعاة العوامل الإقليمية، يمكن لصناعة زيت الزيتون أن تعزز جودة منتجاتها بشكل كبير. كما توفر النتائج رؤى مهمة لتحسين المعايير الصناعية وتشكل أساسًا لأبحاث مستقبلية تهدف إلى تعظيم الفوائد الصحية والقيمة السوقية لزيت الزيتون عالميًا.

ومن المهم التأكيد على أن جودة زيت الزيتون لا تحددها عوامل منفردة، بل هي نتاج لتفاعل معقد بين طرق الحصاد، وظروف التخزين، والعوامل البيئية. فقد ارتبطت الطرق التقليدية مثل ضرب الأغصان بالعصي بانخفاض جودة الزيت، كما يتضح من ارتفاع الحموضة وقيم البيروكسيد وانخفاض المحتوى الفينولي. وبالمثل، أدى التخزين غير المناسب – لا سيما لفترات طويلة في الأكياس البلاستيكية – إلى تسريع التفاعلات التأكسدية التي تؤثر سلبًا على الخصائص الحسية والغذائية للزيت. في المقابل، ساعدت فترات التخزين القصيرة والحاويات المهواة في الحفاظ على جودة الزيت وسلامته الغذائية.

علاوة على ذلك، أظهرت الظروف البيئية الزراعية الإقليمية تأثيرًا واضحًا على خصائص الزيت، مما يبرز الحاجة إلى تبني ممارسات مثلى تراعي خصوصية كل منطقة. فقد ساهمت الاختلافات في التربة والمناخ وصنف الزيتون بشكل كبير في تفاوت العائد وجودة الزيت. وهذا يعزز أهمية تكييف استراتيجيات إنتاج زيت الزيتون بما يتلاءم مع السياقات المحلية.

في نهاية المطاف، يتطلب الحفاظ على زيت زيتون عالي الجودة نهجًا متكاملًا يعالج جميع مراحل الإنتاج – من الحصاد وحتى التخزين والمعالجة. ويُعد هذا النهج بالغ الأهمية في نظم الزراعة التقليدية مثل تلك الموجودة في فلسطين، حيث تسود الممارسات الزراعية منخفضة المدخلات ويقل الاعتماد على الميكنة.