A Methodology for Boosting Circular Economy in Olive Oil and Wine Sectors: Opportunities for the Italian Competitiveness through Eco-Innovation Strategies

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Abstract

Applying the principles of circular economy to agriculture is a very important contemporary issue on the international political and economic agenda. In this context, current knowledge and recent insights on biosurfactant production will be surveyed to apply these novel economic approaches in the field of agricultural waste valorisation.

The main objective of the CREIAMO project is to set up a replicable methodology for boosting the transition towards circular economy of the oil and wine production sectors through the creation of new destinations for residues originated, new options for their economic valorisation and new business models to increase the competitiveness of companies. A first pilot application will be run in the Lombardia Region. To achieve this objective, the project operates on different eco-innovation strategies:

a. Process and product eco-innovation for the exploitation of agriculture wastes from the production of wine and olive oil for producing eco-friendly biosurfactants. Cost-effective production methods will be implemented to improve its market profitability, resulting in higher yields and purity. In CREAIMO, theses bio value-added products will be, therefore, used to treat contaminated soil, which represents a main environmental issue.
b. Systemic eco-innovation through industrial symbiosis (IS), allowing companies to achieve at the same time economic, environmental, and social advantages. This project will represent the first structured attempt of industrial symbiosis implementation in the Lombardia region, aiming at creating a symbiosis network with the active participation of both SMEs and local stakeholders.

Keywords: Circular economy; Rhamnolipids; Waste valorisation, Eco-innovation, Integrative approach.

1. Introduction

Olive and winery cultivation are particularly widespread throughout the Mediterranean region, including Italy, and play vital roles in its rural economy, local heritage, and environment protection (Muhlack et al., 2018; Varelas et al., 2016). Olive oil production in the European Union (EU), was around 75.8% of the world's production from 2009 to 2016, with Spain the largest producer (followed by Italy and Greece) responsible for an average of 62.7% of the total production in the EU over those years (IOOC, 2016). Italy possesses an important olive-growing heritage, with more than 150 million olive trees on approximately 1,100,000 hectares of cultivated land and 825,000 farms (ISMEA 2016). While for winery sector, 7,204,904 tonnes of wine grapes were harvested in Italy in 2016, from a production area of 622 million hectares, which yields a yield per hectare of 115.8 quintals (ISTAT 2018; Muhlack et al., 2018). Production in Lombardy reaches 1.47 million hectoliters (ISTAT 2018). Designation of origin (PDO) wines were 781 thousand hectoliters, while protected geographical indication (PGI) production was 535 thousand hectoliters, reaching 36% of total production, the historical maximum. The vineyard area covers a total of 21220 hectares.

These two agriculture sectors generate diverse adverse effects on the environment, and several Life Cycle Assessment analyses carried out in Italy (Bordiga et al., 2019), have pointed out the generation, management and treatment of those wastes as one of the main opportunities to take into consideration for reaching eco-friendlier production chain (Luciano et al., 2016). Physico-chemical characteristics of the wastes generated vary mainly according to the process used for the extraction of olive oil (e.g., live cake, olive mill wastewaters, olive wet cake) (Roig et al., 2006). Olive cake is usually further processed for soil conditioning and composting, or to produce biomass fuel because of its high calorific power (Roig et al., 2006).

Several attempts were carried out towards detoxification of such wastes and the recovery of high valuable bioactive compounds present in the olive oil wastes, such as polyphenols, which deal with the increasing interest on valorising wastes by recovery biomolecules (Baiano, 2014). In this context, those strategies would valorize olive oil and winery wastes, generates a remarkable by-product rather than just a waste, and at the same time minimizing environmental impact.

Rhamnolipids are one of the major groups of biosurfactant that display an amphipathic property, meaning that their structure comprises one hydrophobic and one hydrophilic moiety (Banat et al., 2010). These amphiphilic compounds are powerful natural emulsifiers capable of reducing the surface tension of water from roughly 76 mN/m to 25 to 30 mN/m. Those proprieties advise these biomolecules a number of characteristics e.g., the ability to reduce surface and interfacial tensions, the formation of microemulsions, a stability over a wide range of temperatures and pH, several biological activities (e.g., anti-inflammatory, anticarcinogenic, immune-modulator, anti-microbial, and antitumor activities) (Du et al., 2017). *Pseudomonas aeruginosa* is a well-known rhamnolipids producer, predominantly Di-rhamnolipid Rha-Rha-C_{10}-C_{10}, known for its pathogenicity on humans, animals, and plants, which has crippled several efforts of commercialization of those biomolecules for safety concerns (Irorere et al., 2017). Based on those limitations, current approaches are focusing on non-pathogens rhamolipides producer such as some *Burkholderia* spp. (Mohamed Elshikh et al., 2017).
In this framework, the project CREIAMO is aimed at producing rhamolipids through adding value to agriculture wastes, demonstrating their applications on nearby contaminated soils in Lambardia region, and, consequently, applying the fundamental principles of circular economy in Lombardia region, in Italy (Fig. 1).

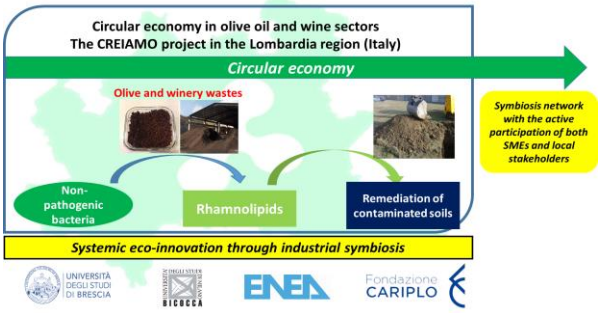

Fig 1. CREIAMO Project

2. Production Of Rhamnolipids Using Olive And Wine-Processing Wastes

This biosurfactant activity of rhamnolipids makes them excellent candidates for assisting in the breakdown and removal of oil spills fields (Deepika et al., 2015). Rhamnolipids also demonstrate antibacterial and antifungal activities, suggesting possible roles in the medical and agricultural fields (Deepika et al., 2015). Since this biosurfactant is derived from a natural source and in, a pure form has low toxicity levels, rhamnolipids are an attractive alternative to synthetic compounds. However, since rhamnolipids are produced by *P. aeruginosa*, a pathogen of humans, animals, and plants. In CREIAMO framework, a nonpathogen strain would be used to produce those surface actives agents for better environment and sustainable eco-compatibility, along with potential ecotoxicity assays.

Eco-friendly rhamnolipids as promising agents for treating contaminated-soils

Soil contaminated with hydrocarbons is a relevant environmental problem worldwide, mainly caused by incomplete combustion or pyrolysis of organic matter generally concerning industrial and urban activities. Due to their properties and, consequently, longterm effects, persistence, bioaccumulation and, above all, their potential mutagenic effects on human health, PAH soil contamination has attracted particular attention (Gkorezis et al., 2016). Bioremediation may be strongly limited by several factors such as the low biodegradation of PAHs and low bioavailability of the nutrient, resulting too lengthy or uneffective (Gkorezis et al., 2016). More effective remedial solutions are then desirable as the use of ecofriendly biosurfactants (Banat et al. 2010).

3. Systemic Eco-Innovation Through Industrial Symbiosis

Industrial symbiosis aims at allowing companies to achieve at the same time economic, environmental, and social advantages (Luciano 2016). CREIAMO project will represent, therefore, the first structured attempt of industrial symbiosis implementation in the Lombardia region, aiming at creating a symbiosis network with the active participation of both SMEs and local stakeholders. Nevertheless just some trend setter companies have already applied industrial symbiosis strategies expected to drive to zero waste processes (Varelas et al., 2006): they are committed to the emerging circular economy, sharing their co-product and waste and supplying in an inter-company and inter-sectorial environment with valorisation of resources through the creation of new high added value products. Industrial symbiosis application can contribute to the systematic reuse of waste and by-products, which minimizes the need to extract natural resources according to the internationally recognized waste hierarchy. For that, within the CREIAMO project, a market of secondary resources and services arises and should be promoted and accelerated within companies.
The methodology adopted in CREIAMO for the Lombardia region will be replicable in other Italian regions.

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