processes

MDPI

Review

Active Polymer Films with Olive Leaf Extract: Potential for Food Packaging, Biomedical, and Cosmetic Applications

Sylwia Grabska-Zielińska

Faculty of Chemical Technology and Engineering, Bydgoszcz University of Science and Technology, Seminaryjna 3, 85-326 Bydgoszcz, Poland; sylwia.grabska-zielinska@pbs.edu.pl

Abstract: This review paper highlights the latest advancements in polymer films modified with olive leaf extract (OLE) for various applications, particularly in food packaging. The overview is focused on the preparation, properties, and multifunctionality of OLE-enhanced polymer materials. Olive leaf extract, known for its antibacterial, antifungal, and antioxidant properties, is also shown to enhance the physicochemical characteristics of polymer films. This review consolidates current knowledge on using OLE as a bioactive additive in polymer-based packaging materials, improving their structural integrity and functionality. In addition to food packaging, the review explores other applications of OLE-modified polymer films in industries such as biomedicine, pharmaceuticals, and cosmetics. The paper also addresses future perspectives in polymer food packaging, suggesting that OLE-modified films offer significant potential for industrial and academic research due to their enhanced properties. Overall, this review provides a comprehensive overview of the role of olive leaf extract in improving the performance of polymer films in diverse fields.

Keywords: olive leaf extract; polymers; films; food packaging; biomedical applications

check for updates

Citation: Grabska-Zielińska, S. Active Polymer Films with Olive Leaf Extract: Potential for Food Packaging, Biomedical, and Cosmetic Applications. *Processes* **2024**, *12*, 2329. https://doi.org/10.3390/pr12112329

Academic Editor: Pavel Mokrejš

Received: 15 September 2024
Revised: 15 October 2024
Accepted: 22 October 2024
Published: 24 October 2024

Copyright: © 2024 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Olea europaea L., known as olive, is an evergreen tree belonging to the *Oleaceae* family. It has great commercial and historical importance, especially in the Mediterranean [1,2]. It is an essential plant to extract olive oil, but practically not only olive fruits can be used in various applications. Olive leaves, olive tree pruning biomass, olive pomace, olive mill wastewater (OMWW), and olive stones could be used in different ways, technologies, and industries [3,4].

Olive fruits and olive oil are important elements of the healthy daily diet of a large part of the world's population, while the olive leaves are of interest to scientists and companies dealing with supplementation, packaging materials, and the food industry, thanks to their high amount of polyphenolic compounds [1]. In the past, olive leaves were commonly used as a remedy for fever and other infections, including malaria, in Mediterranean countries such as Spain, Italy, France, Greece, Morocco, Tunisia, Turkey, and Palestine. Nowadays, the use of fresh or dried olive leaves to make olive tea is popular, as well as consuming their dried, powdered, capsulated form as dietary supplements [5]. Olive leaves are becoming more popular as tea and dietary supplements because they are believed to have antimicrobial, antifungal, antioxidant, hypoglycemic, anti-hypertensive, hypocholesterolemia, and anti-inflammatory properties [5–8].

Olive leaf extract is rich in a large variety of phenolic derivatives, which consist of simple phenols (the most common and important low-molecular-weight phenolic compounds), flavonoids (flavones, flavanones, flavonols, and flavan-3-ols), secoiridoids, and other compounds [2]. Several studies focus on the extraction of olive leaves and the analysis of the phenolic compound composition in the resulting extracts. However, the analysis of these results indicates that the presence of different phenolic compounds in OLE depends on such factors as olive tree cultivation, harvest season and period, environmental and

climatic conditions, plant diseases, maturity, moisture content, time and temperature of extraction, solvent, pH, solvent-to-substrate ratio, adsorbent [8–10]. In addition, it was determined that the extraction method significantly affects the amount and composition of extract obtained from olive leaves. Scientists have adopted numerous extraction methods (conventional and latest) to obtain OLE. Among these techniques maceration, cold solvent extraction, Soxhlet extraction, microwave-assisted extraction, ultrasound-assisted extraction, supercritical fluid extraction, and pressurized liquid methods are commonly used [10–13]. Taking into account the above, it is important to evaluate the composition of the particularly obtained and used OLE. An example list of compounds present in the chloroformic OLE is given in Table 1. The study was performed by LC-MS/MS using negative ionization according to the method described in detail elsewhere [14].

Table 1. Phenolic compounds identified by LC-MS/MS using the negative ionization mode of Chemlali olive leaf cultivar extract. Olive leaves have been collected from Sfax (Tunisia) in July 2019. Adapted from S. Grabska-Zielińska et al., "Polylactide Films with the Addition of Olive Leaf Extract—Physicochemical Characterization" [9].

N°	Molar Mass	Chemical Formula	Compound
1	170.0215	$C_7H_6O_5$	Gallic acid
2	154.0630	$C_8H_{10}O_3$	Hydroxytyrosol
3	180.0425	$C_9H_8O_4$	Caffeic acid
4	640.2003	$C_{29}H_{36}O_{16}$	β-hydroxyverbascoside III
5	610.1534	$C_{27}H_{30}O_{16}$	Quercetin 3-*O*-rutinoside (rutin)
6	624.2054	$C_{29}H_{36}O_{15}$	Verbascoside
7	448.1006	$C_{21}H_{20}O_{11}$	Luteolin 7-*O*-glucoside
8	702.2371	$C_{31}H_{42}O_{18}$	Oleuropein hexoside I
9	624.2054	$C_{29}H_{36}O_{15}$	Isoverbascoside
10	432.1056	$C_{21}H_{20}O_{10}$	Apigenin 7-*O*-glucoside
11	540.1843	$C_{25}H_{32}O_{13}$	Oleuropein I
12	540.1843	$C_{25}H_{32}O_{13}$	Oleuropein II
13	558.2309	$C_{26}H_{38}O_{13}$	6′-*O*-[(2*E*)-2,6-dimethyl-8-hydroxy-2-octenoyloxy]-secologanoside
14	926.3056	$C_{42}H_{54}O_{23}$	Jaspolyoside III

It has been repeatedly reported that oleuropein is the main compound found in olive leaf extract and its content is estimated to be in the range of 17–23% depending upon the harvesting time of the leaves [9,15–17]. Oleuropein is a phenolic secoiridoid glycoside that consists of hydroxytyrosol, elenolic acid, and a glucose molecule. It has been shown to possess anticancer properties, particularly against breast, pancreatic, and prostate cancers. Additionally, oleuropein exhibits various biological activities, including antimicrobial, hypoglycemic, antioxidant, antiviral, anti-hypertensive, hepatoprotective, and neuroprotective effects [17–20]. As the most abundant bioactive compound in olive leaves, oleuropein serves as a chemotaxonomic marker in the Oleaceae family. Numerous articles in the literature summarize its known biological activities and significance [17–22]. Olive leaf extract, particularly oleuropein, has been demonstrated to be non-toxic [23–26]. It showed no mutagenic or genotoxic effects in multiple tests, including the bacterial reverse mutation test, in vitro mammalian chromosomal aberration test, and in vivo mouse micronucleus test. The NOAEL was established at 1000 mg/kg bw/d in a 90-day study [26]. The safety of olive leaf extract (based on the Bonolive™—proprietary water-soluble extract of the leaves of the olive tree *Olea europaea* L.) is also corroborated by the lack of treatment-related adverse events in the long-term (12 months) clinical trial, the history of safe ingestion

of olive leaves as animal feed, and consumption of olive-based products by humans that contain many of the same constituents, such as table olives, olive oils, and other olive-derived products with a lack of known toxicity [26].

Regardless of the extractant (water, chloroform, hexane, acetonitrile, diethyl ether, ethanol, 80% ethanol, 20% methanol), olive leaf extract exhibited antibacterial and antifungal activity [1]. Table 2 shows the microorganisms against which the extract was active. The antimicrobial activity studies were performed for the whole extracts, because extracts may be more beneficial than isolated constituents since a bioactive individual component can change its properties in the presence of other compounds present in the extracts [1,27]. Additionally, the additive and synergistic effects of phytochemicals in fruits and vegetables are responsible for their potent bioactive properties [1,28].

Table 2. The antimicrobial and antibacterial activity of olive leaf extract.

Type of Microorganism	Microorganism	References
Gram + bacteria	*Bacillus cereus*	[1,29]
	Bacillus subtilis	[1]
	Staphylococcus aureus	[1,29–34]
	Staphylococcus epidermidis	[34]
	Staphylococcus hominis	[6,35]
	Staphylococcus xylosus	[6,35]
	Staphylococcus capitis	[6,35]
	Listeria monocytogenes	[32,33,36]
	Listeria innocua	[37]
	Enterococcus faecalis	[30]
	Kocuria rhizophila	[6,35]
	Lactobacillus acidophilus	[6,35]
	Lactobacillus casei	[6,35]
	Micrococcus luteus	[6,35]
	Streptococcus pyogenes	[6,35]
Gram − bacteria	*Escherichia coli*	[1,29–33,36]
	Pseudomonas aeruginosa	[1,30]
	Klebsiella pneumoniae	[1,29]
	Klebsiella aerogenes	[38]
	Yersinia enterocolitica	[33,34]
	Vibrio parahaemolyticus	[39]
	Enterobacter cloacae	[38]
	Campylobacter jejuni	[37]
	Salmonella Typhimurium	[29,33]
	Salmonella enterica	[40]
	Salmonella Typhi	[39]
	Salmonella Enteritidis	[32,36]
	Acinetobacter calcoaceticus	[6,35]
	Helicobacter pylori	[6,35]
	Serratia marcescens	[6,35]

Table 2. *Cont.*

Type of Microorganism	Microorganism	References
Fungi	*Cryptococcus neoformans*	[1,8]
	Aspergillus flavus	[41]
	Aspergillus niger	[42]
	Aspergillus fumigatus	[42]
	Candida albicans	[1,8,30]
	Candida glabrata	[8,30]
	Candida krusei	[30]
	Candida parapsilosis	[8,30]
	Candida oleophila	[6,43]
	Saccharomyces uvarum	[6,43]
	Saccharomyces cerevisiae	[6,43]
	Metschnikowia fructicola	[6,43]
	Kloeckera apiculata	[6,43]
	Schizosaccharomyces pombe	[6,43]

What is more, utilizing olive leaf extract is a smart way to repurpose agricultural waste. Large amounts of leaves are left over after tree maintenance, pruning, and olive harvesting, as olives are primarily used for oil pressing and direct consumption. By extracting valuable compounds from these leaves, it does not only reduce waste but also creates sustainable solutions for food packaging and preservation. This approach supports a circular economy, where by-products are efficiently used, contributing to environmental sustainability while adding value to the food industry [15,44,45].

An important aspect of using olive leaf extract in packaging materials is its application in biodegradable polymers. This is particularly significant given the global challenge of waste accumulation and the difficulties associated with recycling. The development of environmentally friendly packaging materials is a priority for researchers as they seek solutions to mitigate the impact of plastic waste on the environment. In this work, various commercial packaging modified with olive leaf extract is also discussed, highlighting the potential of plant-derived substances as natural preservatives with antioxidant and antimicrobial properties. These modifications demonstrate the viability of using plant-based extracts to enhance both the sustainability and functionality of packaging materials [44,45]. All the reasons and motivations for using olive leaf extract are pointed out in Figure 1.

All in all, this review summarizes the current research on polymer films modified with olive leaf extract for food packaging applications. In addition, it discusses other uses of olive leaf extract in the food industry, including its role as a preservative and antimicrobial agent in direct contact with food, as well as encapsulated olive leaf extract for preservation purposes. The article also explores the extract's applications in the biomedical and pharmaceutical industries and briefly mentions its utilization in cosmetics and the synthesis of silver and gold nanoparticles for medical applications.

The motivation for preparing this review stemmed from the lack of comprehensive articles on the use of olive leaf extract as a modifier for polymer films. In this work, a thorough overview of this topic is provided, as no existing review has yet summarized the research in this area. Additionally, the goal of this manuscript was to compile the various applications and studies conducted on olive leaf extract-modified materials in one place, accompanied by relevant references, making it easier for researchers to access and build upon this knowledge.

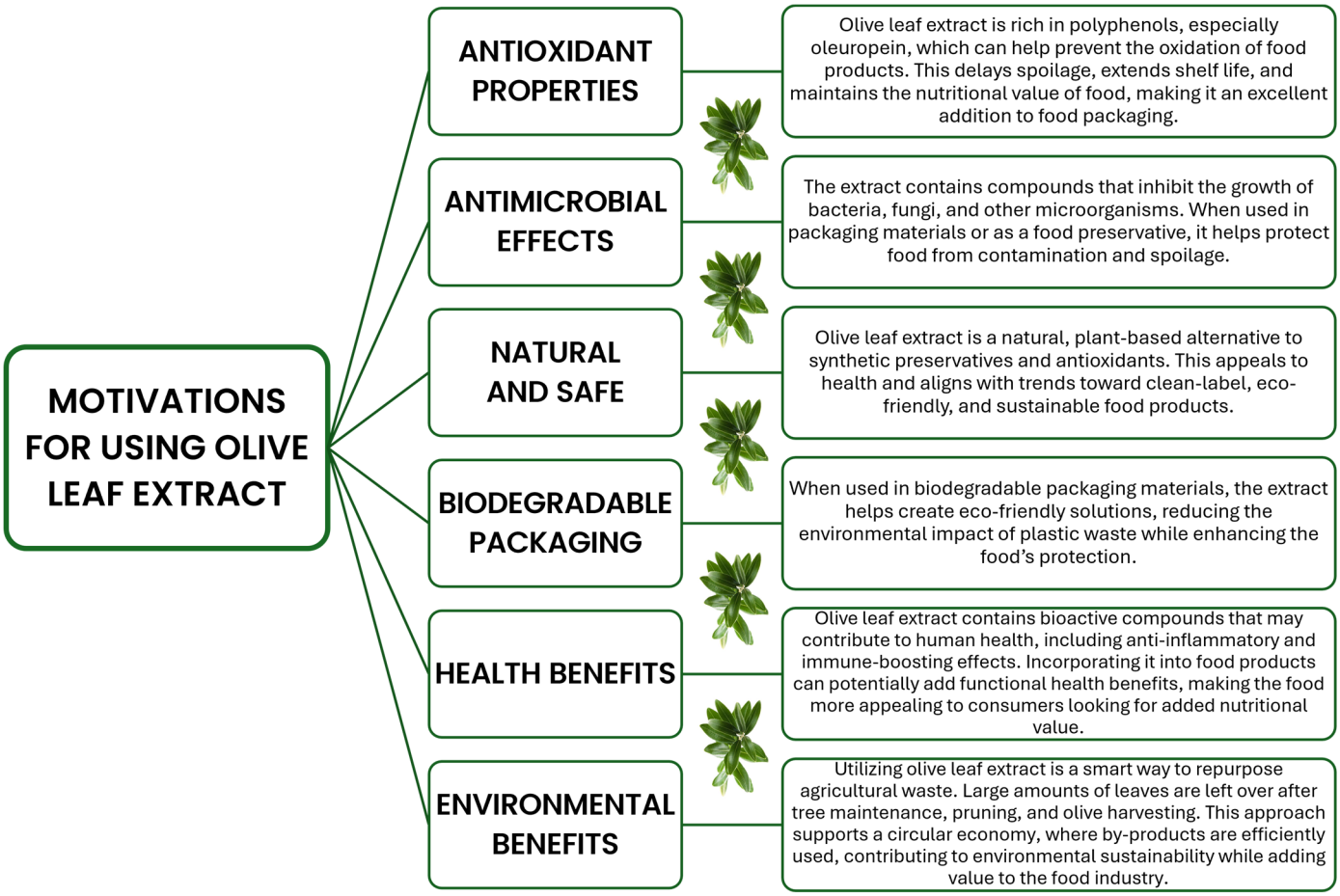


Figure 1. Motivations for using olive leaf extract. The diagram is the author's own work.

2. Incorporation of Olive Leaf Extract in Polymer Films for Food Packaging Applications

Nowadays, advances in food packaging play a primary role in keeping food fresh and safe, as well as in caring for the environment. Consumers want food that is healthy, fresh, high quality, and safe. Moreover, they increasingly pay attention to waste reduction and biodegradability of packaging.

Food packaging materials are very important to ensure the safety of food, to preserve the quality of food, and to extend their shelf life, as well as to prevent food deterioration, which happens as a result of microbial spoilage, metabolism, and oxidation. Food must be protected from the outside world, environmental pollution, and other factors such as light, temperature, humidity, physical damage, dust, odors, and microorganisms.

Epidemiological studies indicate that the number of food-borne illnesses caused by pathogens has increased significantly [46]. They are caused by various types of pathogens. Controlling pathogens could help significantly reduce food-borne epidemics and provide consumers with safe and healthy packaged food products. It can be found that active substances obtained from natural sources have antimicrobial and antibacterial activity. Such substances can serve as packaging additives to inhibit the action of food-borne microorganisms [47]. These naturally active substances can be found in essential oils, herbs, and plants. Thanks to such compounds, it is also possible to achieve longer food storage [46,47].

2.1. Active Packaging Films with OLE

Active packaging is one of the emerging areas where antimicrobial agents are embedded in the packaging materials so those agents can interact with the packaged food in a desirable way to control the growth of microbes. The area of research on food packaging with antimicrobial activity is currently a rapidly growing field. It is happening because it is regarded as an important tool in the combat against most potential food safety hazards [48–51]. Antimicrobial food packaging is one of the most innovative concepts of active packaging, where interactions with the product are envisioned to reduce, inhibit, or delay the growth of microbes that may be present in the packed food or on the surface of the packaging materials, and extend the shelf life of the preserved foodstuffs [48–50,52].

Taking into account the above, scientists are looking for plant extracts and active substances that can modify polymer materials, giving them antibacterial and antioxidant properties. Materials from various polymers, modified with olive leaf extract, are of great interest to science. Olive leaf extract was used to enrich the chitosan (CTS) [53–56], carrageenan (CN) [57–59], gelatin (GEL) [60], methylcellulose (MCEL) [61], sodium alginate (SA) [62], polylactide (PLA) [9,63], polyvinyl alcohol/cellulose (CEL) nanofibers [64], and cellulose nanocrystals/poly(butylene adipate-co-terephthalate) [65] films. Usually, each type of film enriched with OLE was characterized by antioxidant activity, thanks to the high polyphenols content in OLE.

CTS/OLE films exhibited reduced permeability against water vapor, higher solubility in food simulants, and antimicrobial activity against *L. monocytogenes* and *C. jejuni*, which was confirmed by in situ testing using chicken [54]. Nevertheless, the results of antibacterial tests suggest that CTS/OLE films may play an important role in inhibiting microorganisms capable of growing in food at refrigerated temperatures. Furthermore, OLE per se has an inhibitory effect but is not bactericidal at 41.5 °C [54]. When the effect of OLE-enriched CTS films on extending the shelf life of fish fillets was studied, better results were found for 1% than for 2% OLE addition, which can be caused by peroxidation property at high concentrations of the extract [53]. Moreover, the addition of OLE to CTS films improved tensile strength, elongation, and moisture retention capability [55].

G.S. da Rosa et al. [58] and T.R. Martiny et al. [57,59] prepared bio-based active packaging CN films with OLE, and the films were suggested as good materials for the preservation of food products, including lamb meat. The CN/OLE films exhibited good barrier and mechanical properties, with increased stretching capacity, reduced tensile strength, and higher water vapor permeability [58]. Additionally, the CN films enriched with OLE were characterized by changed thickness and color parameters and showed antibacterial activity against *E. coli*, and the packaging demonstrated inhibitory activity of the microbial population in the packed meat product [59]. On the other hand, antibacterial GEL films modified with OLE have been proposed to enhance the quality of cold-smoked salmon. The films significantly reduced the growth of *L. monocytogenes* on the fish over storage [60].

A study of Kasar cheese storage using MCEL films with the addition of OLE is also known [61]. The addition of OLE to MCEL films caused a decrease in water vapor permeation and elongation, and an increase in tensile strength. Antibacterial activity of the films against *S. aureus* and a decrease in the count of *S. aureus* during 7 and 14 days of Kasar cheese storage in the tested films were also observed [61].

If it is about SA films, the addition of OLE improved the barrier properties and promoted changes in resistance and flexibility [62]. Apart from that, the increase in the opacity values after the addition of OLE can help reduce the passage of light and thus be useful to avoid food oxidation. The films showed antibacterial activity against *S. aureus*, and the materials can be advisable for foods with lower water content and potential lipid degradation because of the reduced moisture content and water vapor permeability values after OLE incorporation [62].

Antimicrobial PLA/OLE films showed an antimicrobial effect on *S. aureus* [63]. Moreover, the incorporation of OLE into PLA films had no effect [9] or enhanced [63] the water

vapor permeability, while the color of the polymeric films was strongly dependent on the presence and content of the extract and changed during contact with different solutions (HCl, water, NaOH) [9].

Evaluation of microbial and oxidative changes of 100% Iberian Spanish salchichón in contact with a polyvinyl alcohol/CEL nanofibers composite olive leaf extract food film and vacuum-packaged have been researched by M. Sánchez-Gutiérrez et al. [64]. Only a slight reduction of lipid oxidation and mesophilic aerobic bacteria was observed at 25 °C in the test sample, while at 5 °C no significant differences were found between control and test batches when the active films were tested in contact with sliced 100% Iberian salchichón [64]. CEL nanocrystals/poly(butylene adipate-co-terephthalate) packaging materials have been obtained by melt processing, and their physicochemical properties have been studied [65]. The results corroborate the incorporation of OLE in poly(butylene adipate-co-terephthalate) for food packaging with stable mechanical performance and antioxidant activity and suggest its use in active food packaging [65].

2.2. Edible Films with OLE

Edible films based on chitosan [66–68], sodium alginate [66,69], chitosan/hydroxyethyl cellulose (HCEL) [70], corn starch (CST) [71], corn zein (CZN) [72], and pectin (PEC) [73] enriched with olive leaf extract have been obtained, and their physicochemical and antibacterial properties were studied. Generally, each system was characterized by antioxidant properties, whereas CTS and CTS/HCEL-based films demonstrated antibacterial activity against Gram-negative (*S.* Enteritidis, *S. enterica*, *E. coli*, *P. aeruginosa*) and Gram-positive (*E. faecalis*, *S. aureus*, *B. cereus*, *L. monocytogenes*) bacteria, and antifungal activity against *A. flavus*, *A. niger* [68,70]. CST edible films with OLE showed homogeneity and high visual transparency with significantly improved thermo-oxidative resistance with temperature compared to the control film (non-modified CST film) [71]. The CTS coating with OLE could improve the oxidative status of the pork burgers, facilitating the production of healthier pork products, even though the lack of a noticeable inhibition of microbial growth (Aerobic Psychrotrophic Bacteria and Lactic Acid Bacteria). Nevertheless, incorporation of OLE into CTS coatings is beneficial to limit the changes in texture (hardness, gumminess, and chewiness) of meat that occur over storage, as well as oxidative reactions [67]. The edible CTS or SA-based films enriched with OLE were proven to retard the ripening process of sweet cherries [66], while edible SA coatings with OLE were found to be effective in reducing lipid oxidation in chicken nuggets stored in the deep freezer [69].

Another invention, where active PEC films with OLE were used as soluble sachets for chicken stock powder, was developed and performed by M. Sabbah et al. [73]. The properties of such films were compared to the properties of PEC films enriched with guava leaf extract (GLE). The results indicated that incorporating OLE or GLE into the pectin-based films significantly increased their opacity, greenness, and antioxidant activity, and the films had lower water vapor permeability than the control film. Additionally, sachets with chicken stock powder, after being introduced to boiling water, rapidly dissolved within seconds [73]. These studies suggested the potential of edible films incorporated with a natural olive leaf extract as sustainable systems to wrap hamburgers, chicken nuggets, fruits, vegetables, and sour cream packaging [66–71], as well as to use as soluble sachets for chicken stock powder, for example [73]. Additionally, edible films with olive leaf extract could be used as supplements to reinforce the human diet with polyphenols [68].

Apart from the above-described examples where scientists extracted olive leaves to use extract in their experiments, there are also examples of researchers using commercially available olive leaf extract. For example, the aim of the C. Fioretini et al. study [74], was to test the application on fresh pork burgers of PLA/polyhydroxybutyrate-based films coated with CTS/commercial OLE or MCEL/commercial OLE to evaluate their effect on meat quality preservation. The sample where CTS/commercial OLE coating was used showed a slight slowdown in *Enterobacteriaceae* growth, revealing promising results in maintaining the meat quality longer [74].

2.3. Conventional Materials Modified with OLE

In addition to the fact that scientists are working on creating new polymer films or edible coatings modified with olive leaf extract, they are also working on modifying existing films. An example of such a solution is supercritical solvent impregnation (SSI) of polyethylene terephthalate/polypropylene (PET/PP) commercial plastic films by olive leaf extract [75–77]. The authors carried out a study of OLE active substances migration into food simulants, and they obtained the highest migration rate into 95% ethanol (stimulant C, for food with high lipid content). The effectiveness of the optimum active packaging evaluated against lipid oxidation of sunflower seeds was confirmed. This effectiveness estimation could be possible thanks to the study of the peroxide value of sunflower seeds. The peroxide value of samples packed with impregnated PET/PP films was significantly lower than that obtained on samples packed with non-impregnated film and unpacked samples, which can lead to the opinion that foods with high lipid content are susceptible to the effect of this kind of active films [75].

In another study by F. Khanum et al., three types of commercial plastic films based on different mixtures of nylon, polyethylene, and polypropylene were coated by mixtures of olive leaf extract, methylcellulose, hydroxypropyl methylcellulose, and polyethylene glycol, and the performed studies found significant antioxidant and antibacterial (against *S. aureus*, *E. coli*, *S.* Typhimurium) potential of obtained packaging materials [78].

A study of active substances migration into food simulants (water, 10% ethanol, 50% ethanol) has also been performed for oriented polypropylene (OPP) films coated by shellac and cellulose nitrate lacquers with incorporated OLE [79]. This work provides information not about the possibility of using such a combination of substrates to prepare packaging but about the possibility of using such a research method for the comparison of the retention performances of various coating matrices [79].

Polyamide/polyethylene (20/70) based films with a thickness of 70 µm, coated by OLE, have been used for high-pressure packaging of sliced Iberian ham [80]. Active packaging was not effective because most of the sensory parameters (appearance, taste, flavor, texture) did not show significant differences due to packaging with or without OLE [80], and none of the antioxidant and antimicrobial effects on meat even applying a high dose of the lyophilized OLE [81]. Likely, oxidative characteristics of shoulders from pigs reared outdoors would be partly responsible for the high stability of this product during processing and storage [80].

In the next interesting study, olive leaf extract was incorporated into an aqueous dispersion formula, which was used to glue two different layers of polyethylene/polyethylene (PE/PE) [82,83] or polyethylene/paper (PE/P) [83] materials in such a way that components of OLE were sandwiched in the middle of the two layers. In this study, migration of the phenolic compounds from materials modified with OLE into two simulants was performed and demonstrated a non-migrating behavior. Phenolic compounds from OLE were anchored in the adhesive used to build the multilayer materials; PE/OLE/PE film efficiently enhanced the stability of fresh meat against oxidation processes [82], and it can be proposed as a packaging material for food products [83], especially for fresh minced pork meat.

2.4. Other OLE Applications for Extending Food Shelf Life

When summarizing the potential uses of olive leaf extract as an additive to various types of packaging films, it is also important to briefly mention other applications of this extract.

Olive leaf extract was used as an additive to food as a preservative, antibacterial, and antifungal agent [36,84–87]. For example, poultry meat slices from the chicken breast were dipped for 15 min in OLE at different concentrations (0.25%, 0.5%, 1%). The results of various tests revealed that the OLE addition reduced microbial growth successfully and maintained the chemical quality and sensory attributes of poultry meat [88]. The mixture of olive leaf extract and pomegranate peel extract was used as an antibacterial additive

to poultry, yellow poultry, and rabbit minced meat. Various tests of studied meat were prepared, and the results showed the potential of this mixture in food preservation and shelf life [89]. In addition to meat [88–94], olive leaf extract has also been tested as a preservative of pasteurized milk [95,96], marinated anchovies [97], vacuum-packed salmon burgers [98], raw peeled undeveined shrimps [39], frankfurter type sausages [99], baked snacks [100], as well as gluten-free bread [101], vegetable pate [102], tomato [41], and pepper pastes [103]. Furthermore, OLE has been tested as an agent to improve the quality of refined oils and extra virgin olive oil [8], sunflower [104] and soybean [105] oils.

Other examples will be chitosan-coated nanoliposomes (chitosomes) containing olive leaf extract [106], as well as OLE encapsulated in chitosan [107], alginate [107], or gelatin/tragacanth gum [108] microbeads. Chitosomes were proposed as promising nanocarriers for retention of OLE optimized by response surface methodology (RSM) based on central composite design. The authors suggested encapsulation of OLE to use in different food systems because it is a reasonable solution to overcome some limitations of OLE, like bitter taste or the possibility of degradation of phenolic content due to the external and storage conditions [106,107].

In summary, olive leaf extract extends food shelf life, exhibits antibacterial and antifungal properties, and can be proposed as a food preservative. However, further studies on other types of food and additional microbiological testing are still needed. Table 3 provides a summary of the materials described above, along with their applications and a list of studies performed to characterize them.

Table 3. The summary of the food packaging based on polymers enriched with olive leaf extract.

Polymer Base	Application	Studies	Reference
Chitosan	Coatings for improving food shelf life of fish fillets	Studies of fish samples (fat, protein, thiobarbituric acid, volatile nitrogen, total microbial count on fish fillets)	[53]
	Bioactive films to ensure the microbiological safety of food and prevent earlier oxidative degradation	Thickness; measurements of solubility in aqueous solutions simulating foods; water vapor transmission rate (WVPR); mechanical properties; antimicrobial properties against *L. monocytogenes*, *E. coli* and *C. jejuni*	[54]
	Films for active food packaging	Thickness; light barrier properties; FTIR spectroscopy; X-ray diffraction analysis; mechanical properties; WVPR; moisture retention capability; antioxidant activity (AA); antibacterial properties against *S. aureus*	[55]
	Film coatings to preserve apple fruit	Analysis of coated apple measurements (anthocyanins content; carotenoids and chlorophylls content; total phenolic compounds (TPC) content; total flavonoids content); analysis of apple samples (AA of acetonic extracts; decay apple area determination; microstructure analysis)	[56]
	Edible film coatings to shelf life sweet cherries	Analysis of the sweet cherries (weight loss; total soluble solids and acidity; ascorbic acid content; AA; TPC; anthocyanins determination)	[66]
	Coatings for improving food shelf life of pork burgers	Headspace gas analysis, analysis of meat samples (microbial counts, color and texture measurements, lipid and protein oxidation measurements)	[67]

Table 3. *Cont.*

Polymer Base	Application	Studies	Reference
Chitosan	Edible films as bioplastics to wrap meat hamburgers; supplements to reinforce the human diet with polyphenols	AA; antimicrobial activity against *S.* Enteritidis, *S. enterica*, *E. faecalis*; in vitro oral digestion; mechanical properties	[68]
	Coating to PLA/polyhydroxybutyrate packaging film to test the application on fresh pork burgers	Analysis of meat samples (pH; color measurements; thiobarbituric acid reactive substances measurements, microbiological analysis, sensory analysis—appearance and odor)	[74]
	Chitosan-coated nanoliposomes (chitosomes) containing OLE to food shelf life	TPC; electrical conductivity; accelerated centrifugal stability of chitosomes; encapsulation efficiency; particle size; zeta potential; SEM; TEM; FTIR spectroscopy; stability of formulation during storage; release behavior of chitosomes	[106]
	Nanocarriers containing OLE for food shelf life	TPC; oxidation test; encapsulation efficiency	[107]
Chitosan/hydroxyethyl cellulose	Biodegradable, edible films for sour cream packaging	FTIR spectroscopy; contact angle; mechanical properties; barrier properties; antimicrobial properties against *S.* Typhimurium, *L. monocytogenes*, *S. aureus*, *E. coli*, *P. aeruginosa*, *B. cereus*, *A. niger*, *A. flavus*; AA; analysis of sour cream samples (oxidative stability parameters; pH; microbiological analysis)	[70]
Gelatin	Antimicrobial films for enhancing the quality of cold-smoked Salmon	Antimicrobial activity against *L. monocytogenes*; TPC; AA; color measurements; WVPR; storage studies: inhibition of *L. monocytogenes* in salmon samples	[60]
Gelatin/tragacanth gum	Nanocarriers containing OLE for food shelf life	AA; study of the pH effect (turbidimetry); encapsulation efficiency; SEM; FTIR spectroscopy; DSC	[108]
Pectin	Soluble sachets for chicken stock powder	Mechanical properties; thickness; AA; opacity; moisture content; color measurements; barrier properties	[73]
Corn starch	Edible films to prevent the oxidative deterioration of packaged foodstuff such as nuts, seeds and sausages	Thickness; color measurements; ATR-FTIR spectroscopy; thermal properties; mechanical properties; barrier properties; AA; antimicrobial activity against *E. coli* and *S. aureus*	[71]
Corn zein	Edible coatings to foodstuff	Mechanical properties; color measurements; thickness; moisture content; barrier properties	[72]
Methylcellulose	Active films to control *S. aureus* during storage of Kasar cheese	Mechanical properties; water vapor permeation; antibacterial activity against *S. aureus*; Kasar cheese storage	[61]
	Coating to PLA/polyhydroxybutyrate packaging film to test the application on fresh pork burgers	Analysis of meat samples (pH; color measurements; thiobarbituric acid reactive substances measurements; microbiological analysis; sensory analysis—appearance and odor)	[74]

Table 3. *Cont.*

Polymer Base	Application	Studies	Reference
Sodium alginate	Packaging for foods with lower water content and potential lipid degradation	Thickness; WVPR; color measurements; opacity; moisture content; water solubility; mechanical properties; SEM imaging; FTIR spectroscopy; antibacterial activity against *L. monocytogenes*, *S. aureus*, *E. faecalis*, *S.* Typhimurium, and *E. coli*; migration tests	[62]
	Edible film coatings to shelf life sweet cherries	Analysis of sweet cherries (weight loss; total soluble solids and acidity; ascorbic acid content; AA; TPC; anthocyanins determination)	[66]
	Packaging to improve the quality of chicken nuggets during refrigerated and deep-freeze storage	Analysis of chicken nugget samples (moisture content, pH, color measurements, lipid oxidation analysis, microbiological analysis)	[69]
	Nanocarriers containing OLE for food shelf life	TPC; oxidation test; encapsulation efficiency	[107]
Carrageenan	Active films for lamb meat preservation	Thickness; WVPR; mechanical properties; color measurements; FTIR spectroscopy; antimicrobial activity of films in the packaging of lamb meat	[57]
	Films for food packaging applications	Thickness; WVPR; mechanical properties; color measurements; TPC; AA; SEM imaging; FTIR spectroscopy	[58]
	Active films for lamb meat preservation	Thickness; WVPR; mechanical properties; color measurements; water solubility of films; inhibition of psychrophiles in meat samples (storage studies)	[59]
Polylactide	Active food packaging films	TPC; AA; FTIR-ATR spectroscopy; thermal properties; mechanical properties; thickness; WVPR; color measurements; SEM imaging	[9]
	Antimicrobial food packaging to reduce post-process growth of *S. aureus*	WVPR; mechanical properties; antimicrobial activity against *S. aureus*; thermal properties; water absorption; degradability	[63]
Polyethylene terephthalate/ polypropylene	Films to extend food shelf life (e.g., cherry tomatoes)	AA; antimicrobial activity against *P. aeruginosa*, *S. aureus*, *E. coli* and *S.* Enteritidis; application of active film to the preservation of cherry tomatoes	[75]
	Films to extend food shelf life	AA; SEM imaging	[76]
	Films to extend food shelf life	Color parameters; UV barrier properties; WVPR; mass transfer of OLE into food simulant	[77]
Polyethylene/ polyethylene layers	Packaging for fresh minced pork meat	Analysis of meat samples (color measurements; assay of thiobarbituric acid reactive substances)	[82]
	Food multilayer films to scavenge the free radicals from the package headspace	AA; migration tests	[83]
Methylcellulose/ hydroxypropyl methylcellulose/ polyethylene glycol	Coating to commercial plastic packaging materials	Thickness; AA, antibacterial activity against *S. aureus*, *E. coli*, *S.* Typhimurium; WVPR; oxygen transmission rate	[78]
Polyamide/ polyethylene	Preservation of sliced dry-cured shoulders from Iberian pigs	Analysis of ham samples (color, lipid oxidation, protein oxidation, flavor, taste, texture)	[80]
Polyethylene/ paper layers	Food multilayer films to scavenge the free radicals from the package headspace	AA; migration tests	[83]

Table 3. *Cont.*

Polymer Base	Application	Studies	Reference
Oriented polypropylene films coated by shellac and cellulose nitrate lacquers	Antioxidant packaging for food	AA; migration tests	[79]
Cellulose nanocrystals/poly(butylene adipate-co-terephthalate)	Active packaging for food	Thermal properties; mechanical properties; SEM imaging; release tests in simulant food; AA; oxidation induction temperature; study of π-π stacking interactions	[65]
-	Preservative, antibacterial, and antifungal agent to food shelf life	Tests on poultry meat slices from the chicken breast; poultry, yellow poultry, and rabbit minced meat; pasteurized milk; marinated anchovies; vacuum-packed salmon burgers; raw, peeled undeveined shrimps; frankfurter-type sausages; baked snacks; gluten-free bread; vegetable pate; tomato and pepper pastes	[39,41,88–103]
-	Agent to improve the quality of oils	Tests on refined oils, extra virgin olive oil, sunflower and soybean oils	[8,104,105]

3. Biomedical and Pharmaceutical Applications of Olive Leaf Extract

When reviewing the available literature on the use of olive leaf extract as an enrichment for polymer films, the most commonly mentioned application is in food packaging films. This chapter will focus on the other applications of olive leaf extract, which are not as widely considered but can also be found in the literature—biomedical and pharmaceutical applications.

3.1. Wound-Healing Materials Modified with OLE

CTS [109], SA/PEC [110], and SA/CTS [111] blends have been used to obtain films for potential wound healing. The materials loaded with plant-derived compounds ensure faster tissue repair thanks to the fact that they show better biocompatibility and biological properties. If it is about the use of polymeric material in wound healing, it is important to develop films with good mechanical properties, antibacterial properties, and good stability in water conditions with good permeation ability.

Chitosan membrane enriched with olive leaf extract presented an increase in fluid drainage capacity, promoting an improvement in wound healing [109]. Thanks to the adequate absorption of exudates and mechanical properties, the developed membranes showed visible characteristics for use as wound dressing. Additionally, CTS/OLE films exhibited antibacterial activity against *E. coli* and *S. aureus*, the most common bacteria in skin wounds [109]. An innovative approach to creating a suitable material for wound healing was the development of the 3D-printed patch using SA, PEC, and OLE as an active additive [110]. The obtained materials showed high antioxidant activity with an almost complete release of the polyphenols within 48 h. Further, the patches demonstrated the capacity to absorb exudates and maintain an optimal moisture balance. Most importantly, in this experiment, SA/PEC/OLE films showed the ability to promote cell motility and wound healing and to increase collagen I expression in BJ fibroblast cells [110]. Another promising strategy for potential in skin lesions involves using double-layer membranes composed of CTS and SA, enhanced with the addition of OLE [111]. Thanks to the antioxidant capacity, antibacterial activity (against *E. coli*), good flexibility, ease of manipulation, excellent adhesion between the layers, fluid drainage capacity, and water vapor transmission rate, bilayer CTS/SA films with OLE can be promising for utilization as wound dressings [111].

The objective of A. Casado-Diaz et al.'s study was to evaluate the antioxidant and wound-healing properties of EHO-85, a novel multifunctional amorphous hydrogel in which olive leaf extract was incorporated [112,113]. Apart from the fact that the materials showed antioxidant activity due to the presence of OLE polyphenols, these compounds act as reactive-oxygen-species (ROS) scavengers, thus protecting and promoting the viability of the cell types involved in the structure and regeneration of the skin, such as dermal fibroblasts (HDFs) and keratinocytes (HaCaT) [112]. Nowel EHO-85 hydrogel can modulate the wound microenvironment, mainly through its antioxidant effect and pH and moistening regulation [113].

3.2. Tissue Engineering Materials Modified with OLE

In addition to film-form materials, electrospun fibers can also be used for tissue engineering. An example of such a solution is the incorporation of olive leaf extract inside poly(hydroxybutyrate-co-hydroxyvalerate) (PHBHV) [114], zein (ZN) [115], carboxymethylcellulose/alginate [116], silk fibroin (SF)/hyaluronic acid (HA) [117], or poly(ω-pentadecalactone-co-δ-valerolactone)/gelatin (enzymatically synthesized lactone-based copolymer and gelatin, PDL-VL/GEL) [118] fibers *via* electrospinning to obtain bioactive materials that are useful in biomedical applications. The PHBHV/OLE materials showed adequate stability in the presence of metalloproteinase 9 (MMP-9, an enzyme produced in chronic wounds), together with adequate cytocompatibility with human Caucasian foreskin fetal fibroblasts (HFFF2) and human keratinocytes (HaCaT) [114], while ZN/OLE materials were biocompatible with mouse fibroblasts (NIH/3T3) which proliferated and spread on fiber surface [115]. Additionally, the release of the OLE polyphenols occurred within 4–8 days, and in SEM imaging, the fibrous meshes resulted in smooth fiber surfaces [114,115,117]. Antimicrobial tests have shown that carboxymethylcellulose/alginate/OLE electrospun mats and PDL-VL/GEL/OLE electrospun membranes achieve reduction toward the tested microorganisms (*S. aureus* [116,118], *E. coli* [116,118], *E. faecalis* [116], *P. aeruginosa* [116], *B. subtilis* [118]) while the high antioxidant activity of OLE was preserved during the electrospinning procedure. SF/HA/OLE nanofiber webs can be good candidates for wound dressing applications as well as tissue engineering, thanks to the antioxidant activity, controlled release of OLE, and nontoxicity against the human epidermal keratinocytes [117].

3.3. Drug Delivery Systems with OLE

Mouth-dissolving films (MDFs) are a drug delivery system that can offer some benefits, like the possibility of dispensing the drug with a film dispersed in the mouth, which eliminates problems of conventional drug delivery methods such as swallowing common among pediatric and geriatric patients [119]. Carboxymethyl chitosan/okra gum films with the addition of olive leaf extract as mucoadhesive oral films have been prepared by casting method, and their physicochemical properties have been studied. The authors prepared 17 different propositions of films and performed numerous tests, and the results showed that the addition and amount of OLE directly related to the surface properties of obtained films and their disintegration time. The formulation with the most suitable properties as flexibility and homogeneity, the lower disintegration time (200 s), and a high antioxidant capacity (3.21 mM TEAC/g MDF) have been suggested as a possibility to deliver polyphenols with the mouth dissolving films [120].

Olive leaf extract has been used to obtain silver (AgNP) [121–124] and gold (AuNP) [125] nanoparticles via the environmentally friendly method. AgNPs have the potential for use in medicine, including anticancer therapy [121,124], and as antibacterial agents against drug-resistant bacterial isolates [122], while AuNPs have great potential for use in biomedical applications and will play an important role in future optoelectronic and biomedical device applications [125].

3.4. OLE in Human and Animal Dietary Supplementation

Nowadays, olive leaf extract is proposed and marked as an antioxidant, anti-aging, cardioprotective, immune stimulator, antibiotic, anti-inflammatory, and blood sugar-regulating agent [8]. Several studies have been conducted on olive leaf extract supplementation involving both animals (e.g., chickens, rabbits, rats, fish) and humans. Dietary supplementation of common carp (*Cyprinus carpio*) increases hematological, serum biochemical parameters, and immune-related gene expression levels [126], as well as enhances growth performance, digestive enzyme activity, and growth-related gene expression [127]. If it is about hens supplementation, G.A. Papadopoulos et al. evaluated the effects of OLE, when supplemented at different levels in laying hens' diets, on egg yolk antioxidant properties, egg quality, fatty acid content, and liver pathology characteristics [128]. P. Xie et al. studied the effect of OLE addition to broiler diets on growth performance, breast meat quality, and antioxidant capacity, as well as caecal bacterial populations [129]. On the other hand, regarding dietary supplementation in rabbits, G.E. Younan et al. evaluated the effect of OLE on productive performance, blood parameters, and carcass traits in growing rabbits [130]. Generally, olive leaf extract presented a positive effect in many aspects and is recommended for use in supplementation.

The anticancer effect of olive leaf extract has been confirmed [8,131]. Both inflammatory and cancer cell models have shown that olive leaf polyphenols are anti-inflammatory and protect against DNA damage initiated by free radicals [131]. Nevertheless, it is important to take into account that cell models are very different from the complex human body, and applying these findings to cancer outcomes in humans is difficult. To prove that OLE improves cancer outcomes in humans, clinical trials would be required [131]. The supplementation with OLE yielded beneficial effects on lipid profile and blood pressure in adults, especially in patients with hypertension [132–134], and may represent an effective adjunct therapy that normalizes glucose homeostasis in individuals with diabetes [135]. Moreover, the impact of OLE on upper respiratory illness (URI) has been controlled in high school athletes, and the results showed that OLE supplementation over a season did not significantly reduce URI incidence but did decrease duration in athletes, potentially aiding return to play [136].

To sum up, OLE demonstrated positive effects in terms of antinociceptive, anticancer, cardiovascular, and neuroprotective activities, but human studies on this topic are still extremely uncommon, and the data are still inadequate [8]. Table 4 provides a summary of the materials described above, along with their applications and a list of studies performed to characterize them.

Table 4. The summary of the materials enriched with olive leaf extract used in biomedical and pharmaceutical fields.

Polymer Base	Application	Studies	Reference
Chitosan	Membranes to wound healing	Thickness; mechanical properties; SEM imaging; WVPR; solubility; swelling; fluid drainage capacity; FTIR-ATR spectroscopy; antibacterial activity against *E. coli* and *S. aureus*	[109]
Sodium alginate/ pectin	3D-printed patches for wound healing	Thermal properties; SEM imaging; film expansion profile; WVPR; TPC; AA; evaluation of the anti-inflammatory properties: nitric oxide scavenging activity; in vitro release study; in vitro diffusion study; cell viability assay with BJ fibroblasts; wound-healing scratch assay; hemolysis assay	[110]
Chitosan/sodium alginate	Double-layer membranes for potential in skin lesions	Thickness; mechanical properties; fluid drainage capacity; WVPR; thermal stability; ATR-FTIR spectroscopy; SEM imaging; antimicrobial activity against *E. coli* and *S. aureus*	[111]

Table 4. *Cont.*

Polymer Base	Application	Studies	Reference
EHO-85	Novel Multifunctional Amorphous Hydrogel to wound healing	AA; protection against oxidative damage of OLE on cell cultures (HDFs and HaCaT); in vivo wound-healing activity; moistening ability; study of the effect of EHO-85 on lipid peroxidation and pH in the wound bed; effect of EHO-85 on wound pH in an animal model	[112,113]
Poly(hydroxybutyrate-co-hydroxyvalerate)	Electrospun fibers to wound healing	SEM imaging; FTIR spectroscopy; degradation study; in vitro phenol release study; cytocompatibility with HFFF2 fibroblasts and HaCaT	[114]
Zein	Electrospun fibers to wound healing	SEM imaging; FTIR spectroscopy; thermogravimetric analysis; in vitro release studies; cytocompatibility with NIH/3T3 mouse fibroblasts	[115]
Carboxylmethylcellulose/ alginate	Electrospun mats for wound healing	AA; in vitro release studies; SEM imaging; antimicrobial tests against *S. aureus*, *E. coli*, *E. faecalis* and *P. aeruginosa*	[116]
Silk fibroin/ hyaluronic acid	Electrospun nanofiber webs	AA; in vitro drug release tests; in vitro cytotoxicity tests with the human epidermal keratinocytes	[117]
Poly(ω-pentadecalactone-co-δ-valerolactone)/ gelatin	Electrospun membranes to wound healing	AA; SEM imaging wettability; thermal behavior; antibacterial activity against *E. coli*, *S. aureus*, *B. subtilis*; cytotoxicity tests with fibroblasts	[118]
Carboxymethyl chitosan/okra gum	Mouth-dissolving films for drug delivery	Thickness and weight; disintegration time; pH; SEM imaging; FTIR spectroscopy; AFM; AA	[120]
-	Agent to obtain silver (AgNP) and gold (AuNP) nanoparticles via the environmentally friendly method	SEM; TEM; TGA; XRD; FTIR spectroscopy; UV-Vis spectroscopy; zeta potential; dynamic light scattering (DLS); antimicrobial tests; cytotoxicity tests on healthy lines (HDF) and cancerous cell lines (U118, CaCo-2, Skov-3, MCF-7)	[121–124]
-	Supplementation agent to animals and humans	Tests on chickens, rabbits, rats and fishes; cell culture; human studies	[126–136]

EHO-85—amorphous hydrogel composed of purified water, *Olea Europea* leaf extract, Fucocert®, glycerin, Carbopol 980®, trieathanolamine, disodic ethylenediaminetetraacetic acid (EDTA), and Geogard ultra® [113].

4. Cosmetic Applications of OLE

An interesting application of olive leaf extract is its use, either in its pure form [137–144] or combined with nanoparticles [145], as a cosmetic ingredient. M.L. Cádiz-Gurrea et al. studied olive leaf extract enriched with oleuropein [137]. A total of 49 compounds were detected in olive leaf extract, using HPLC coupled with QTOF/MS, while 10 compounds were detected for the first time in olive leaves. All detected compounds demonstrated high antioxidant and antiradical activities. Regarding enzyme inhibition, the promising potential of OLE against skin damage related to aging by elastase and hyaluronidase inhibition was reported. Additionally, OLE did not lead to a decrease in keratinocyte viability [137].

Usually, solvents such as acetone, methanol, ethanol, diethyl ether, and their mixtures, among others, are used for the extraction of active compounds from olive leaves. The novelty lies in the use of eco-friendly solvents such as polypropylene glycol (PPG), lactic acid (LA), and water [138]. In vitro and anti-aging bioactivities of prepared extracts were evaluated, and excellent antioxidant activity was observed, as well as inhibition of elastase, collagenase, tyrosinase, and lipoxygenase. The obtained results suggest that the extracts could be directly used in cosmetic products [138].

Day creams, anti-aging creams, and shampoo with the addition of olive leaf extract were prepared [139–141,143]. No significant changes were observed in the physicochemical parameters of cosmetics enriched with olive leaf extract [139,141], apart from a slight reduction in viscosity by improving the extracts' concentrations in day creams [140]. Furthermore, stability studies showed stable homogenous appearance and effectiveness during a year storage period at room temperature [139]. Apart from that, after two months of anti-aging cream applications by experiment participants, transepidermal water loss decreased, skin hydration increased, wrinkles improved, and skin imaging showed improvement in skin texture [141].

Another study presents the encapsulation of olive leaf extract in biodegradable poly(lactic acid) nanoparticles, characterization, and incorporation of them in a cosmetic formulation [145]. The stability studies of the prepared o/w cream containing loaded nanoparticles demonstrated enhanced stability, particularly in terms of viscosity, pH, organoleptic properties, emulsion phases, and texture [145].

5. Conclusions and Future Perspectives

The use of olive leaf extract (OLE) as a bioactive component in packaging materials offers a natural, sustainable alternative to synthetic preservatives, promoting food safety and shelf life extension. The utilization of olive leaf extract as a bioactive component in packaging materials presents a sustainable and innovative approach to extending product shelf life through its natural antioxidant and antimicrobial properties. Derived from olive tree by-products, including leaves obtained during pruning and harvests, OLE offers a natural, eco-friendly alternative to synthetic preservatives and contributes to waste reduction. However, optimizing extraction efficiency while maintaining environmental and economic sustainability remains a crucial challenge.

Future studies should focus on several key areas:

(1) Maximizing extraction efficiency and functionality: future research should prioritize developing extraction methods that maximize both yield and functionality while minimizing costs. Although advances have been made in extraction techniques such as supercritical fluid extraction or ultrasound-assisted extraction, further efforts are needed to refine these processes to achieve greater reproducibility, flexibility, and scalability [146,147].

(2) Mechanism of action: The specific biochemical pathways through which OLE exerts its antioxidant, anti-inflammatory and antimicrobial actions may not be fully explored [148,149]. A complete understanding of these mechanisms is critical to improving the formulation of OLE-based treatments, ensuring their efficacy in real-world food and medical applications.

(3) Analytical and cultivar variability: One of the challenges in utilizing OLE is the variability in phenolic biosynthesis and bioactivity across different olive cultivars. To address this, innovative analytical techniques like metabolic fingerprinting can be used to classify cultivars based on their molecular profiles, identifying the most suitable varieties for OLE extraction [150]. Understanding the specific composition and activity of OLE components from different cultivars is critical to ensuring the consistency and effectiveness of OLE in packaging applications.

(4) Replacement of synthetic preservatives: OLE's natural preservative qualities can effectively replace synthetic antioxidants and antimicrobials in packaging. Its ability to inhibit the growth of bacteria such as *E. coli*, *S. aureus*, and *S.* Typhimurium makes it a valuable component in active packaging systems. These systems can help reduce the need for artificial preservatives, contributing to safer, cleaner packaging solutions and potentially lowering health risks associated with chemical additives [88].

(5) Economic benefits and minimizing environmental impact: a key consideration for future developments is minimizing the use of toxic chemicals in the extraction and production process. Non-conventional extraction methods that reduce the use of solvents and chemicals are increasingly being explored to present an innovative

alternative or complement to traditional extraction methods (supercritical fluid extraction; cloud point extraction) [146,151]. Reducing the use of solvents and chemical residues is critical not only for improving extraction efficiency and environmental sustainability but also for consumer safety. This makes the process more cost-effective and aligns with environmental sustainability goals, particularly in industries looking to minimize waste (food shelf life and packaging, as well as the biomedical field). Additional in vivo toxicological studies on olive leaves and their phenolic compounds are necessary to fully substantiate the safety of OLE in industrial applications.

(6) Sustainability and circular economy practices: OLE extraction aligns with the principles of the circular economy by utilizing olive tree by-products, which are abundant due to regular pruning and olive harvesting [152,153]. Future perspectives should emphasize integrated approaches to ensure the maximum reuse of biomass, contributing to economic and environmental sustainability. Research into the flexible processing of olive leaves and biomass stabilization techniques will be essential to make OLE extraction more efficient and economically feasible. Furthermore, sequential extraction of various fractions from olive residues should be explored to increase the recovery of valuable components for packaging, food, pharmaceutical, and nutraceutical applications [152,154].

(7) Regulations and market acceptance of OLE-modified packaging materials: OLE not only provides antimicrobial and antioxidant protection for food products but also helps reduce food waste by extending shelf life. However, for such solutions to gain market acceptance, they must meet both consumer expectations as well as regional and global regulatory requirements. Future studies should evaluate the long-term stability, effectiveness, and safety of OLE in packaging under real-world conditions while also addressing any regulatory hurdles and certification processes for its commercial use. Additionally, research into consumer preferences will be important to the commercial success of OLE-infused packaging.

Additionally, future directions that extend beyond the field of packaging materials could be mentioned. One of the most promising applications of OLE is its incorporation into functional foods and nutraceuticals. The development of foods enriched with OLE to provide antioxidant, hypocholesterolemic, and anti-inflammatory benefits represents a promising direction in promoting public health. Despite the compelling evidence of OLE's health benefits, it has yet to be fully integrated into modern medical practice. With additional research, OLE could find a place in the treatment of bacterial infections, inflammatory diseases, and chronic conditions, potentially as a complement to existing medications. To truly unlock the therapeutic potential of OLE, more human studies are needed. Current research is predominantly preclinical, with limited human trials addressing specific areas like skin protection, platelet aggregation, and hypoglycemic effects. Broader human studies are required to confirm OLE's anticancer, cardiovascular, and anti-inflammatory effects.

OLE's potential to replace synthetic antioxidants and antimicrobials positions it as an innovative solution in the packaging sector, aligning with global trends toward sustainability and responsible production. By focusing on integrated approaches that optimize extraction, minimize environmental impact, and maximize the reuse of agricultural by-products, OLE can become a cornerstone of future sustainable packaging technologies, contributing to both environmental and economic goals outlined in the United Nations' 2030 Agenda for Sustainable Development [15].

Funding: This research received no external funding.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The author declares no conflicts of interest.

References

1. Pereira, A.P.; Ferreira, I.C.F.R.; Marcelino, F.; Valentão, P.; Andrade, P.B.; Seabra, R.; Estevinho, L.; Bento, A.; Pereira, J.A. Phenolic Compounds and Antimicrobial Activity of Olive (*Olea europaea* L. Cv. Cobrançosa) Leaves. *Molecules* **2007**, *12*, 1153–1162. [CrossRef]
2. Borjan, D.; Leitgeb, M.; Knez, Ž.; Hrnčič, M.K. Microbiological and Antioxidant Activity of Phenolic Compounds in Olive Leaf Extract. *Molecules* **2020**, *25*, 5946. [CrossRef] [PubMed]
3. Dauber, C.; Parente, E.; Zucca, M.P.; Gámbaro, A.; Vieitez, I. *Olea europea* and By-Products: Extraction Methods and Cosmetic Applications. *Cosmetics* **2023**, *10*, 112. [CrossRef]
4. Khwaldia, K.; Attour, N.; Matthes, J.; Beck, L.; Schmid, M. Olive Byproducts and Their Bioactive Compounds as a Valuable Source for Food Packaging Applications. *Compr. Rev. Food Sci. Food Saf.* **2022**, *21*, 1218–1253. [CrossRef]
5. Bilel, H.; Yahia, M.; Moustafa, S.M.N. An Overview of Chemical Composition and Fungicidal Activity of Olive (*Olea europea* L.) Leaf Extract. *Egypt. J. Chem.* **2023**, *66*, 303–311. [CrossRef]
6. Rahmanian, N.; Jafari, S.M.; Wani, T.A. Bioactive Profile, Dehydration, Extraction and Application of the Bioactive Components of Olive Leaves. *Trends Food Sci. Technol.* **2015**, *42*, 150–172. [CrossRef]
7. Talhaoui, N.; Vezza, T.; Gómez-Caravaca, A.M.; Fernández-Gutiérrez, A.; Gálvez, J.; Segura-Carretero, A. Phenolic Compounds and in Vitro Immunomodulatory Properties of Three Andalusian Olive Leaf Extracts. *J. Funct. Foods* **2016**, *22*, 270–277. [CrossRef]
8. Selim, S.; Albqmi, M.; Al-Sanea, M.M.; Alnusaire, T.S.; Almuhayawi, M.S.; AbdElgawad, H.; Al Jaouni, S.K.; Elkelish, A.; Hussein, S.; Warrad, M.; et al. Valorizing the Usage of Olive Leaves, Bioactive Compounds, Biological Activities, and Food Applications: A Comprehensive Review. *Front. Nutr.* **2022**, *9*, 1008349. [CrossRef]
9. Grabska-Zielińska, S.; Gierszewska, M.; Olewnik-Kruszkowska, E.; Bouaziz, M. Polylactide Films with the Addition of Olive Leaf Extract— Physico-Chemical Characterization. *Materials* **2021**, *14*, 7623. [CrossRef]
10. Topuz, S.; Bayram, M. Oleuropein Extraction from Leaves of Three Olive Varieties (*Olea europaea* L.): Antioxidant and Antimicrobial Properties of Purified Oleuropein and Oleuropein Extracts. *J. Food Process Preserv.* **2022**, *46*, e15697. [CrossRef]
11. Martín-García, B.; Pimentel-Moral, S.; Gómez-Caravaca, A.M.; Arráez-Román, D.; Segura-Carretero, A. Box-Behnken Experimental Design for a Green Extraction Method of Phenolic Compounds from Olive Leaves. *Ind. Crops Prod.* **2020**, *154*, 112741. [CrossRef]
12. da Rosa, G.S.; Vanga, S.K.; Gariepy, Y.; Raghavan, V. Comparison of Microwave, Ultrasonic and Conventional Techniques for Extraction of Bioactive Compounds from Olive Leaves (*Olea europaea* L.). *Innov. Food Sci. Emerg.* **2019**, *58*, 102234. [CrossRef]
13. Khalil, A.A.; Rahman, M.M.; Rauf, A.; Islam, M.R.; Manna, S.J.; Khan, A.A.; Ullah, S.; Akhtar, M.N.; Aljohani, A.S.M.; Abdulmonem, W.A.; et al. Oleuropein: Chemistry, Extraction Techniques and Nutraceutical Perspectives—An Update. *Crit. Rev. Food Sci. Nutr.* **2023**, 1–22. [CrossRef]
14. Frikha, N.; Bouguerra, S.; Kit, G.; Abdelhedi, R.; Bouaziz, M. Smectite Clay KSF as Effective Catalyst for Oxidation of M-Tyrosol with H_2O_2 to Hydroxytyrosol. *React. Kinet. Mech. Cat.* **2019**, *127*, 505–521. [CrossRef]
15. Markhali, F.S.; Teixeira, J.A.; Rocha, C.M.R. Olive Tree Leaves-A Source of Valuable Active Compounds. *Processes* **2020**, *8*, 1177. [CrossRef]
16. Medina, E.; Romero, C.; García, P.; Brenes, M. Characterization of Bioactive Compounds in Commercial Olive Leaf Extracts, and Olive Leaves and Their Infusions. *Food Funct.* **2019**, *10*, 4716–4724. [CrossRef]
17. Afaneh, I.; Yateem, H.; Al-Rimawi, F. Effect of Olive Leaves Drying on the Content of Oleuropein. *Am. J. Analyt. Chem.* **2015**, *6*, 246–252. [CrossRef]
18. Otero, D.M.; Oliveira, F.M.; Lorini, A.; da Fonseca Antunes, B.; Oliveira, R.M.; Zambiazi, R.C. Oleuropein: Methods for Extraction, Purifying and Applying. *Rev. Ceres* **2020**, *67*, 315–329. [CrossRef]
19. Omar, S.H. Oleuropein in Olive and Its Pharmacological Effects. *Sci. Pharm.* **2010**, *78*, 133–154. [CrossRef]
20. Przychodzen, P.; Wyszkowska, R.; Gorzynik-Debicka, M.; Kostrzewa, T.; Kuban-Jankowska, A.; Gorska-Ponikowska, M. Anticancer Potential of Oleuropein, the Polyphenol of Olive Oil, with 2-Methoxyestradiol, Separately or in Combination, in Human Osteosarcoma Cells. *Anticancer Res.* **2019**, *39*, 1243–1251. [CrossRef]
21. Rishmawi, S.; Haddad, F.; Dokmak, G.; Karaman, R. A Comprehensive Review on the Anti-Cancer Effects of Oleuropein. *Life* **2022**, *12*, 1140. [CrossRef] [PubMed]
22. Nediani, C.; Ruzzolini, J.; Romani, A.; Calorini, L. Oleuropein, a Bioactive Compound from *Olea europaea* L., as a Potential Preventive and Therapeutic Agent in Non-Communicable Diseases. *Antioxidants* **2019**, *8*, 578. [CrossRef] [PubMed]
23. Acar-Tek, N.; Ağagündüz, D. Olive Leaf (*Olea europaea* L. Folium): Potential Effects on Glycemia and Lipidemia. *Ann. Nutr. Metab.* **2020**, *76*, 10–15. [CrossRef]
24. Hamdi, H.K.; Castellon, R. Oleuropein, a Non-Toxic Olive Iridoid, Is an Anti-Tumor Agent and Cytoskeleton Disruptor. *Biochem. Biophys. Res. Commun.* **2005**, *334*, 769–778. [CrossRef]
25. Guex, C.G.; Reginato, F.Z.; Figueredo, K.C.; da da Silva, A.R.H.; Pires, F.B.; Jesus, R.d.S.; Lhamas, C.L.; Lopes, G.H.H.; Bauermann, L.d.F. Safety Assessment of Ethanolic Extract of *Olea europaea* L. Leaves after Acute and Subacute Administration to Wistar Rats. *Reg. Toxicol. Pharm.* **2018**, *95*, 395–399. [CrossRef]
26. Clewell, A.E.; Béres, E.; Vértesi, A.; Glávits, R.; Hirka, G.; Endres, J.R.; Murbach, T.S.; Szakonyiné, I.P. A Comprehensive Toxicological Safety Assessment of an Extract of *Olea europaea* L. Leaves (Bonolive^{TM}). *Int. J. Toxicol.* **2016**, *35*, 208–221. [CrossRef]

27. Borchers, A.T.; Keen, C.L.; Gershwini, M.E. Mushrooms, Tumors, and Immunity: An Update. *Exp. Biol. Med.* **2004**, *229*, 393–406. [CrossRef]
28. Liu, R.H. Health Benefits of Fruit and Vegetables Are from Additive and Synergistic Combinations of Phytochemicals. *Am. J. Clin. Nutr.* **2003**, *78*, 517S–520S. [CrossRef]
29. Aliabadi, M.A.; Darsanaki, R.K.; Rokhi, M.L.; Nourbakhsh, M.; Raeisi, G. Antimicrobial Activity of Olive Leaf Aqueous Extract. *Ann. Biol. Res.* **2012**, *3*, 4189–4191.
30. Brahmi, F.; Flamini, G.; Issaoui, M.; Dhibi, M.; Dabbou, S.; Mastouri, M.; Hammami, M. Chemical Composition and Biological Activities of Volatile Fractions from Three Tunisian Cultivars of Olive Leaves. *Med. Chem. Res.* **2012**, *21*, 2863–2872. [CrossRef]
31. Qabaha, K.; Al-Rimawi, F.; Qasem, A.; Naser, S.A. Oleuropein Is Responsible for the Major Anti-Inflammatory Effects of Olive Leaf Extract. *J. Med. Food* **2018**, *21*, 302–305. [CrossRef] [PubMed]
32. Baysal, G.; Kasapbaşı, E.E.; Yavuz, N.; Hür, Z.; Genç, K.; Genç, M. Determination of Theoretical Calculations by DFT Method and Investigation of Antioxidant, Antimicrobial Properties of Olive Leaf Extracts from Different Regions. *J. Food Sci. Technol.* **2021**, *58*, 1909–1917. [CrossRef] [PubMed]
33. Sánchez-Gutiérrez, M.; Bascón-Villegas, I.; Rodríguez, A.; Pérez-Rodríguez, F.; Fernández-Prior, Á.; Rosal, A.; Carrasco, E. Article Valorisation of *Olea europaea* L. Olive Leaves through the Evaluation of Their Extracts: Antioxidant and Antimicrobial Activity. *Foods* **2021**, *10*, 966. [CrossRef]
34. Giacometti, J.; Milovanović, S.; Jurčić Momčilović, D.; Bubonja-Šonje, M. Evaluation of Antioxidant Activity of Olive Leaf Extract Obtained by Ultrasound-Assisted Extraction and Their Antimicrobial Activity against Bacterial Pathogens from Food. *Int. J. Food Sci. Technol.* **2021**, *56*, 4843–4850. [CrossRef]
35. Sudjana, A.N.; D'Orazio, C.; Ryan, V.; Rasool, N.; Ng, J.; Islam, N.; Riley, T.V.; Hammer, K.A. Antimicrobial Activity of Commercial *Olea europaea* (Olive) Leaf Extract. *Int. J. Antimicrob. Agents* **2009**, *33*, 461–463. [CrossRef]
36. Liu, Y.; McKeever, L.C.; Malik, N.S.A. Assessment of the Antimicrobial Activity of Olive Leaf Extract against Foodborne Bacterial Pathogens. *Front. Microbiol.* **2017**, *8*, 113. [CrossRef]
37. Šimat, V.; Skroza, D.; Tabanelli, G.; Čagalj, M.; Pasini, F.; Gómez-Caravaca, A.M.; Fernández-Fernández, C.; Sterniša, M.; Smole Možina, S.; Ozogul, Y.; et al. Antioxidant and Antimicrobial Activity of Hydroethanolic Leaf Extracts from Six Mediterranean Olive Cultivars. *Antioxidants* **2022**, *11*, 1656. [CrossRef]
38. Keskin, D.; Ceyhan, N.; Uğur, A.; Dbeys, A.D. Antimicrobial Activity and Chemical Constitutions of West Anatolian Olive (*Olea europaea* L.) Leaves. *J. Food Agric. Environ.* **2012**, *10*, 99–102.
39. Ahmed, A.M.; Rabii, N.S.; Garbaj, A.M.; Abolghait, S.K. Antibacterial Effect of Olive (*Olea europaea* L.) Leaves Extract in Raw Peeled Undeveined Shrimp (*Penaeus semisulcatus*). *Int. J. Vet. Sci. Med.* **2014**, *2*, 53–56. [CrossRef]
40. Debib, A.; Boukhatem, M.N. Phenolic Content, Antioxidant and Antimicrobial Activities of "Chemlali" Olive Leaf (*Olea europaea* L.) Extracts. *Int. J. Pharm. Phytochem. Ethnomed.* **2017**, *6*, 38–46. [CrossRef]
41. Ganje, M.; Jafari, S.M.; Dusti, A.; Dehnad, D.; Amanjani, M.; Ghanbari, V. Modeling Quality Changes in Tomato Paste Containing Microencapsulated Olive Leaf Extract by Accelerated Shelf Life Testing. *Food Bioprod. Process* **2016**, *97*, 12–19. [CrossRef]
42. Shialy, Z.; Zarrin, M.; Sadeghi-Nejad, B.; Yusef Naanaie, S. In Vitro Antifungal Properties of Pistacia Atlantica and Olive Extracts on Different Fungal Species. *Curr. Med. Mycol.* **2015**, *1*, 40–45. [CrossRef] [PubMed]
43. Korukluoglu, M.; Sahan, Y.; Yigit, A.; Karakas, R. Antifungal Activity of Olive Leaf (*Olea europaea* L.) Extracts from the Trilye Region of Turkey. *Ann. Microbiol.* **2006**, *56*, 359–362. [CrossRef]
44. Espeso, J.; Isaza, A.; Lee, J.Y.; Sörensen, P.M.; Jurado, P.; de Jesús Avena-Bustillos, R.; Olaizola, M.; Arboleya, J.C. Olive Leaf Waste Management. *Front. Sustain. Food Syst.* **2021**, *5*, 660582. [CrossRef]
45. Abbattista, R.; Ventura, G.; Calvano, C.D.; Cataldi, T.R.I.; Losito, I. Bioactive Compounds in Waste By-Products from Olive Oil Production: Applications and Structural Characterization by Mass Spectrometry Techniques. *Foods* **2021**, *10*, 1236. [CrossRef]
46. Elbehiry, A.; Abalkhail, A.; Marzouk, E.; Elmanssury, A.E.; Almuzaini, A.M.; Alfheeaid, H.; Alshahrani, M.T.; Huraysh, N.; Ibrahem, M.; Alzaben, F.; et al. An Overview of the Public Health Challenges in Diagnosing and Controlling Human Foodborne Pathogens. *Vaccines* **2023**, *11*, 725. [CrossRef]
47. Hou, T.; Sana, S.S.; Li, H.; Xing, Y.; Nanda, A.; Netala, V.R.; Zhang, Z. Essential Oils and Its Antibacterial, Antifungal and Anti-Oxidant Activity Applications: A Review. *Food Biosci.* **2022**, *47*, 101716. [CrossRef]
48. Ahmed, J.; Mulla, M.; Arfat, Y.A. Application of High-Pressure Processing and Polylactide/Cinnamon Oil Packaging on Chicken Sample for Inactivation and Inhibition of *Listeria monocytogenes* and *Salmonella* Typhimurium, and Post-Processing Film Properties. *Food Control* **2017**, *78*, 160–168. [CrossRef]
49. Olewnik-Kruszkowska, E.; Burkowska-But, A.; Tarach, I.; Walczak, M.; Jakubowska, E. Biodegradation of Polylactide-Based Composites with an Addition of a Compatibilizing Agent in Different Environments. *Int. Biodeterior. Biodegrad.* **2020**, *147*, 104840. [CrossRef]
50. Ahmed, J.; Mulla, M.Z.; Arfat, Y.A. Thermo-Mechanical, Structural Characterization and Antibacterial Performance of Solvent Casted Polylactide/Cinnamon Oil Composite Films. *Food Control* **2016**, *69*, 196–204. [CrossRef]
51. Ahmed, J.; Hiremath, N.; Jacob, H. Antimicrobial, Rheological, and Thermal Properties of Plasticized Polylactide Films Incorporated with Essential Oils to Inhibit *Staphylococcus aureus* and *Campylobacter jejuni*. *J. Food Sci.* **2016**, *81*, E419–E429. [CrossRef] [PubMed]

52. Ahmed, J.; Hiremath, N.; Jacob, H. Efficacy of Antimicrobial Properties of Polylactide/Cinnamon Oil Film with and without High-Pressure Treatment against *Listeria monocytogenes* and *Salmonella* Typhimurium Inoculated in Chicken Sample. *Food Packag. Shelf Life* **2016**, *10*, 72–78. [CrossRef]
53. Meherpour, A.; Ghafouri-O, H.; Nasiri, N.; Kioumarsi, H. Effect of Chitosan Coating with Olive Leaf Extract on Shelf Life of Bighead Fish (*Hypophthalmichthys nobilis*) Chilled Fillet. *Res. J. Med. Plants* **2020**, *14*, 111–118. [CrossRef]
54. Musella, E.; El Ouazzani, I.C.; Mendes, A.R.; Rovera, C.; Farris, S.; Mena, C.; Teixeira, P.; Poças, F. Preparation and Characterization of Bioactive Chitosan-Based Films Incorporated with Olive Leaves Extract for Food Packaging Applications. *Coatings* **2021**, *11*, 1339. [CrossRef]
55. Kazan, A.; Demirci, F. Olive Leaf Extract Incorporated Chitosan Films for Active Food Packaging. *Konya J. Eng. Sci.* **2023**, *11*, 1061–1072. [CrossRef]
56. Khalifa, I.; Barakat, H.; El-Mansy, H.A.; Soliman, S.A. Preserving Apple (*Malus domestica* Var. Anna) Fruit Bioactive Substances Using Olive Wastes Extract-Chitosan Film Coating. *Inf. Proc. Agric.* **2017**, *4*, 90–99. [CrossRef]
57. Martiny, T.R.; Pacheco, B.S.; Pereira, C.M.P.; Mansilla, A.; Astorga–España, M.S.; Dotto, G.L.; Moraes, C.C.; Rosa, G.S. A Novel Biodegradable Film Based on κ-Carrageenan Activated with Olive Leaves Extract. *Food Sci. Nutr.* **2020**, *8*, 3147–3156. [CrossRef]
58. da Rosa, G.S.; Vanga, S.K.; Gariepy, Y.; Raghavan, V. Development of Biodegradable Films with Improved Antioxidant Properties Based on the Addition of Carrageenan Containing Olive Leaf Extract for Food Packaging Applications. *J. Polym. Environ.* **2020**, *28*, 123–130. [CrossRef]
59. Martiny, T.R.; Raghavan, V.; de Moraes, C.C.; da Rosa, G.S.; Dotto, G.L. Bio-Based Active Packaging: Carrageenan Film with Olive Leaf Extract for Lamb Meat Preservation. *Foods* **2020**, *9*, 1759. [CrossRef]
60. Albertos, I.; Avena-Bustillos, R.J.; Martín-Diana, A.B.; Du, W.X.; Rico, D.; McHugh, T.H. Antimicrobial Olive Leaf Gelatin Films for Enhancing the Quality of Cold-Smoked Salmon. *Food Packag. Shelf Life* **2017**, *13*, 49–55. [CrossRef]
61. Ayana, B.; Turhan, K.N. Use of Antimicrobial Methylcellulose Films to Control Staphylococcus Aureus during Storage of Kasar Cheese. *Packag. Technol. Sci.* **2009**, *22*, 461–469. [CrossRef]
62. Moura-Alves, M.; Souza, V.G.L.; Silva, J.A.; Esteves, A.; Pastrana, L.M.; Saraiva, C.; Cerqueira, M.A. Characterization of Sodium Alginate-Based Films Blended with Olive Leaf and Laurel Leaf Extracts Obtained by Ultrasound-Assisted Technology. *Foods* **2023**, *12*, 4076. [CrossRef] [PubMed]
63. Erdohan, Z.Ö.; Çam, B.; Turhan, K.N. Characterization of Antimicrobial Polylactic Acid Based Films. *J. Food Eng.* **2013**, *119*, 308–315. [CrossRef]
64. Sánchez-Gutiérrez, M.; Rivera-Ruiz, A.; Sánchez-Fernández, L.; Rodríguez, A.; Carrasco, E. Evaluation of Microbial and Oxidative Changes of 100% Iberian Spanish Salchichón in Contact with a Composite Olive-Leaf-Extract Food Film and Vacuum-Packaged. *Future Foods* **2024**, *10*, 100417. [CrossRef]
65. De Cristofaro, G.A.; Paolucci, M.; Pappalardo, D.; Pagliarulo, C.; Sessini, V.; Lo Re, G. Interface Interactions Driven Antioxidant Properties in Olive Leaf Extract/Cellulose Nanocrystals/Poly(Butylene Adipate-Co-Terephthalate) Biomaterials. *Int. J. Biol. Macromol.* **2024**, *272*, 132509. [CrossRef]
66. Zam, W. Effect of Alginate and Chitosan Edible Coating Enriched with Olive Leaves Extract on the Shelf Life of Sweet Cherries (*Prunus avium* L.). *J. Food Qual.* **2019**, *2019*, 8192964. [CrossRef]
67. Carrapiso, A.I.; Pimienta, M.; Martín, L.; Cardenia, V.; Andrés, A.I. Effect of a Chitosan Coating Enriched with an Olive Leaf Extract on the Characteristics of Pork Burgers. *Foods* **2023**, *12*, 3757. [CrossRef]
68. Famiglietti, M.; Savastano, A.; Gaglione, R.; Arciello, A.; Naviglio, D.; Mariniello, L. Edible Films Made of Dried Olive Leaf Extract and Chitosan: Characterization and Applications. *Foods* **2022**, *11*, 2078. [CrossRef]
69. Ozvural, E.B. Fabrication of Olive Leaf Extract and Hazelnut Skin Incorporated Films to Improve the Quality of Nuggets during Refrigerated and Deep Freeze Storage. *Br. Poult. Sci.* **2019**, *60*, 708–715. [CrossRef]
70. El-Sayed, S.M.; El-Sayed, H.S.; Hashim, A.F.; Youssef, A.M. Valorization of Edible Films Based on Chitosan/Hydroxyethyl Cellulose/Olive Leaf Extract and TiO_2-NPs for Preserving Sour Cream. *Int. J. Biol. Macromol.* **2024**, *268*, 131727. [CrossRef]
71. García, A.V.; Álvarez-Pérez, O.B.; Rojas, R.; Aguilar, C.N.; Garrigós, M.C. Impact of Olive Extract Addition on Corn Starch-Based Active Edible Films Properties for Food Packaging Applications. *Foods* **2020**, *9*, 1339. [CrossRef] [PubMed]
72. Mousavi, S.B.; Mirzaei, H.; Kashiri, M.; Ziaiifar, A.M. The Effect of Olive Leaf Extract on Physical and Mechanical Properties of Zein Corn Edible Film. *J. Food Sci. Technol.* **2019**, *16*, 313–324.
73. Sabbah, M.; Al-Asmar, A.; Younis, D.; Al-Rimawi, F.; Famiglietti, M.; Mariniello, L. Production and Characterization of Active Pectin Films with Olive or Guava Leaf Extract Used as Soluble Sachets for Chicken Stock Powder. *Coatings* **2023**, *13*, 1253. [CrossRef]
74. Fiorentini, C.; Bassani, A.; Zaccone, M.; Luana, M.; Díaz, E.; Apodaca, D.; Spigno, G. Active Coated PLA-PHB Film with Formulations Containing a Commercial Olive Leaf Extract to Improve Quality Preservation of Fresh Pork Burgers. *Chem. Eng. Trans.* **2023**, *102*, 85–90. [CrossRef]
75. Cejudo Bastante, C.; Casas Cardoso, L.; Fernández Ponce, M.T.; Mantell Serrano, C.; Martínez de la Ossa-Fernández, E.J. Characterization of Olive Leaf Extract Polyphenols Loaded by Supercritical Solvent Impregnation into PET/PP Food Packaging Films. *J. Supercrit. Fluids* **2018**, *140*, 196–206. [CrossRef]

76. Cejudo Bastante, C.; Casas Cardoso, L.; Fernández-Ponce, M.T.; Mantell Serrano, C.; Martínez de la Ossa, E.J. Supercritical Impregnation of Olive Leaf Extract to Obtain Bioactive Films Effective in Cherry Tomato Preservation. *Food Packag. Shelf Life* **2019**, *21*, 100338. [CrossRef]
77. Bastante, C.C.; Cran, M.J.; Cardoso, L.C.; Serrano, C.M.; Bigger, S.W. Mass Transfer and Optical Properties of Active PET/PP Food-Grade Films Impregnated with Olive Leaf Extract. *Polymers* **2022**, *14*, 84. [CrossRef]
78. Khanum, F.; Zahoor, T.; Khan, M.I.; Asghar, M.; Sablani, S.S. Antioxidant, Antibacterial and Functional-Food-Packaging Potential of Leaf Extract from Pakistani Olive Cultivars. *Pack. J. Agric. Sci.* **2020**, *57*, 735–742. [CrossRef]
79. Licciardello, F.; Wittenauer, J.; Saengerlaub, S.; Reinelt, M.; Stramm, C. Rapid Assessment of the Effectiveness of Antioxidant Active Packaging-Study with Grape Pomace and Olive Leaf Extracts. *Food Packag. Shelf Life* **2015**, *6*, 1–6. [CrossRef]
80. Amaro-Blanco, G.; Delgado-Adámez, J.; Martín, M.J.; Ramírez, R. Active Packaging Using an Olive Leaf Extract and High Pressure Processing for the Preservation of Sliced Dry-Cured Shoulders from Iberian Pigs. *Innov. Food Sci. Emerg. Technol.* **2018**, *45*, 1–9. [CrossRef]
81. Delgado-Adámez, J.; Bote, E.; Parra-Testal, V.; Martín, M.J.; Ramírez, R. Effect of the Olive Leaf Extracts In Vitro and in Active Packaging of Sliced Iberian Pork Loin. *Packag. Technol. Sci.* **2016**, *29*, 649–660. [CrossRef]
82. Moudache, M.; Nerín, C.; Colon, M.; Zaidi, F. Antioxidant Effect of an Innovative Active Plastic Film Containing Olive Leaves Extract on Fresh Pork Meat and Its Evaluation by Raman Spectroscopy. *Food Chem.* **2017**, *229*, 98–103. [CrossRef]
83. Moudache, M.; Colon, M.; Nerín, C.; Zaidi, F. Phenolic Content and Antioxidant Activity of Olive By-Products and Antioxidant Film Containing Olive Leaf Extract. *Food Chem.* **2016**, *212*, 521–527. [CrossRef]
84. Korukluoglu, M.; Sahan, Y.; Yigit, A. Antifungal Properties of Olive Leaf Extracts and Their Phenolic Compounds. *J. Food Saf.* **2008**, *28*, 76–87. [CrossRef]
85. Korukluoglu, M.; Sahan, Y.; Yigit, A.; Ozer, E.T.; GÜCer, S. Antibacterial Activity and Chemical Constitutions of *Olea europaea* L. Leaf Extracts. *J. Food Process Preserv.* **2010**, *34*, 383–396. [CrossRef]
86. Difonzo, G.; Squeo, G.; Pasqualone, A.; Summo, C.; Paradiso, V.M.; Caponio, F. The Challenge of Exploiting Polyphenols from Olive Leaves: Addition to Foods to Improve Their Shelf-Life and Nutritional Value. *J. Sci. Food Agric.* **2021**, *101*, 3099–3116. [CrossRef]
87. Thielmann, J.; Kohnen, S.; Hauser, C. Antimicrobial Activity of *Olea europaea* Linné Extracts and Their Applicability as Natural Food Preservative Agents. *Int. J. Food Microbiol.* **2017**, *251*, 48–66. [CrossRef]
88. Saleh, E.; Morshdy, A.E.; El-Manakhly, E.; Al-Rashed, S.; Hetta, H.F.; Jeandet, P.; Yahia, R.; El-Saber Batiha, G.; Ali, E. Effects of Olive Leaf Extracts as Natural Preservative on Retailed Poultry Meat Quality. *Foods* **2020**, *9*, 1017. [CrossRef]
89. Forgione, G.; De Cristofaro, G.A.; Sateriale, D.; Pagliuca, C.; Colicchio, R.; Salvatore, P.; Paolucci, M.; Pagliarulo, C. Pomegranate Peel and Olive Leaf Extracts to Optimize the Preservation of Fresh Meat: Natural Food Additives to Extend Shelf-Life. *Microorganisms* **2024**, *12*, 1303. [CrossRef]
90. Rubel, S.A.; Yu, Z.N.; Murshed, H.M.; Islam, S.M.A.; Sultana, D.; Rahman, S.M.E.; Wang, J. Addition of Olive (*Olea europaea*) Leaf Extract as a Source of Natural Antioxidant in Mutton Meatball Stored at Refrigeration Temperature. *J. Food Sci. Technol.* **2021**, *58*, 4002–4010. [CrossRef]
91. Elama, C.; Tarawa, M.; Al-Rimawi, F. Oleuropein from Olive Leaf Extract as Natural Antioxidant of Frozen Hamburger. *J. Food Sci. Eng.* **2017**, *7*, 406–412. [CrossRef]
92. El-Sawah, K.T.; El-Shahawy, R.M.; Nageeb, A.I.; Atalla, K.M. Antimicrobial Activity of Olive Leaves Extracts and Application of Leaves Powder in Meat Preservation. *Fayoum J. Agric. Res. Dev.* **2024**, *38*, 45–55. [CrossRef]
93. Altemimi, A. A Study of the Protective Properties of Iraqi Olive Leaves against Oxidation and Pathogenic Bacteria in Food Applications. *Antioxidants* **2017**, *6*, 34. [CrossRef] [PubMed]
94. Shalaby, A.R.; Anwar, M.M.; Sallam, E.M. Improving Quality and Shelf-Life of Minced Beef Using Irradiated Olive Leaf Extract. *J. Food Process Preserv.* **2018**, *42*, e13789. [CrossRef]
95. El Dessouky Abdel-Aziz, M.; Darwish, M.S.; Mohamed, A.H.; El-Khateeb, A.Y.; Hamed, S.E. Potential Activity of Aqueous Fig Leaves Extract, Olive Leaves Extract and Their Mixture as Natural Preservatives to Extend the Shelf Life of Pasteurized Buffalo Milk. *Foods* **2020**, *9*, 615. [CrossRef]
96. Palmeri, R.; Parafati, L.; Trippa, D.; Siracusa, L.; Arena, E.; Restuccia, C.; Fallico, B. Addition of Olive Leaf Extract (OLE) for Producing Fortified Fresh Pasteurized Milk with an Extended Shelf Life. *Antioxidants* **2019**, *8*, 255. [CrossRef]
97. Testa, B.; Lombardi, S.J.; Macciola, E.; Succi, M.; Tremonte, P.; Iorizzo, M. Efficacy of Olive Leaf Extract (*Olea europaea* L. Cv Gentile Di Larino) in Marinated Anchovies (*Engraulis encrasicolus*, L.) Process. *Heliyon* **2019**, *5*, e01727. [CrossRef]
98. Khemakhem, I.; Fuentes, A.; Lerma-García, M.J.; Ayadi, M.A.; Bouaziz, M.; Barat, J.M. Olive Leaf Extracts for Shelf Life Extension of Salmon Burgers. *Food Sci. Technol. Int.* **2019**, *25*, 91–100. [CrossRef]
99. Alirezalu, K.; Hesari, J.; Eskandari, M.H.; Valizadeh, H.; Sirousazar, M. Effect of Green Tea, Stinging Nettle and Olive Leaves Extracts on the Quality and Shelf Life Stability of Frankfurter Type Sausage. *J. Food Process Preserv.* **2017**, *41*, e13100. [CrossRef]
100. Difonzo, G.; Pasqualone, A.; Silletti, R.; Cosmai, L.; Summo, C.; Paradiso, V.M.; Caponio, F. Use of Olive Leaf Extract to Reduce Lipid Oxidation of Baked Snacks. *Food Res. Int.* **2018**, *108*, 48–56. [CrossRef]
101. Moghaddam, M.F.T.; Jalali, H.; Nafchi, A.M.; Nouri, L. Evaluating the Effects of Lactic Acid Bacteria and Olive Leaf Extract on the Quality of Gluten-Free Bread. *Gene Rep.* **2020**, *21*, 100771. [CrossRef]

102. Difonzo, G.; Squeo, G.; Calasso, M.; Pasqualone, A.; Caponio, F. Physico-Chemical, Microbiological and Sensory Evaluation of Ready-to-Use Vegetable Pâté Added with Olive Leaf Extract. *Foods* **2019**, *8*, 138. [CrossRef] [PubMed]
103. Gamli, Ö.F.; Eraslan, Z.; Akben, S.B. Determination of the Protective Effects of Olive Leaf Extracts on Microbiological and Physicochemical Properties of Pepper Paste Using the Image Processing Methods. *J. Food Process Eng.* **2018**, *41*, e12861. [CrossRef]
104. Rafiee, Z.; Jafari, S.M.; Alami, M.; Khomeiri, M. Antioxidant Effect of Microwave-Assisted Extracts of Olive Leaves on Sunflower Oil. *J. Agric. Sci. Technol.* **2012**, *14*, 1497–1509.
105. Mohammadi, A.; Jafari, S.M.; Esfanjani, A.F.; Akhavan, S. Application of Nano-Encapsulated Olive Leaf Extract in Controlling the Oxidative Stability of Soybean Oil. *Food Chem.* **2016**, *190*, 513–519. [CrossRef]
106. Katouzian, I.; Taheri, R.A. Preparation, Characterization and Release Behavior of Chitosan-Coated Nanoliposomes (Chitosomes) Containing Olive Leaf Extract Optimized by Response Surface Methodology. *J. Food Sci. Technol.* **2021**, *58*, 3430–3443. [CrossRef]
107. Toprakçı, İ.; Şahin, S. Encapsulation of Olive Leaf Antioxidants in Microbeads: Application of Alginate and Chitosan as Wall Materials. *Sustain. Chem. Pharm.* **2022**, *27*, 100707. [CrossRef]
108. Oliveira, F.M.; Oliveira, R.M.; Gehrmann Buchweitz, L.T.; Pereira, J.R.; Cristina dos Santos Hackbart, H.; Nalério, É.S.; Borges, C.D.; Zambiazi, R.C. Encapsulation of Olive Leaf Extract (*Olea europaea* L.) in Gelatin/Tragacanth Gum by Complex Coacervation for Application in Sheep Meat Hamburger. *Food Control* **2022**, *131*, 108426. [CrossRef]
109. Alves, R.C.; Contessa, C.R.; Moraes, C.C.; da Rosa, G.S. Biopolymeric Membranes with Active Principle of Olive Leaves (*Olea europaea* L.) for Potential Topical Application. *Macromol* **2023**, *3*, 314–325. [CrossRef]
110. Patitucci, F.; Motta, M.F.; Dattilo, M.; Malivindi, R.; Leonetti, A.E.; Pezzi, G.; Prete, S.; Mileti, O.; Gabriele, D.; Parisi, O.I.; et al. 3D-Printed Alginate/Pectin-Based Patches Loaded with Olive Leaf Extracts for Wound Healing Applications: Development, Characterization and In Vitro Evaluation of Biological Properties. *Pharmaceutics* **2024**, *16*, 99. [CrossRef]
111. Paulino, L.G.S.; Avila, L.B.; Moraes, C.C.; Khan, M.R.; Manoharadas, S.; dos Reis, G.S.; Dotto, G.L.; da Rosa, G.S. Double-Layer Membranes of Chitosan and Sodium Alginate Added to Natural Olive Leaf Extract for Potential Use in Skin Lesions. *Resources* **2023**, *12*, 97. [CrossRef]
112. Casado-Diaz, A.; Moreno-Rojas, J.M.; Verdú-Soriano, J.; Lázaro-Martínez, J.L.; Rodríguez-Mañas, L.; Tunez, I.; La Torre, M.; Pérez, M.B.; Priego-Capote, F.; Pereira-Caro, G. Evaluation of Antioxidant and Wound-Healing Properties of EHO-85, a Novel Multifunctional Amorphous Hydrogel Containing *Olea europaea* Leaf Extract. *Pharmaceutics* **2022**, *14*, 349. [CrossRef]
113. Casado-Díaz, A.; La Torre, M.; Priego-Capote, F.; Verdú-Soriano, J.; Lázaro-Martínez, J.L.; Rodríguez-Mañas, L.; Berenguer Pérez, M.; Tunez, I. EHO-85: A Multifunctional Amorphous Hydrogel for Wound Healing Containing *Olea europaea* Leaf Extract: Effects on Wound Microenvironment and Preclinical Evaluation. *J. Clin. Med.* **2022**, *11*, 1229. [CrossRef] [PubMed]
114. De la Ossa, J.G.; Danti, S.; Esposito Salsano, J.; Azimi, B.; Tempesti, V.; Barbani, N.; Digiacomo, M.; Macchia, M.; Uddin, M.J.; Cristallini, C.; et al. Electrospun Poly(3-Hydroxybutyrate-Co-3-Hydroxyvalerate)/Olive Leaf Extract Fiber Mesh as Prospective Bio-Based Scaffold for Wound Healing. *Molecules* **2022**, *27*, 6208. [CrossRef] [PubMed]
115. Erdogan, I.; Demir, M.; Bayraktar, O. Olive Leaf Extract as a Crosslinking Agent for the Preparation of Electrospun Zein Fibers. *J. Appl. Polym. Sci.* **2015**, *132*, 41338. [CrossRef]
116. Peršin, Z.; Ravber, M.; Stana Kleinschek, K.; Knez, Ž.; Škerget, M.; Kurečič, M. Bio-Nanofibrous Mats as Potential Delivering Systems of Natural Substances. *Text. Res. J.* **2017**, *87*, 444–459. [CrossRef]
117. Basal, G.; Tetik, G.D.; Kurkcu, G.; Bayraktar, O.; Gurhan, I.D.; Atabey, A. Olive Leaf Extract Loaded Silk Fibroin/Hyaluronic Acid Nanofiber Webs for Wound Dressing Applications. *Dig. J. Nanomater. Biostruct.* **2016**, *11*, 1113–1123.
118. Ulker Turan, C.; Derviscemaloglu, M.; Guvenilir, Y. Enzymatically Synthesized Lactone-Based Copolymer and Gelatin Nanofibrous Blends Loaded with an Olive Leaf Phenolic Compound. *Mater. Today Commun.* **2024**, *38*, 108215. [CrossRef]
119. Sayed, A.M.; Kulkarni, A.D.; Pardeshi, P.U.; Kapile, C.R.; Nehe, A.D. Oral Fast Disintegrating Films of Phytochemicals: A Novel Drug Delivery System. *J. Drug Deliv. Ther.* **2022**, *12*, 226–232. [CrossRef]
120. Köse, M.D.; Gümüş Işık, Ş.; Bayraktar, O. Olive Leaf Polyphenols Loaded Mucoadhesive Oral Films. *J. Eng. Sci. Des.* **2021**, *9*, 366–380. [CrossRef]
121. Atalar, M.N.; Baran, A.; Baran, M.F.; Keskin, C.; Aktepe, N.; Yavuz, Ö.; İrtegun Kandemir, S. Economic Fast Synthesis of Olive Leaf Extract and Silver Nanoparticles and Biomedical Applications. *Part. Sci. Technol.* **2022**, *40*, 589–597. [CrossRef]
122. Khalil, M.M.H.; Ismail, E.H.; El-Baghdady, K.Z.; Mohamed, D. Green Synthesis of Silver Nanoparticles Using Olive Leaf Extract and Its Antibacterial Activity. *Arab. J. Chem.* **2014**, *7*, 1131–1139. [CrossRef]
123. Ramazanli, V.N.; Ahmadov, I.S. Synthesis of Silver Nanoparticles by Using Extract of Olive Leaves. *Adv. Biol. Earth Sci.* **2022**, *7*, 238–244.
124. Rashidipour, M.; Heydari, R. Biosynthesis of Silver Nanoparticles Using Extract of Olive Leaf: Synthesis and in Vitro Cytotoxic Effect on MCF-7 Cells. *J. Nanostruct. Chem.* **2014**, *4*, 112. [CrossRef]
125. Khalil, M.M.H.; Ismail, E.H.; El-Magdoub, F. Biosynthesis of Au Nanoparticles Using Olive Leaf Extract. 1st Nano Updates. *Arab. J. Chem.* **2012**, *5*, 431–437. [CrossRef]
126. Zemheri-Navruz, F.; Acar, Ü.; Yılmaz, S. Dietary Supplementation of Olive Leaf Extract Increases Haematological, Serum Biochemical Parameters and Immune Related Genes Expression Level in Common Carp (*Cyprinus carpio*) Juveniles. *Fish Shellfish Immunol.* **2019**, *89*, 672–676. [CrossRef]

127. Zemheri-Navruz, F.; Acar, Ü.; Yılmaz, S. Dietary Supplementation of Olive Leaf Extract Enhances Growth Performance, Digestive Enzyme Activity and Growth Related Genes Expression in Common Carp *Cyprinus carpio*. *Gen. Comp. Endocrinol.* **2020**, *296*, 113541. [CrossRef]
128. Papadopoulos, G.A.; Lioliopoulou, S.; Nenadis, N.; Panitsidis, I.; Pyrka, I.; Kalogeropoulou, A.G.; Symeon, G.K.; Skaltsounis, A.L.; Stathopoulos, P.; Stylianaki, I.; et al. Effects of Enriched-in-Oleuropein Olive Leaf Extract Dietary Supplementation on Egg Quality and Antioxidant Parameters in Laying Hens. *Foods* **2023**, *12*, 4119. [CrossRef]
129. Xie, P.; Deng, Y.; Huang, L.; Zhang, C. Effect of Olive Leaf (*Olea europaea* L.) Extract Addition to Broiler Diets on the Growth Performance, Breast Meat Quality, Antioxidant Capacity and Caecal Bacterial Populations. *Ital. J. Anim. Sci.* **2022**, *21*, 1246–1258. [CrossRef]
130. Younan, G.; Mohamed, M.; Morsy, W. Effect of Dietary Supplementation of Olive Leaf Extract on Productive Performance, Blood Parameters and Carcass Traits of Growing Rabbits. *Egypt. J. Nutr. Feeds* **2019**, *22*, 173–182. [CrossRef]
131. Boss, A.; Bishop, K.S.; Marlow, G.; Barnett, M.P.G.; Ferguson, L.R. Evidence to Support the Anti-Cancer Effect of Olive Leaf Extract and Future Directions. *Nutrients* **2016**, *8*, 513. [CrossRef]
132. Razmpoosh, E.; Abdollahi, S.; Mousavirad, M.; Clark, C.C.T.; Soltani, S. The Effects of Olive Leaf Extract on Cardiovascular Risk Factors in the General Adult Population: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Diabetol. Metab. Syndr.* **2022**, *14*, 151. [CrossRef] [PubMed]
133. Perrinjaquet-Moccetti, T.; Busjahn, A.; Schmidlin, C.; Schmidt, A.; Bradl, B.; Aydogan, C. Food Supplementation with an Olive (*Olea europaea* L.) Leaf Extract Reduces Blood Pressure in Borderline Hypertensive Monozygotic Twins. *Phytother. Res.* **2008**, *22*, 1239–1242. [CrossRef]
134. Lockyer, S.; Rowland, I.; Spencer, J.P.E.; Yaqoob, P.; Stonehouse, W. Impact of Phenolic-Rich Olive Leaf Extract on Blood Pressure, Plasma Lipids and Inflammatory Markers: A Randomised Controlled Trial. *Eur. J. Nutr.* **2017**, *56*, 1421–1432. [CrossRef] [PubMed]
135. Wainstein, J.; Ganz, T.; Boaz, M.; Bar Dayan, Y.; Dolev, E.; Kerem, Z.; Madar, Z. Olive Leaf Extract as a Hypoglycemic Agent in Both Human Diabetic Subjects and in Rats. *J. Med. Food* **2012**, *15*, 605–610. [CrossRef]
136. Somerville, V.; Moore, R.; Braakhuis, A. The Effect of Olive Leaf Extract on Upper Respiratory Illness in High School Athletes: A Randomised Control Trial. *Nutrients* **2019**, *11*, 358. [CrossRef]
137. Cádiz-Gurrea, M.d.l.L.; Pinto, D.; Delerue-Matos, C.; Rodrigues, F. Olive Fruit and Leaf Wastes as Bioactive Ingredients for Cosmetics—A Preliminary Study. *Antioxidants* **2021**, *10*, 245. [CrossRef]
138. Marijan, M.; Mitar, A.; Jakupović, L.; Kardum, J.P.; Končić, M.Z. Optimization of Bioactive Phenolics Extraction and Cosmeceutical Activity of Eco-Friendly Polypropylene-Glycol–Lactic-Acid-Based Extracts of Olive Leaf. *Molecules* **2022**, *27*, 529. [CrossRef]
139. Al-rimawi, F.; Odeh, I.; Bisher, A.; Yateem, H.; Taraweh, M. Natural Antioxidants, Antibacterials from Olive Leaf Extracts Used in Cosmetics, Pharmaceutical, and Food Industries. In Proceedings of the Qatar Foundation Annual Research Conference Proceedings, Doha, Qatar, 19–20 March 2018; Hamad bin Khalifa University Press (HBKU Press): Ar Rayyan, Qatar, 2019; Volume 2014, p. HBPP0116.
140. d'Avanzo, N.; Mancuso, A.; Mare, R.; Silletta, A.; Maurotti, S.; Parisi, O.I.; Cristiano, M.C.; Paolino, D. Olive Leaves and Citrus Peels: From Waste to Potential Resource for Cosmetic Products. *Cosmetics* **2024**, *11*, 41. [CrossRef]
141. Wanitphakdeedecha, R.; Ng, J.N.C.; Junsuwan, N.; Phaitoonwattanakij, S.; Phothong, W.; Eimpunth, S.; Manuskiatti, W. Efficacy of Olive Leaf Extract–Containing Cream for Facial Rejuvenation: A Pilot Study. *J. Cosmet. Dermatol.* **2020**, *19*, 1662–1666. [CrossRef]
142. Oliveira, A.L.S.; Gondim, S.; Gómez-García, R.; Ribeiro, T.; Pintado, M. Olive Leaf Phenolic Extract from Two Portuguese Cultivars –Bioactivities for Potential Food and Cosmetic Application. *J. Environ. Chem. Eng.* **2021**, *9*, 106175. [CrossRef]
143. Sekar, M.; Noordin, H.A.M.N.N.M. Formulation and Evaluation of Herbal Shampoo Containing Rambutan Leaves Extract. *Int. J. Pharma Bio Sci.* **2016**, *7*, P146–P151. [CrossRef]
144. Rodrigues, F.; Pimentel, F.B.; Oliveira, M.B.P.P. Olive By-Products: Challenge Application in Cosmetic Industry. *Ind. Crops Prod.* **2015**, *70*, 116–124. [CrossRef]
145. Kesente, M.; Kavetsou, E.; Roussaki, M.; Blidi, S.; Loupassaki, S.; Chanioti, S.; Siamandoura, P.; Stamatogianni, C.; Philippou, E.; Papaspyrides, C.; et al. Encapsulation of Olive Leaves Extracts in Biodegradable PLA Nanoparticles for Use in Cosmetic Formulation. *Bioengineering* **2017**, *4*, 75. [CrossRef] [PubMed]
146. Le Floch, F.; Tena, M.T.; Ríos, A.; Valcárcel, M. Supercritical Fluid Extraction of Phenol Compounds from Olive Leaves. *Talanta* **1998**, *46*, 1123–1130. [CrossRef]
147. Ilgaz, C.; Kelebek, H.; Kadiroglu, P. Ultrasound-Assisted Extraction of Hydroxytyrosol from Lactiplantibacillus Plantarum Fermented Olive Leaves: Process Optimization and Bioactivity Assessment. *Fermentation* **2023**, *9*, 514. [CrossRef]
148. Al-Rimawi, F.; Sbeih, M.; Amayreh, M.; Rahhal, B.; Mudalal, S. Evaluation of the Antibacterial and Antifungal Properties of Oleuropein, *Olea europea* Leaf Extract, and *Thymus vulgaris* Oil. *BMC Complement. Med. Ther.* **2024**, *24*, 297. [CrossRef]
149. Owen, R.W.; Giacosa, A.; Hull, W.E.; Haubner, R.; Würtele, G.; Spiegelhalder, B.; Bartsch, H. Olive-Oil Consumption and Health: The Possible Role of Antioxidants. *Lancet Oncol.* **2000**, *1*, 107–112. [CrossRef]
150. Di Donna, L.; Mazzotti, F.; Naccarato, A.; Salerno, R.; Tagarelli, A.; Taverna, D.; Sindona, G. Secondary Metabolites of *Olea europaea* Leaves as Markers for the Discrimination of Cultivars and Cultivation Zones by Multivariate Analysis. *Food Chem.* **2010**, *121*, 492–496. [CrossRef]
151. Arya, S.S.; Kaimal, A.M.; Chib, M.; Sonawane, S.K.; Show, P.L. Novel, Energy Efficient and Green Cloud Point Extraction: Technology and Applications in Food Processing. *J. Food Sci. Technol.* **2019**, *56*, 524–534. [CrossRef]

152. Martínez, M.M.M.; Buitrago, E.M.E.; Yñiguez, R.; Puig-Cabrera, M. Circular Economy and Agriculture: Mapping Circular Practices, Drivers, and Barriers for Traditional Table-Olive Groves. *Sustain. Prod. Consum.* **2024**, *46*, 430–441. [CrossRef]
153. Lo Giudice, V.; Faraone, I.; Bruno, M.R.; Ponticelli, M.; Labanca, F.; Bisaccia, D.; Massarelli, C.; Milella, L.; Todaro, L. Olive Trees By-Products as Sources of Bioactive and Other Industrially Useful Compounds: A Systematic Review. *Molecules* **2021**, *26*, 5081. [CrossRef] [PubMed]
154. Berbel, J.; Posadillo, A. Review and Analysis of Alternatives for the Valorisation of Agro-Industrial Olive Oil By-Products. *Sustainability* **2018**, *10*, 237. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.