Journal of Agricultural, Environmental and Veterinary Sciences (JAEVS) • Vol 9, Issue 4 (2025) • P: 94 - 88
https://journals.ajsrp.com/index.php/jaevs
ISSN: 2522-3364 (Online) • ISSN: 2522-3364 (Print)

Sustainable Valorization of Olive Oil By-products for Food Applications: Mini Review

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Received: 23/08/2025

Revised: 03/09/2025

Accepted: 28/09/2025

Published: 15/12/2025

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Citation: Almasaudi, O. H., Azhari, A., & Gadallah, M. G. (2025). Sustainable Valorization of Olive Oil By-products for Food Applications: Mini Review. *Journal of Agricultural, Environmental and Veterinary Sciences, 9*(4), 88 – 94. https://doi.org/10.26389/AJSRP.D250825

Abstract: The production of olive fruits is a major agricultural and industrial activity with significant economic and vital importance. During the pressing process, about 80% of the material becomes a residue called olive pomace, while only 20% is oil. This ratio varies depending on the type of olive fruit and the extraction method employed, which presents a major challenge for olive presses in terms of draining, disposing of the residue, and protecting the environment. (Medeiros et al., 2016).

The chemical analysis of waste from the olive oil industry shows it is high in dietary fiber (54.5%), lipids (11.5%), protein (8.9%), fatty acids, minerals (4%), and antioxidants. This encouraged researchers to utilize it as a food source to fortify food and to benefit from it in the improvement and development of food products as value-added ingredients (Nunes et al., 2019). Some previous studies have also demonstrated the high nutritional value of olive oil industry waste in preventing atherosclerosis, diabetes, obesity, and many other chronic diseases. Additionally, many studies have focused solely on extracting phenols from olive oil industry waste for pharmaceutical and cosmetic uses (Difonzo et al., 2021).

The goal of this review is to highlight the positive features of olive pomace, allowing for the introduction of its important components into the development of certain food items. This technology aims to improve the nutritional profile of these meals while also addressing environmental problems related to the disposal of this byproduct.

Keywords: Olive oil, olive oil pomace, bioactive contents, food Industry.

التقييم المستدام لمنتجات صناعة زيت الزيتون الثانوية في تطبيقات الأغذية

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كلية الزراعة والأغذية | جامعة القصيم | المملكة العربية السعودية

المستخلص: يُعد إنتاج ثمار الزيتون نشاطًا زراعيًا وصناعيًا رئيسيًا ذا أهمية اقتصادية وحيوية كبيرة. وخلال عملية العصر، يتحول حوالي 80% من المادة إلى بقايا تُعرف باسم "تفلة الزيتون"، بينما يشكل الزيت فقط 20%. وتختلف هذه النسبة حسب نوع ثمار الزيتون وطريقة الاستخلاص المستخدمة، مما يشكل تحديًا كبيرًا لمعاصر الزيتون من حيث تصريف هذه البقايا والتخلص منها وحماية البيئة. (Medeiros وآخرون، 2016).

تُظهر التحاليل الكيميائية لمخلفات صناعة زيت الزيتون أنها غنية بالألياف الغذائية (54.5%)، والدهون (11.5%)، والبروتين (8.9%)، والأحماض الدهنية، والمعادن (4%)، ومضادات الأكسدة. وقد شجّع هذا الباحثين على استخدامها كمصدر غذائي لتدعيم الأغذية والاستفادة منها في تحسين وتطوير المنتجات الغذائية كمكونات ذات قيمة مضافة. (Nunes وآخرون، 2019)

كما أظهرت بعض الدراسات السابقة القيمة الغذائية العالية لمخلفات صناعة زيت الزيتون في الوقاية من تصلب الشرايين، والسكري، والسمنة، والعديد من الأمراض المزمنة الأخرى. بالإضافة إلى ذلك، ركزت العديد من الدراسات على استخراج المركبات الفينولية فقط من هذه المخلفات لاستخدامها في المجالات الدوائية والتجميلية. (Difonzo وآخرون، 2021)

يهدف هذا الاستعراض إلى تسليط الضوء على الجوانب الإيجابية لتفلة الزيتون، مما يسمح بإدخال مكوناتها المهمة في تطوير بعض المنتجات الغذائية. وتستهدف هذه التقنية تحسين القيمة الغذائية لتلك الوجبات، إلى جانب معالجة المشكلات البيئية المتعلقة بالتخلص من هذا الناتج الثانوي.

الكلمات المفتاحية: زيت الزيتون، تفل زيت الزيتون، المحتويات البيولوجية النشطة، صناعة الأغذية.

Introduction:

Olive is a popular fruit of all civilizations worldwide with multifaceted use purposes. It is widely appreciated and integrated as a main ingredient in the daily diet of several countries (Rivas-Garcia et al. 2023).

Global olive oil production has increased significantly, rising from approximately 1.8 million tons per year in the early 1990s to around 3 million tons annually by 2017 (International Olive Council, 2019). The byproducts from olive processing, including olive mill wastewater (OMW), have significant adverse effects on the environment. These impacts include threats to aquatic life, the release of unpleasant odors, the formation of dense membranes that block oxygen flow, color changes in natural water bodies, and overall toxicity (Yaya et al., 2012).

The industry of olive has experienced substantial growth within the Mediterranean basin, characterized by the rapid production of olive oil in considerable volumes. However, the processing chain associated with olive oil production resulted in the generation of significant quantities…throughout the processing chain. This byproduct presents significant environmental challenges in the Mediterranean region, necessitating careful management and mitigation strategies to address the resulting ecological impacts. In recent years, the food industry has generated substantial quantities of both solid and liquid waste, presenting significant challenges related to disposal and environmental pollution.

Despite of the economic and dietetic benefits of olive oil, huge amounts of wastes are generated either in the cultivation fields from pruning or in the olive mills during olive oil processing. Therefore, it is of importance to consider all potential pathways for circular economy in the olive oil supply chain. Stempfle et al. (**2021**) mapped these potential pathways based on an intensive literature review study.

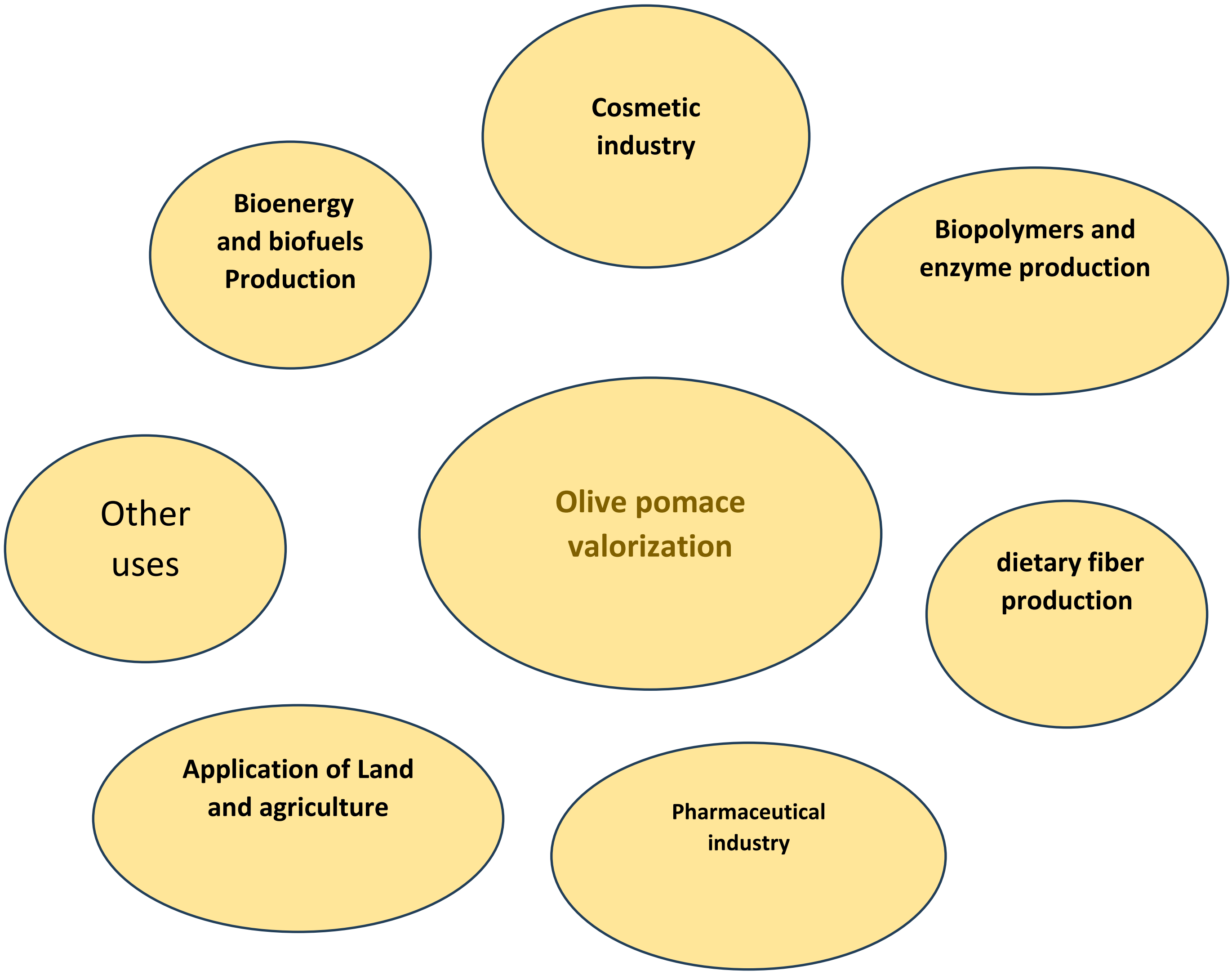

Fig 1. Industries that maximize olive pomace

Chemical Composition of Olive Pomace:

Olive pomace, a byproduct of olive oil extraction, exhibits a diverse composition influenced by several factors, including the variety of olives used, agricultural practices, storage duration, and extraction methodologies. Typically, olive pomace comprises approximately 75–80% dry matter, with mineral content ranging from 3–5%. The total nitrogenous fraction constitutes about 5–10% of its composition. In addition, the average cellulose content is reported to be between 35–50%, while the fatty matter accounts for 8–15% of the pomace (Dermeche et al. 2021).

Pomace is primarily a lignin-rich component derived from seed fragments. It also contains a section high in carbohydrates, including cellulose and hemicellulose. Smaller proportions of protein and oil are also present. The exact quantities depend on how it was processed.

Components	Percentage (%)	References
Oils	20	Dermeche et al. (2013)
Water	48	Dermeche et al. (2013)
Mineral materials	1.6–2.5	Dermeche et al. (2013)
Mono et disaccharides	3	Dermeche et al. (2013)
Polysaccharides (hemicelluloses, celluloses, pectin's)	27	Dermeche et al. (2013)
pH	2.24–5.9	Dermeche et al. (2013) and Akar et al. (2009)
Electrical conductivity (dS/m)	5.5–10	Dermeche et al. (2013) and Aggoun et al. (2016)
Total carbon (%)	2–3.3	Rajhi etal. (2018) and Regni et al. (2021)
Organic matter (%)	57.2–62.1	Dermeche et al. (2013) and Foti et al. (2021)
Chemical oxygen demand (g/L)	30–320	Al Bawab et al. (2018)
Total organic carbon (g/L)	20.19–39.8	Dermeche et al. (2013) and Rahmanian et al. (2014)
Total suspended solids (g/L)	25–30	Elayadi et al. (2019)
Mineral suspended solids (g/L)	1.5–1.9	Mauro et al. (2019)
Mineral solids (g/L)	6.7	Mauro et al. (2019)
Total nitrogen (%)	0.63	Bombino et al. (2021)and Ochando-Pulido et al. (2017)
Total phenols (%)	0.63–5.45	Al Bawab et al. (2018) and Mauro et al. (2019)
Fe (%)	0.26 ± 0.03	Dermeche et al. (2013)
Cu (%)	0.0022	Dermeche et al. (2013), Bombino et al. (2021) and Ochando-Pulido et al. (2017)
Zn (%)	0.0057	Dermeche et al. (2013), Bombino et al. (2021)

Table 1. Main bioactive compounds identified in olive oil and principal by-products of its production

Extraction of olive oil and its related By-Products:

Olive oil (OO) production generates significant amounts of by-products, including olive leaves and pruning residues, olive pomace, OO wastewater, and olive stones. These by-products are rich in bioactive compounds, particularly polyphenols and secoiridoids, which possess antioxidant, anti-inflammatory, antimicrobial, and cardio-protective properties. However, their stability and bioavailability remain challenges, necessitating innovative recovery and stabilization techniques, highlighting their potential in high-value industries such as food, cosmetics, nutraceuticals, and pharmaceuticals

Olive oil can be obtained by several methods, which are generally divided into three main categories based on the physical forces and water consumption during separation (Yang et al., 2019; Silva and Schmiele, 2021). These methods include pressing, centrifugation, and percolation olive oil (OO) extraction process has been studied using stone mortars since 5000 BC. Three different techniques are used to extract OL from olives, including traditional presses and two- or three-phase centrifugation systems (Ammari et al., 2025). The growing demand for OO necessitates the refinement and development of extraction techniques to meet this demand (Mili and Bouhaddane, 2021). At the same time, new agricultural policies adopted in several countries have led to an increase in the number of new plantations to meet the growing demand for OO (Neves and Pires, 2018).Olive oil (OO) production generates substantial residues, estimated at 30 million m^3 annually, which pose significant economic and environmental challenges due to high organic loads and phytotoxic compounds (Ammari et al. 2025; Abboud et al. 2025). The conversion of OO waste into sustainable bioenergy can mitigate environmental burdens and support the green economy by decreasing fossil fuel reliance (Alharbi and Ghonimy 2025). However, the nutritional and bio-functional potential of OO by-products remains largely untapped. Consequently, there is a pressing need to explore sustainable technological strategies for valorizing these liquid and solid by-products to enhance their utility while fostering innovation and environmental sustainability.

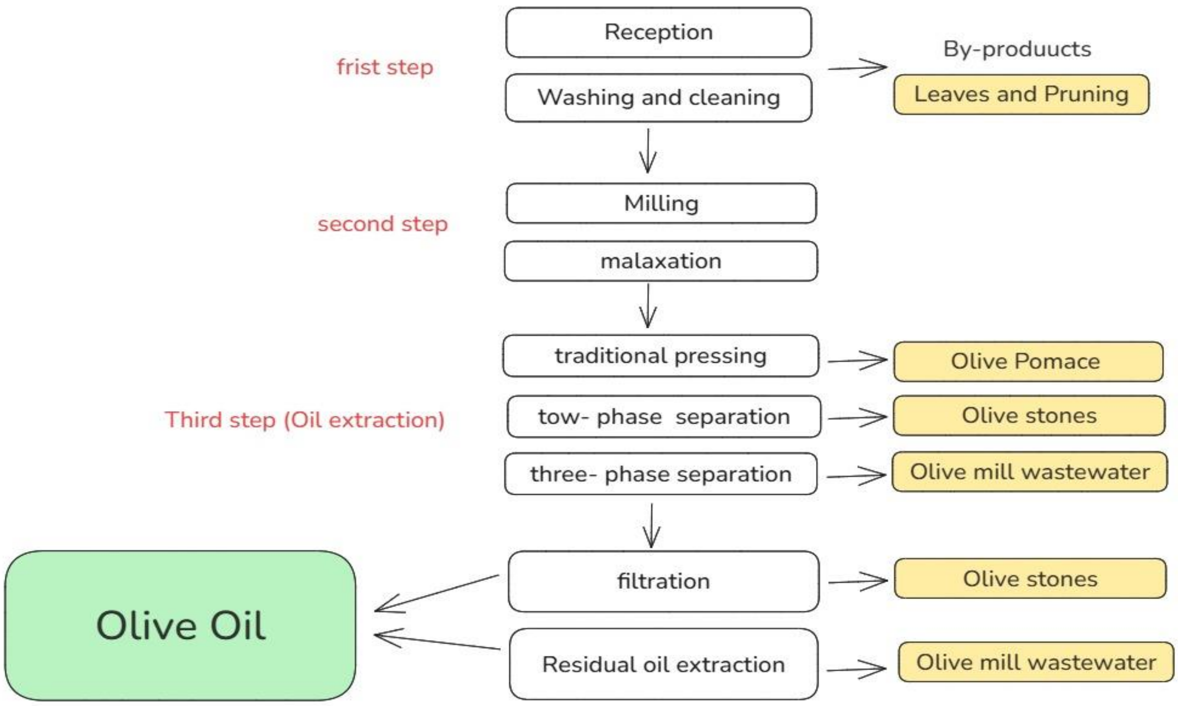

Fig. 2. Process of olive oil production and its by-products.

Food industry byproducts pose significant environmental and economic challenges (Goldsmith et al., 2018). Consequently, there is growing interest in reusing food industry byproducts as they can be a potential source of energy and bioactive compounds. These bioactive compounds from food industry byproducts can be used to enrich various food products, pharmaceuticals, and cosmetics (Galanakis, 2022). In the Mediterranean region, olive oil is the primary edible vegetable oil, widely consumed in large quantities and valued for its health-promoting bioactive properties (Jimenez-Lopez et al., 2020). Currently, olive oil production is a significant source of income for Mediterranean countries, with only about 2% of global olive oil production originating from outside the region. Extra virgin olive oil production involves a process that generates large amounts of waste, such as olive leaves and olive wood, as well as byproducts such as olive pomace and wastewater. These waste streams present a critical issue for Mediterranean countries, as increased olive oil production leads to a rapid rise in waste and by-product quantities (Banias et al., 2017).

Utilization of olive pomace in the food industry:

Olive pomace is produced in large quantities as a byproduct of olive oil processing. It represents a promising source of polyphenolic compounds and fiber that could find applications in the food industry.

To meet the high expectations and growing demands of consumers for a healthier lifestyle, who want to consume foods with fewer synthetic preservatives, there is a trend toward incorporating olive pomace byproducts as natural preservatives and technologically functional ingredients into food production, in line with an integrated strategy consistent with a responsible environmental and social impact (Laura et al., 2025).

Khaled et al. (2020) conducted a study to examine how different extracting solvents affect the recovery of phenolic compounds from olive pomace produced by a two-phase olive oil extraction process. The study measured total phenolic content, flavonoids, and flavonols, along with the antioxidant activity of the extracts using the DPPH assay. Additionally, cellulose from olive pomace was added at various concentrations to bread formulations to evaluate its effect on bread quality. The proximate chemical analysis of the olive pomace showed the following composition on a fresh weight basis: protein (2.48%), fat (2.33%), ash (1.33%), and fiber (20.37%). In total, seven solvents were tested for their effectiveness in extracting phenolic compounds.

Olive pomace (OP) is known for its high fiber content, mainly cellulose (40.7% of total fiber). The total phenolic content in various OP extracts ranges from 8.29 to 36.24 mg GAE per gram, while total flavonoids range from 2.23 to 12.52 mg QE per gram. Antioxidant activity was strongest in an 80:20 methanol-water extract, with an EC50 of 1.373 µg/µg DPPH, compared to the acetone extract, which had an EC50 of 8.052 µg/µg DPPH. Incorporating cellulose isolated from OP into toast bread at levels of 2%, 4%, and 6% showed no significant sensory differences between the control and the 2% cellulose sample. The 2% addition notably improved the bread's texture and was more acceptable than the control. Overall, the results suggest that olive pomace is a valuable source of dietary fiber and polyphenolic compounds, with potential uses in the food industry.

Pamela et al. (2023) developed biscuits with partial wheat flour substitution using olive pomace flour (OPF). The substitution levels used were 0%, 10%, and 20%. They examined how these flours affected the chemical composition, lipid profile, and sensory attributes of the biscuits. The results showed that OPF has a high dietary fiber content of 43.75% and lipid content of 27.70%. Biscuits with 10% OPF contained 4.29% dietary fiber and 22.61% lipids, while those with 20% OPF had 8.52% dietary fiber and 23.78% lipids. Adding OPF increased levels of lipids, minerals, and dietary fiber.

Annamarie et al. (2019) studied how adding dry olive paste flour (DOPF) from the Cellina di Nardò variety influences bread's sensory and nutritional qualities. Their results showed that including DOPF increased overall phenolic compounds, flavonoids, and antioxidant activity, while the bread remained generally acceptable. The bioavailability of polyphenols after digestion was 59.3% in the control bread and 72.1% in the DOPF-enriched bread. Additionally, the glycemic response of the fortified bread was significantly improved.

Studies show that cereal products are effective carriers of bioactive compounds, mainly due to their high consumption (Duranti, 2006). Pasta is especially notable, ranking among the most consumed foods worldwide. A recent study examined the sensory and nutritional properties of durum wheat pasta, aiming to improve its composition by adding an industrial byproduct of olive oil production, known as olive paste. The results indicated that spaghetti containing 10% olive paste flour and 0.6% transglutaminase received positive sensory reviews from the panel. Nutritional analysis revealed that adding 10% olive paste flour significantly increased the overall flavonoid and polyphenol levels in the pasta. This strategic use of olive paste flour with transglutaminase offers a promising initial approach for utilizing industrial byproducts from olive oil production, helping to develop new, health-promoting food products (Padalino et al., 2018).

Additionally, a functional yogurt fortified with olive pomace lipid bioactive, administered to 92 overweight but otherwise healthy volunteers in a randomized double-blind, three-arm trial, resulted in decreased activity of the main regulatory enzymes of Platelet-Activating-Factor (PAF) biosynthesis. Thus, consuming yogurt fortified with olive pomace may optimize PAF-biosynthesis and catabolic pathways (Schieber et al., 2001).

It is worth mentioning that consumption of fortified biscuits led to a significant increase of the amounts of homovanillic acid and 3,4-dihydroxyphenyl acetic acid, as compared to the control samples, which may consequently minimize oxidative LDL cholesterol; additionally, the raising levels of phenolic acids in urine have suggested a boost of these bioactive modifications in the intestine (Conterno et al., 2019 and Lin et al., 2017).

Conclusion:

The olive oil industry produces a considerable amount of waste each year, which poses potential risks to vegetation. However, olive oil is rich in valuable natural compounds that can be utilized in food products. The reduction of waste and the effective utilization of by-products not only enhances the value of the industry but also contributes positively to both its financial viability and environmental sustainability. Olive pomace, the principal waste by-product of olive oil production, represents a significant opportunity for olive growers when utilized effectively. This practice supports the establishment of a green production system, aligning with contemporary bio-economy concepts.

In recent years, there has been a growing recognition of the importance of environmental protection alongside an increasing demand for the sustainable valorization of olive oil co-products. This dual awareness has prompted leading scientists and industries to harness these natural resources and explore innovative alternatives. Presently, the integration of bioactive components, particularly phenolic compounds derived from the olive oil production process, is becoming a prominent trend within the pharmaceutical and food sectors as a source of nutraceuticals and food additives.

References:

- Annamaria, C., Amalia, C., Angela, C. (2019). Enrichment of Bread with Olive Oil Industrial By-Product. Journal of Agricultural Science and Technology. DOI: 10.17265/2161-6264/2019.02.005.
- Dermeche, S., Nadour, M., Larroche, C., Moulti-Mati, F., Michaud, P. (2013). Olive mill wastes: biochemical characterizations and valorization strategies. Process Biochem 48(10):1532–1552. https://doi. org/10.1016/j.procbio.2013.07.010.
- Jimenez-Lopez C, Carpena M, Lourenço-Lopes C, et al. (2020) Bioactive compounds and quality of extra virgin olive oil. Foods 9: 1014. https://doi.org/10.3390/foods9081014
- Aggoun, M., Arhab, R., Cornu, A., Portelli, J., Barkat, M., Graulet, B. (2016). Olive mill wastewater micro constituent's composition according to olive variety and extraction process. Food Chem 209:72–80.
- Akar, T., Tosun, I., Kaynak, Z., Ozkara, E., Yeni, O., Sahin, E. N., Akar, S. T. (2009). An attractive agro-industrial by-product in environmental cleanup: Dye biosorption potential of untreated olive pomace. J Hazard Mater 166:1217–1225.
- Al Bawab, A., Ghannam, N., Abu-Mallouh, S., Bozeya, A., Abu-Zurayk, R. A., Al-Ajlouni, Y. A., Abu-Dalo, M. A. (2018). Olive mill wastewater treatment in Jordan: a review. IOP Conf Ser Mater Sci Eng 305(1):012002.
- Alharbi, A., and M. Ghonimy. (2025). Environmental Benefits of Olive by Products in Energy, Soil, and Sustainable Management." Sustainability17: 4722.
- Ammari, M., M. Merzouki, I. Zoufri, Y. El-Byari, and K. Faiz. (2025). "Assessment of the Impact of the Three Different Methods of Crushing Olives on the Microbiological and Physicochemical Properties of Wastewater in Olive Mills." Environmental Monitoring and Assessment 197: 315. https://doi.org/10.1007/s10661-025-13681-8.
- Banias, G., Achillas, C., Vlachokostas, C., et al. (2017) Environmental impacts in the life cycle of olive oil: A literature review. J Sci Food Agric 97: 1686–1697. https://doi.org/10.1002/jsfa.8143
- Bombino, G., Andiloro, S., Folino, A., Lucas-Borja, M. E., Zema, D. A. (2021). Short-term effects of olive oil mill wastewater application on soil water repellency. Agric Water Manag 244:106563.
- Conterno, L., Martinelli, F., Tamburini, M., et al. (2019). Measuring the impact of olive pomace enriched biscuits on the gut microbiota and its metabolic activity in mildly hypercholesterolemia subjects. https://doi.org/10.1007/s00394-017-1572-2 high Eur J Nutr 58: 63–81.
- Difonzo, G., Troilo, M., Squeo, G., Pasqualone, A., and Caponio, F. (2021). Functional compounds from olive pomace to obtain high added value foods–a review. Journal of the Science of Food and Agriculture, 101(1), 15-26. http://dx.doi.org/10.1002/jsfa.10478. PMid:32388855
- Domenech, P., Duque, A., Higueras, I., Fernandez, J. L., Manzanares, P. (2021). Analytical characterization of water-soluble constituents in olive-derived by-products. Foods 10:1299. https://doi.org/10. 3390/foods10061299.
- Elayadi, F., El Adlouni, C., El Herradi, M. A. E., El Krati, M., Tahiri, S., Naman, M. N. F. (2019). Effects of raw and treated olive mill wastewater (OMW) by coagulation-flocculation, on the germination and the growth of three plant species (wheat, white beans, lettuce). Moroccan J Chem 7(1):7–- Abboud, S., A. Ouni, N. Sghaier, R. A. B. Abdallah, and S. Dbara. (2025). "Phytotoxicity Evaluation of Olive Mill Solid Wastes and Their Feasibility as Biofertiliser." Soil Use and Management 41: e70071. https://doi.org/10. 1111/sum.70071.
- Foti, P., Romeo, F. V., Russo, N., Pino, A., Vaccalluzzo, A., Caggia, C., Randazzo, C. L. (2021). Olive mill wastewater as renewable raw materials to generate high added-value ingredients for agro-food industries. Appl Sci 11(16):7511.
- Galanakis CM (2022) Sustainable applications for the valorization of cereal processing by-products. Foods 11: 241. https://doi.org/10.3390/foods11020241
- Goldsmith CD, Vuong QV, Stathopoulos CE, et al. (2018) Ultrasound increases the aqueous extraction of phenolic compounds with high antioxidant activity from olive pomace. LWT 89: 284–290. https://doi.org/10.1016/j.lwt.2017.10.065
- International Olive Council, (2019). World olive oil and table olive figures. [Online] Available at: https://www.internationaloliveoil.org/what-we-do/ economic-affairs-promotion-unit figures [Accessed 20 6 2019].
- Khaled, A. S., Waleed, Z. B. and Smetanska, I. (2020). Utilization of Olive Pomace As A Source of Bioactive Compounds in Quality Improving of Toast Bread. Egypt. J. Food. Sci. Vol. 48, No.1, pp. 27-40 (2020).
- Laura, A., Hassan, L., Driss, O., Meryem, B., Badiaa, L., Pedro, F. (2025). Sustainable Valorization of Olive Oil By-Products: Green Extraction of Phytochemicals, Encapsulation Strategies, and Food Applications. Journal of Food Science; https://doi.org/10.1111/1750-3841.70412.
- Lin, S., Chi, W., Hu, J., et al. (2017). Sensory and nutritional properties of Chinese olive pomace based fiber biscuit. Emirates https://doi.org/10.9755/ejfa.2016-12-1908.

- Medeiros, R. M. L., Villa, F., Silva, D. F., and Cardoso, L. R. Fo. (2016). Destinação e reaproveitamento de subprodutos da extração olivícola. Scientia Agrária Paranaensis, 15(2), 100-108. http://dx.doi. org/10.18188/1983-1471/sap.v15n2p100-108.
- Mili, S., and M. Bouhaddane (2021). "Forecasting Global Developments and Challenges in Olive Oil Supply and Demand: A Delphi Survey from Spain." Agriculture 11: 191. https://doi.org/10.3390/agriculture11030191.
- Neves, B., and Pires, M. (2018). "The Mediterranean Diet and the Increasing Demand of the Olive Oil Sector: Shifts and Environmental Consequences." Region 5: 101–112. https://doi.org/10.18335/region.v5i1. 219.
- Nunes, M. A., Pawlowski, S., Costa, A. S. G., Alves, R. C., Oliveira, M. B. P. P., and Velizarov, S. (2019). Valorization of olive pomace by a green integrated approach applying sustainable extraction and membrane-assisted concentration. Science of The Total Environment, 652, 40–47. https://doi.org/10.1016/j.scitotenv.2018.10.204
- Ochando-Pulido, J. M., Pimentel-Moral, S., Verardo, V., Martinez-Ferez, A. (2017) A focus on advanced physico-chemical processes for olive mill wastewater treatment. Sep Purif Technol 179:161–174.
- Padalino, L., D'Antuono, I., Durante, M., Conte, A., Cardinali, A., Linsalata, V., Mita, G., Logrieco, A. F., & Del Nobile, M. A. (2018). Use of Olive Oil Industrial By-Product for Pasta Enrichment. Antioxidants, 7(4), 59. https://doi.org/10.3390/antiox7040059
- Pamela C. O., Alice, d. C., Camila, S. M., Roger, W., Bibiana, A., Flávia, M., Silvani, V., Cláudia, S., (2023). Development and characterization of biscuits with olive pomace, Food Science and Technology, DOI: https://doi.org/10.1590/fst.99922.
- Rahmanian, N., Jafari, S. M., Galanakis, C. M. (2014). Recovery and removal of phenolic compounds from olive mill wastewater. J Am Oil Chem Soc 91(1):1–18.
- Rajhi, H., Mnif, I., Abichou, M., Rhouma, A. (2018). Assessment and valorization of treated and non-treated olive mill wastewater (OMW) in the dry region. Int J Recycl Org Waste Agric 7(3):199–210.
- Regni, L., Pezzolla, D., Ciancaleoni, S., Marozzi, G., Albertini, E., Gigliotti, G., Proietti, P. (2021). Long term effects of amendment with olive mill wastewater on soil chemical properties, microbial community, and olive tree vegetative and productive activities. Agronomy 11(12):2562.
- Rivas-Garcia, L., M. D. Navarro-Hortal, J. M. Romero-Marquez, et al. (2023). "Valorization of Olea europaea and Olive Oil Processing By-Products/Wastes." In Advances in Food and Nutrition Research, 193–212. Academic Press. https://doi.org/10.1016/bs.afnr.2023.07.001.
- Silva, B. S., Schmiele, M. (2021) From olive to olive oil: a general approach. Res Soc Dev 10(3):32210313408–e32210313408.
- Stempfle, S., Carlucci, D., de Gennaro, B. C., Roselli, L., & Giannoccaro, G. (2021). Available pathways for operationalizing circular economy into the olive oil supply chain: Mapping evidence from a scoping literature review. Sustainability, 13, 9789.
- Yang, S., Hallett, I., Oh, H. E., Woolf, A. B., Wong, M. (2019) Application of electrical impedance spectroscopy and rheology to monitor changes in olive (Olea europaea L.) pulp during cold-pressed oil extraction. J Food Eng 245:96–103.
- Yaya, A., Oral, H., Onay, T. and Yenigün, O., (2012). A study on olive oil mill wastewater management in Turkey: a questionnaire and experimental approach. Res. Conserv. Recycl. 60, 64–71.