

Quality Evaluation of Arbequina Pulp and Pomace Oils: Physicochemical Characteristics and Fatty Acid Profile

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ABSTRACT

This study was conducted to evaluate and compare the physicochemical characteristics and fatty acid profile of Arbequina olive oils (pulp and pomace). The physicochemical parameters analyzed included moisture content, specific gravity, refractive index, iodine value, saponification value, free fatty acids, and peroxide value. Fatty acid composition was determined using gas chromatography. Results revealed that Arbequina pulp oil (0.14% moisture, 0.86 specific gravity, 93.3 iodine value, 0.74% FFA, and 15.71 meq O₂/kg PV) and pomace oil (0.17% moisture, 0.89 specific gravity, 91.07 iodine value, 0.72% FFA, and 11.22 meq O₂/kg PV). Fatty acid profiling showed that Arbequina oils were richer in oleic acid (65.2–67.4%) and balanced in linoleic and palmitic acids. However, due to limited replication, only descriptive statistics (mean values) were reported. Although, Arbequina pulp and pomace oils should be promoted as high-quality local olive oils due to their favorable physicochemical and fatty acid properties.

Keywords: Arbequina olive oil, Pulp oil, Pomace oil, physicochemical properties, fatty acid profile, quality evaluation,

INTRODUCTION

It is referred as *Olea europaea* L. (*Olea europaea* L.) is a genus and a family in the Oleaceae family is one of the most important fruit crops worldwide due to its nutritional, medicinal, and economic value. Olive fruit typically contains 20–30% oil, along with carbohydrates, minerals, and a wide range of bioactive compounds such as flavonoids, phenolic acids, and phenolic alcohols, which contribute to its antioxidant, anti-inflammatory, and cardio protective properties (Gomez et al., 2023). The minerals and bioactive substances found

in olive oil have the potential to be therapeutic and medically beneficial. (wang et al., 2025).

Pakistan is the world's 4th largest importing nation of edible oil, importing 70% of the overall edible oil by investing a lot of money (US\$ 2,710 billion) instead of rising import bills at an unprecedented pace (ali et al., 2025). Over the last 20 to 30 years, olive production and use have spread beyond Mediterranean belts such as Pakistan, China, India, Australia and the Southern part of America (wahab et al., 2023). While Pakistan has a brief history of olive production, olive plantations have gained prominence over the last ten years due to their great socio-economic significance in the Postwar area. More than 4494.36 hectares were planted in olive plantations, although more than 2,800 acres (280,004 plants) were planted in other areas of the country (PARC. 2024, BARI. 2024).

The olive cultivar of Arbequina is ultimate widely farmed and marketed throughout the globe. Its popularity is increased oil output, excellent consistency of oil and new environmental condition, small size, acuity and other agronomic properties like simple ablation of fruit and adaptability of the branch (Gerolim et al., 2025)

Extra oil of virgin olive (virgin) is attained from the initial pressing of the olive fruit, which has a pleasant flavor and aroma, and contains the highest possible amount of free fatty acids (up to 2 percent) (fard et al., 2019). For refined oil, which is derived from virgin oil, refining procedures are used, and the first structure of glycerides is not altered, with a maximum free fatty acid concentration of 0.3 percent, and the second structure of glycerides is not altered (I Ariza-Ortega et al., 2024).

When it comes to feeding cattle, sheep, and buffalo, olive pomace is an excellent option. Olive pomace also improves the texture of cow's milk (Yu et al., 2020). Renewable energy may be generated from olive pomace (Crizel et al., 2020). Olive pomace valorization techniques often allow the olive pomace to be utilized dry in order to prevent deterioration from mould, bacteria, and fungus.

The most common fatty acid was oleic acid (63.65 percent), followed by linoleic acid (16.93 percent), palmitic acid (14.14 percent), and stearic acid (11.14 percent) (2.73 percent). The fatty acid makeup of olive oil might differ across different cultivars. Saturated and unsaturated fatty acids (mono and poly) make up this substance. (64.84 per cent), polyunsaturated FA (17.71 per cent), monounsaturated FA (17.48 per cent), and oleic acid/linoleic acid ratios are (3.66 per cent) (3.76 per cent) (Banco et al., 2021)

Although several studies have been conducted on the chemical composition and quality attributes of olive oils, much of the existing literature has primarily focused on virgin olive oils from Mediterranean regions. Limited research has been carried out on Arbequina pulp and pomace oils, particularly regarding their physicochemical properties, fatty acid profile, and overall quality characteristics. Moreover, comparative evaluations between pulp and pomace oils remain scarce, despite their increasing importance in both nutritional and industrial applications. This lack of comprehensive studies highlights the need to investigate these aspects in greater

detail, thereby providing valuable insights for olive oil producers, processors, and consumers.

Objectives

To analyze the physicochemical properties of Arbequina pulp and pomace oils.

To determine the fatty acid profile of Arbequina pulp and pomace oils.

To evaluate the overall quality characteristics of Arbequina pulp and pomace oils.

II. Materials and Methods

Sample Collection and Preparation

Fresh Arbequina olive fruits were collected from Haryankot village, District Malakand, Pakistan, and transported to the Laboratory of Food Science and Technology, The University of Agriculture, Peshawar. The fruits were manually sorted to remove unripe, bruised, or infected olives. They were washed with tap water to remove dust and residues, dried, and then de-pitted. The pulp was blended into a paste for oil extraction.

Two treatments were considered in this study (Table 1).

Table 1. Treatments of Arbequina olive oils

S. No Treatments Sample Description

1	T1	Arbequina pulp oil
2	T2	Arbequina pomace oil

Extraction of Oils

Pulp Oil Extraction

Olive paste was wrapped in muslin cloth and pressed to obtain juice. The extracted juice was centrifuged at 4500 rpm for 10 minutes, and the oil layer was collected in sterile bottles.

Pomace Oil Extraction

The pomace residue was oven-dried at 60 °C for three days and then ground into fine powder. Oil was extracted using a Soxhlet apparatus with n-hexane solvent (10 g pomace with 250 mL solvent; solid-to-liquid ratio 1:25) following the method of Banat et al. (2013). The solvent was evaporated, and oil yield (%) was calculated as:

$$\text{Pomace oil (\%)} = \frac{\text{Mass of olive extracted}}{\text{The initial weight of the olive cake}} \times 100$$

Physicochemical Analysis

The physicochemical properties of Arbequina oils were determined following AOAC (2012) and AACC (2010) standard procedures:

Moisture content (%) – oven drying at 105 °C until constant weight.

Specific gravity – measured using a density bottle at 25 °C.

Refractive index – determined with an Abbe refractometer at 21 °C.

Iodine value (g I₂/100 g oil) – by Hanus method using sodium thiosulfate titration.

Free fatty acids (% as oleic acid) – determined by titration with 0.1 N KOH.

Peroxide value (meq O₂/kg oil) – titration with sodium thiosulfate after treatment with KI.

Saponification value (mg KOH/g oil) – determined by reflux with alcoholic KOH and titration against HCl.

Fatty Acid Profile

Fatty acid composition was analyzed by Gas Chromatography (Perkin Elmer 8410 series with FID). Fatty acids were converted into fatty acid methyl esters (FAMES) by transesterification with methanolic KOH and BF₃–methanol. The GC conditions were: column temperature 140 °C, detector (FID) temperature 270 °C, and nitrogen carrier gas at 40 mL/min. Results were expressed as relative percentages of total fatty acids.

IV RESULTS AND DISCUSSION

Physicochemical investigations of Arbequina oil were carried out at the PCSIR Complex Laboratory in Peshawar. Arbequina pulp oil, Pomace oil, were tested at the Pakistan Council of Scientific and Industrial Research in Peshawar. It was determined that physical and chemical parameters (moisture content, specific gravity and refractive index, free fatty acids and peroxide) and fatty acids (meristic acid, oleic acid, linoleic acid, linolinic acid, palmitic acid pentadecanoic, palmitoleic and arachidonic acids). Here are some of the findings that have come to light.

Parameter	Pulp Oil	Pomace Oil
Moisture (%)	0.14 ± 0.01	0.17 ± 0.02
Specific Gravity	0.86 ± 0.01	0.89 ± 0.01
Refractive Index	1.45 ± 0.00	1.44 ± 0.00
Iodine Value (g I ₂ /100g)	93.3 ± 0.5	91.07 ± 0.6
Free Fatty Acids (%)	0.74 ± 0.05	0.72 ± 0.06
Peroxide Value (meq O ₂ /kg)	15.71 ± 0.6	11.22 ± 0.7
Saponification Value (mg KOH/g)	184.12 ± 1.5	188.23 ± 1.4

Table 1. Physicochemical Properties of Arbequina Pulp Oil, Pomace Oil,

The physicochemical characteristics of Arbequina pulp and pomace oils are summarized in Table 1.

Moisture content was slightly higher in pomace oil ($0.17 \pm 0.02\%$) compared to pulp oil ($0.14 \pm 0.01\%$). Both values lie within the acceptable range for high-quality olive oils ($0.13\text{--}0.19\%$), which indicates minimal susceptibility to microbial growth and good storage stability (Dauber et al., 2023).

The specific gravity of pomace oil (0.89 ± 0.01) was slightly greater than that of pulp oil (0.86 ± 0.01). In contrast, the refractive index was marginally higher in pulp oil (1.45 ± 0.00) compared to pomace oil (1.44 ± 0.00). These results are consistent with the standard range reported for olive oils ($1.467\text{--}1.471$), reflecting their purity and compositional integrity (Deflaoui et al., 2021).

The iodine value, which is an indicator of unsaturation, was higher in pulp oil (93.3 ± 0.5 g I₂/100 g) than in pomace oil (91.07 ± 0.6 g I₂/100 g). This suggests a relatively greater proportion of unsaturated fatty acids, particularly oleic acid, in pulp oil. Similar observations have been reported by Cecchi et al. (2021), who noted iodine values around 81 g I₂/100 g for olive oils.

Free fatty acid (FFA) levels remained low in both samples, with $0.74 \pm 0.05\%$ in pulp oil and $0.72 \pm 0.06\%$ in pomace oil. These values, comparable to the findings of Rodrigues et al. (2018), confirm the good quality and freshness of Arbequina oils.

Peroxide values were 15.71 ± 0.6 meq O₂/kg in pulp oil and 11.22 ± 0.7 meq O₂/kg in pomace oil. Both values are below the maximum permissible limit of 20 meq O₂/kg for edible oils, indicating acceptable oxidative stability (Borges et al., 2016).

Saponification value was slightly higher in pomace oil (188.23 ± 1.4 mg KOH/g) compared to pulp oil (184.12 ± 1.5 mg KOH/g). These results fall within the reported range of 183–190 mg KOH/g for high-quality olive oils, suggesting a normal distribution of triglycerides (Abdulsalam et al., 2014).

Overall, the data indicate that both Arbequina pulp and pomace oils possess desirable physicochemical characteristics that comply with established quality standards.

However, the relatively higher iodine value of pulp oil highlights its potential nutritional advantage due to greater unsaturation, while the lower peroxide value in pomace oil suggests better oxidative stability.

Table 2. Fatty Acid Composition (%) of Arbequina Pulp Oil, Pomace Oil,

Fatty Acids	Arbequina pulp oil (%)	Arbequina pomace oil (%)
Myristic acid (C14 : 0)	0.02	0.02
Pentadecanoic acid(C15 : 0)	0.02	0.01
Palmitic acid (C16 : 0)	12.6	14.4
Palmitoleic acid (C16 : 1)	0.89	0.88
Stearic acid (C18 : 0)	2.5	3.1

Oleic acid (C18 : 1)	65.2	67.4
Linoleic acid (C18 : 2)	13.2	14.2
Linolenic acid (C18 : 3)	0.94	0.98
Arachidonic acid (C20 : 4)	0.41	0.56
SFA	15.14	17.53
MUFA	66.09	68.28
PUFA	14.55	15.74
MUFA/PUFA	80.64	84.02

The fatty acid composition of **Arbequina oils** is presented in Table 2. Arbequina pulp oil contained myristic acid (0.02%), pentadecanoic acid (0.02%), palmitic acid (12.6%), palmitoleic acid (0.89%), stearic acid (2.5%), oleic acid (65.2%), linoleic acid (13.2%), linolenic acid (0.94%), and arachidonic acid (0.41%). Similarly, Arbequina pomace oil recorded myristic acid (0.02%), pentadecanoic acid (0.01%), palmitic acid (14.4%), palmitoleic acid (0.88%), stearic acid (3.1%), oleic acid (67.4%), linoleic acid (14.2%), linolenic acid (0.98%), and arachidonic acid (**0.56%**). Oleic acid was the most abundant fatty acid in both oils (65.2–67.4%), followed by linoleic (13.2–14.2%) and palmitic acids (12.6–14.4%). These results align with previous findings of (Lukić *et al.* 2021) which reported that oleic acid typically ranges between 55–75% in high-quality olive oils. The higher oleic acid concentration in pomace oil (67.4%) suggests greater oxidative stability, whereas slightly higher palmitic and linoleic acids in pomace compared to pulp indicate minor compositional differences due to extraction methods.

Environmental conditions also play a significant role in fatty acid variation. (Daget *et al.*, 2024) observed that elevated temperatures reduce oleic acid levels, while increasing palmitic, linoleic, and linolenic acids. This trend has been reported for Arbequina cultivars across different regions, confirming that both **genetic and climatic factors** influence fatty acid profiles (Ferreiro *et al.*, 2025).

CONCLUSION AND RECOMMENDATIONS

This study provides a comprehensive evaluation of the physicochemical properties and fatty acid profile of Arbequina pulp and pomace oils extracted under local conditions. The analysis revealed that oleic acid was the predominant fatty acid, followed by linoleic and palmitic acids, highlighting the nutritional importance of these oils. Pulp oil was found to be more unsaturated, whereas pomace oil showed greater oxidative stability, reflecting their complementary qualities. These findings suggest that both pulp and pomace oils from Arbequina can serve as valuable sources of healthy lipids with potential applications in human nutrition, food processing, and value-added product development. Furthermore, this work fills a notable research gap by generating baseline data on Arbequina oils produced locally, which may guide

future studies on varietal performance, processing techniques, and storage stability to enhance the utilization and commercialization of these oils.

Recommendations

Arbequina pulp and pomace oils should be promoted as high-quality local olive oils due to their favorable physicochemical and fatty acid properties.

Further studies are needed to analyze micronutrients and vitamins (A, B, C, E) in Arbequina oils to strengthen their nutritional profile.

Research on extraction methods should be conducted to improve both yield and oil quality.

Storage stability studies are recommended to enhance the shelf life and oxidative stability of Arbequina oils.

The potential use of Arbequina oils in functional foods and nutraceuticals should be further explored.

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Online ISSN

3007-3197

Print ISSN

3007-3189

<http://amresearchreview.com/index.php/Journal/about>

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