Chapter

Perspective Chapter: Recent Advancements in the Use of Olive Products for Biotechnological Processes

Georgios Efthimiou

Abstract

This chapter discusses the most recent applications of olive-derived materials in biotechnology, agriculture and food technology. Although the high-quality olive oil is usually destined for human consumption, lower oil grades or waste materials from the olive mill can be used to produce a plethora of valuable products, such as biofuel, soil fertilisers, medicines, enzymes, food packaging biopolymers and even building materials and textile dyes. Furthermore, compounds from olive mill wastewater have been found to stimulate plant growth by affecting their metabolism and also have potent antimicrobial properties, helping the biocontrol of hazardous plant pathogens. All these applications of olive products and by-products can help establish a sustainable circular economy through recycling of waste and resources.

Keywords: olive, olive mill wastewater, olive oil, biotechnology, high-value products, waste valorisation, circular economy

1. Introduction

1.1 Olive products and by-products

The olive is the fruit of the olive tree (*Olea europaea* L.), which is mainly found in the Mediterranean basin, but also cultivated in other areas of the world that allow its growth, such as North and South America, South Africa, Australia and New Zealand [1]. Traditionally, the flesh of the fruit is used for the production of olive oil, which is destined for human consumption in a variety of dietary applications [1].

The kernel of the olive fruit is often used to produce olive kernel (or pomace) oil, an oil which is considered of lower dietary quality compared to olive oil [2].

The waste produced during the olive oil extraction procedure is called olive mill wastewater (OMW) and has been identified as useful material for the synthesis of various key products *via* several pathways of waste valorisation [3].

1.2 Vegetable oils in bio-fermentation

Olive oil, as well as other vegetable oils has a long history of use in microbial fermentation in large industrial bioreactors, where the oil is slowly added as a carbon source during the fermentation process [4, 5]. This can lead to the production of many high-value products such as antibiotics, organic acids or enzymes [6–8].

1.3 Pyrolysis of OMW

OMW can be treated with pyrolysis, a process that can be used to convert olive mill wastewater (OMW) into bio-oil, biochar and syngas [9]. Different pyrolysis methods have been recently suggested, such as fast pyrolysis and low-temperature microwave-assisted pyrolysis [10, 11]. These processes have been supported with modelling approaches in order to predict and optimise product yield [12]. Pyrolysis products from OMW are traditionally used as biofuel or soil amenders for agricultural purposes.

1.4 Anaerobic digestion for biogas production

Anaerobic digestion of OMW can also lead to useful products, such as methane [13]. During anaerobic digestion, the OMW sludge is being digested by microbes that eventually produce different types of biogas under anaerobic conditions. Methane and other useful gases can be then utilised for production of energy and/or electricity.

1.5 Range of products synthesised from olive-derived materials

In this chapter, new developments in biotechnological applications of olive products and by-products will be highlighted and discussed. In Section 2, different types of valuable products from olive-derived starting materials will be portrayed, including biosurfactants and biolubricants (Section 2.1), high-value products such as antibiotics, enzymes and organic acids (Section 2.2), agricultural (Section 2.3) and food technology (Section 2.4) applications and finishing with novel innovative products such as leather dyes, building materials and polyurethane foam (Section 2.5).

2. Recent advancements in the use of olive products in biotechnology

2.1 Bio-lubricants and biosurfactants

Olive oil itself has lubricating and surfactant (emulsifying) properties and can be used in a variety of industrial and food-related applications. It also prevents formation of foam in bioreactors with microbial cultures [6]. However, due to its high price, other olive by-products are often used to synthesise bio-lubricants and biosurfactants. Lubricant dry substances or coating is used to reduce friction between two surfaces, while surfactants can be used in several homogenisation processes in the food industry or for facilitating digestion of petroleum spills by microbes [14, 15]. Olive-derived materials have been recently reported to lead to the synthesis of such agents [16, 17].

2.2 High-value products

Olive products and by-products have been described to be able to lead to the biosynthesis of high-value compounds when used as carbon sources in biofermentation vessels with microbial cultures [18]. In these cases, the microbes (usually bacteria,

yeast or filamentous fungi) utilise the vegetable oil or waste for supporting their metabolism, increasing their biomass and synthesising key primary or secondary products. For example, the antibiotic clavulanic acid is known to be produced in high yields when olive or olive kernel oil is added in the culture [6, 19]. Enzymes, such as lipases, can be efficiently produced by microbes in oil-containing media and subsequently be extracted and purified [20]. The yeast *Yarrowia lipolytica* has been recently reported to facilitate the biosynthesis of ethanol (biofuel, beverages and research), citric acid (important for the food industry) and magnesium oxide nanoparticles (antibacterial activity) from olive-derived materials [21–24]. Lastly, utilisation of exhausted olive pomace by *Crypthecodinium cohnii* led to the synthesis of omega-3 fatty acids [25], while oleochemical modification by application of ascorbic acid led to the synthesis of bio-based cyclic carbonates that can be used as green biofuels [26].

2.3 Agricultural applications

Olive-derived materials have also been used in agriculture as fertilisers and biocontrol agents. For instance, OMW can be used as fertiliser for crops, while it can also be treated for production of clean water that can be used for irrigation of crops [27]. Olive waste composts have also been applied for high-yield growth of tomato seedlings [28]. Other groups have previously tested similar composts from olive pomace or leaves on lettuce, tomato and emmer seedlings, all reporting higher yields compared to the untreated control crops [29–31]. Finally, OMW is a source of bioactive molecules for plant growth and protection against pathogens [32]. Humic acids extracted from OMW can be used as plant biostimulant in agriculture, thanks to their positive effects on plant biomass production, nutrition and activity of enzymes implied in N metabolism and glycolysis. Drobek et al. [33] showed that plant biostimulant formed as a by-product of the olive oil can induce an increase in the protein content of maize grains up to 19%.

Phenols from OMW have similar biostimulating effects on plants [33]. Finally, OMW water has been found to have strong antifungal properties that protect crops against *Fusarium oxysporum*, *Pythium* spp., *Sclerotinia sclerotiorum*, *Verticillium dahlia* and *Botrytis cinerea* [34, 35].

2.4 Food technology applications

Valorization of by-products from olive oil industry has also led to the development of a variety of innovative functional foods [36, 37]. Olive oil itself has been used together with potato starch for creating edible films reinforced with nanoparticles for their use as edible food packaging [38]. Moreover, phenols from olive oil by-products have been employed for food applications through microencapsulation approaches [39]. More specifically, most of phenolic compounds present in olive oil by-products lose their activity quite quickly due to environmental factors such as temperature, pH and light exposure. Therefore, prior to food fortification with phenolic-rich extracts obtained from olive oil by-products, they should be protected through microencapsulation approaches, allowing a sustained release of phenolic compounds in the fortified foods. Finally, more examples of food packaging from olive pomace-based biocomposites and other alternatives to conventional petrochemical-based packaging materials often reinforced with plant essential oils, natural additives, improved oxygen barrier, and antibacterial and antifungal properties [40, 41].

2.5 Innovative manufacturing applications

A variety of novel products based on olive-derived materials have been developed recently. These include the use of olive oil polyols for making renewable polyurethane foams [42] and bio-based insulating building materials from recycled olive core [43]. Finally, leather and textile dyes can be developed from OMW that are of great importance for the tanning industry [44].

3. Conclusions

In this chapter, several examples of biotechnological applications of olive products and by-products were presented and discussed. It is clear that these materials can be exploited *via* different pathways and lead to the synthesis of a wide variety of valuable products. Several parts of the olive tree such as the wood and the leaves can be used for energy generation, while the olive fruit and its core can also be used for making medicines, fertilisers, biofuel, food coatings and even building materials and textile dyes. Further research will definitely suggest more such applications in the near future. All these examples make olive a precious fruit for the biotech industry and a significant player in the maintenance of a sustainable circular economy, aiming to reduce waste and conserve resources by recycling and reusing products and components [45].

Author details

Georgios Efthimiou
Centre for Biomedicine, Hull York Medical School, Hull, UK

*Address all correspondence to: g.efthimiou@hull.ac.uk

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