

Implementing Circular Economy in Wineries: The Case of Greece

KOUNANI A.^{1,*}, SOTIROPOULOU E.², and SELEVENTI M. K.¹

¹University of the Aegean, University Hill, 81100 Mytilene, Greece

²National and Kapodistrian University of Athens

*corresponding author: Kounani Aristeia

e-mail: akounani@yahoo.gr

Abstract. Grape is considered one of the largest fruit crops in the world, since its 2017 production, the vast majority of which was used in winemaking, reached 74 MT globally and 24 MT in the EU. The main target of this paper is to highlight the urgent need for transforming the linear model into a circular one in the case of agriculture, and especially in wine production. According to the International Organization of Vine and Wine, Greece held 1.3% of the total European wine production in 2018 (300,031 tons of wine), while at the same time it was ranked in the twelfth place in terms of wine production on a global scale. Therefore, it is of great significance to implement the circular economy model in Greek wineries. After an extensive literature review, this paper aims to examine whether a circular economy could be implemented in wineries adequately. Last but not least, it presents some of the valuable products that can be obtained from grape marc not only in the food industry but also in cosmetics, phyto-pharmaceutical sector, and in the animal feeding or bio-fertilizers.

Keywords: circular economy, winery, wine industry, agriculture, wine waste management

1. Introduction

Global warming, climate change and pollution are today's greatest environmental global issues that challenge policy-makers and academics to seek for emergent solutions that ensure the sustainability of the planet (Shama 2019). This fact has led to the adoption of circular economy (CE), an economic model that symbolizes pattern alterations in the way that humanity interacts with the natural environment. CE aims to prevent the depletion of resources, close energy and materials loops, and facilitate sustainable development (Grafstrom and Aasma 2021). Therefore, CE focuses on the efficient usage of resources through waste minimization, long-term value retention, closed loops of products and materials, and decrease of primary resources, within the margins of socio-economic benefits and environmental conservation (Morsetto 2020).

In recent years, while CE has gained momentum as a new economic paradigm and sets a defined vision for a

sustainable future, it still operates in the present (Weigend Rodriguez et al. 2020). The estimates of gains from a CE are substantial, fact that reveals the necessity of implementing CE in all human activities such as agriculture, tourism etc. (Grafstrom and Aasma 2021).

The purpose of the current paper is to examine whether a circular economy could be adequately implemented in agriculture activities, and more specifically in winery production. Given that the demand for wine as an alcoholic beverage is on the rise, achieving 243 million hectoliters, and that the amounts of waste and other by-products produced worldwide are considerable, the need for the application of CE in the wine waste treatment is imperative. Not only does this paper presents some of the valuable products that can be obtained from grape marc in the food industry, but also it proposes how it could be used in cosmetics, phyto-pharmaceutical sector, and in the animal feeding or bio-fertilizers. Lastly, this study aims to reveal the extent of implementation of CE in Greek wineries specifically.

2. Circular Agriculture

The urgent need to transform the linear model into a circular one is particularly vital in the agriculture sector.

Circular agriculture (CA) is an ecological concept based on the principle of optimizing the use of all biomass, centering at closing the loop of materials and substances, and reducing both discharges into the environment (wastes and emissions) and resource use. What was earlier considered as waste or surplus, becomes a resource that is (re)valorized (Berkum and Denninger 2019). Circular economy in agriculture can be achieved through the (re)design of maintenance, repair, reuse, remanufacturing, refurbishing, and recycling (Bhattarai et al. 2021). Using the principles of CE in agriculture provides a kind of solution to minimize waste in agri-food systems, while meeting the demands for food (EU 2020).

The wider benefits of the CE include the reduction of current carbon dioxide emissions (MFMKCBE 2015). Therefore, the CE measures are closely linked to key EU priorities, including employment and growth, the investment agenda, climate change and energy, the social agenda and industrial innovation, as well as to global efforts in the field of sustainable development (Visa and

Milea 2018). Consequently, new measures like environmental taxes, insurance for liability resulting from environmental damage, cap and trade system and environmental labelling can be explored to promote the transition from a current linear model to a circular one (Bhattarai et al. 2021).

3. Wineries and Circular Economy

The wine industry is one of the most powerful in different regions of the world. The large amount of wine production is associated with the use of a large number of resources (water consumption, organic and inorganic fertilizers etc) (Rockenbach et al. 2011), as well as with the production of considerable amounts of waste during the complex process of wine making (Zacharof 2017), that must be treated adequately to avoid contaminating the areas of production (Maicas and Mateo 2020).

Although winemaking is considered an environmental friendly process, it produces between 1.3 and 1.5 kg of waste per liter of wine produced, 75% of which is liquid residues (Ioannou et al. 2015). Solid waste and liquid residues mainly produced during the harvest period account for 74% and 87% respectively (Oliveira 2016).

Vine cultivation itself and basically wine making in cellars produces high amounts of waste and side-off products, including pomace, seeds, stems, pruning, yeast and bacteria lees, organic acids (tartrate), CO₂ and water (Rockenbach et al. 2011, Pigno et al. 2013). Most of the waste produced in a winery (80 to 85%) is organic (Ruggieri et al. 2009), whereas the composition of inorganic compounds in winemaking effluents depends mainly (up to 76%) on the components of the detergents used (Mosse et al. 2011). Unfortunately, only a few quantities of these materials are used for fertilization, animal feed, or generation of other products (Rockenbach et al. 2011, Rondeau et al. 2013).

The possibility of recovering organic wine wastes to soil vineyards may be considered as a sustainable strategy for waste management. The reuse of vinification residues could anyway find a second life in different areas (Manniello et al. 2020). Ferrer et al. (2001) have used stalks mainly as compost for the restoration of soil fertility with consequent spreading in the soil. Israilides et al. (1998) used grape pomace extract for pullulan production. Portilla-Rivera et al. (2007, 2010) used the pomace as a carbon source for lactic acid fermentation, for the production of bio-emulsifiers, hydrolytic enzymes (Diaz et al. 2009), bio-ethanol (Rodriguez et al. 2010), while tannins have been extracted (Jiang et al. 2011). Ping et al. (2011) used the polyphenols present in the pomace as dyes for the food industry and as antioxidants. The pomace, as a means of phytopathogenic control, (Bai et al. 2008, Santos et al. 2008) or the vinification dregs, as an essential raw material, has also been recommended for use in the ethanol and tartaric acid production process (Versari et al. 2001, Braga et al. 2002). From the marcs, through the process of composting, a substrate for plants has been produced (Paradelo et al. 2010, Manios et al. 2007, Pardo et al. 2009, Garcia-Martinez et al. 2009) as well as a special substrate for the cultivation of mushrooms (Pardo et al. 2007).

Moreover, the by-products of wine can be used for valorization of functional ingredients or bioactive

phytochemicals that can be devoted to the generation of pharmaceutical, food, and cosmetic ingredients (Rockenbach et al. 2011). Grape seed oil extracted from grape seeds is valuable low-fat oil, rich in Vitamin E (anti-oxidant) and is cholesterol free. It is also used in various products and processes such as baking, marinades, salad dressings and cosmetics such as hair products, hand cream and lip balm (Bonamente et al. 2016).

4. The Case of Greece

4.1. Circular Economy in Greece

Greece lags significantly behind in the adoption of circular economy models, depriving the economy and society of the added value that it entails. Municipal waste production in Greece amounts to 5 million tons per year, of which only 20% is recycled. The remaining 4 million tons (80%) are disposed to landfills, 3 million tons of which are potentially recyclable and biodegradable materials, and are transported to landfills at a cost of € 135 million (ABI 2018).

The CE can be a catalyst for productive reconstruction and has a clear regional dimension. According to the National Documentation Center, Greece presents great possibilities for the application of this productive/economic model. A study of the Greek Industrialists Association for Sustainable Development (May 2016) regarding the implementation of the circular economy in Greece, revealed that there is a need for legislative and regulatory reform, significant improvement in excavation, construction and demolition waste management, significant improvement in food waste management, and increase in the penetration of secondary fuels in certain industrial uses (NDC 2019).

4.2. Waste Management and CE in Greek Wineries

As data released by the International Organization of Vine and Wine reveal, Greece accounted for 1.3% of the total European wine production in 2018 (300,031 tons of wine), while at the same time it achieved the twelfth place concerning wine production globally (IOV 2018). It is estimated that approximately 807,570 tons of grapes were processed in 2019 (FAOSTAT 2021) and consequently 142,000 tons of by-products, when Europe reaches 14.5 million tons of grape by-products on an annual basis (Maicas and Mateo 2020).

The area of vineyards has been stable over the last decade, area that occupies 61,633 hectares (in 2015) (Eurostat 2021). The number of viticulturists is about 180,000, which is about one fifth of the landowners engaged in agriculture. There are more than 1,290 wineries producing wine, with that number growing every week (WOG 2021).

Cultivation and harvesting result in about 5 tonnes of solid waste per hectare per year, whereas the total amount of wastewater deriving from winemaking reaches 650,000 m³ in Greece (Zacharof 2017).

Little research has been conducted so far in order to reveal the current level of implementation of CE in wine industry in Greece.

Varelas et al. (2016) reported the use of the winery yeast waste (wine lees) for the production of added value products such as β -glucan, which has a lot of applications in the food industry. as a part of an intergraded and sustainable wine industry.

Sotiropoulou et al. (2018) focused on the utilization of grape pomace and the production of single cell protein. The outcomes of the study revealed a potential use of winery by-products in the food and animal feed industry.

In 2020, Fragkos conducted a research in Thessaly, a Greek region, towards the CE in wineries. He concluded that CE is implemented in the last phase of production chain, due to the lack of new technologies that have not been developed yet or the high cost. However, 'spin off' companies have created processes that convert wine waste products into animal food or compost. Obviously, the CE model is beginning to be developed in wineries of Thessaly and mostly in waste management. Based on these findings, CE is competing to replace the traditional wine product processing policy, but still more effort is needed to make it a viable alternative and a generic one in the future (Fragkos 2020).

Domaine Agrovision, a winery located in Northern Greece, applying in practice the principles of the circular economy, utilizes the residues after the fermentation of the red wine for the production of pizza and bread, in collaboration with local companies. More specifically, almost 100 kg of wine lees has already been reused, while the winery's overall waste for 2020 was reduced by nearly 40%. Additionally, it creates bicycle bases from by-products of the viticultural sector and uses marcs as feed for sheep and goats. At the same time, it has launched the creation of a circular economy park with the main emphasis on wine and its local history, in order to connect waste management/by-products with history and the real economy (Interreg Europe 2021).

Moreover, Oinosporos, a company focused on research in winery byproducts, has created a complete beauty line of products utilizing grape seed oil and grape seeds while promoting the Global Sustainable Goals through circular economy (Sotiropoulou 2018).

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5. Conclusions

Reusing residues deriving from agricultural activities could be profoundly beneficial in the implementation of a circular bioeconomy, as waste could be put in good use resulting in a considerable number of positive effects in relation to non-disposal costs, transportation and waste management, soil improvement and replenishment of its fertility given that the cooperation among the basic parts namely productive agricultural activities, agri-food industries and entrepreneurs is fostered—and that the analysis of economic and environmental feasibility is performed.

The by-products and residues of the vinification could well, after proper treatment, constitute a new financial resource and at the same time meet the rules of environmental protection. In addition to the above, by utilizing them, the reduction of the production cost of the winery, the reduction of the environmental footprint, but also the creation of new jobs could be achieved.

The wine industry is definitely engaged in sustainability. In addition, the industry has shown an involvement in sustainability in general, people in the wine industry wonder about the effectiveness of sustainable practices and under what conditions it pays to be oriented towards sustainability.

However, the Greek National Strategy for the Circular Economy following the line of the European strategy, Greece lags significantly behind in the adoption of circular economy models, depriving the economy and society of the added value it entails. The government must immediately proceed with the removal of existing barriers and ancillaries arising from the existing legal framework, such as e.g. waste utilization tests in industrial activities. The Greek wine industry as a whole should adopt circular economy practices, in order to promote the principles of sustainability and at the same time create new business opportunities. It would be interesting to conduct in-depth future research to depict the degree of implementation of sustainability and the CE in Greek wineries.

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