Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 12(X), 2024: http://dx.doi.org/10.7770/safer-V10N1-art2459

Circular economy in the wine industry: an agent based model for the wine supply chain.

Economía circular en la industria del vino: un modelo basado en agentes para la cadena de suministro del vino.

Irfan Pottachola

Department of Construction Management and Engineering University of Twente

Enchede, Netherlands, email: ipottachola@gmail.com

ABSTRACT

In the last decades, the concept of sustainability has driven many industries into a reconfiguration of their operations to reduce environmental impact. Accordingly, governments and public institutions are shaping the boundaries for new regulations, especially in the agriculture sector. Wine production is a major global industry, and its interest in becoming greener and more sustainable is growing. Since most of the wastes in the wine industry are attributable to organic composition, people share the belief that these wastes are not dangerous for the environment. However, the waste proportion in wine production is significant, reaching a 2:1 ratio, which means that for every two bottles of wine produced, the companies must discard a "bottle of waste". This study concerns the winemaking process and the possibility to implement Circular Economy (CE) practices in it. The paper also shows several applications of circular economy in the wine sector, identifying benefits, drivers and actions that can lead towards more sustainable business models.

Keywords—Wine, wine industry, winemaking, sustainable, circular economy, business model

RESUMEN

En las últimas décadas, el concepto de sustentabilidad ha llevado a muchas industrias a reconfigurar sus operaciones para reducir el impacto ambiental. En consecuencia, los gobiernos y las instituciones públicas están dando forma a los límites de las nuevas regulaciones, especialmente en el sector agrícola. La producción de vino es una industria global importante, y su interés en volverse más verde y más sostenible está creciendo. Dado que la mayoría de los desechos en la industria del vino son atribuibles a la composición orgánica, la gente comparte la creencia de que estos desechos no son

peligrosos para el medio ambiente. Sin embargo, la proporción de residuos en la producción de vino es significativa, alcanzando una proporción de 2:1, lo que significa que por cada dos botellas de vino producidas, las empresas deben desechar una "botella de residuos". Este estudio se refiere al proceso de elaboración del vino y la posibilidad de implementar prácticas de Economía Circular (EC) en él. El documento también muestra varias aplicaciones de la economía circular en el sector del vino, identificando beneficios, impulsores y acciones que pueden conducir hacia modelos comerciales más sostenibles.
Palabras clave—Vino, industria vitivinícola, enología, sostenible, economía circular, modelo de negocio

INTRODUCTION

Wine production is a major global industry, and its interest in becoming greener and more sustainable is growing. If in the past this tradition was mainly characterised by small producers and limited quantities of product, nowadays the success and appreciation of wine are leading this sector towards intensive agriculture worldwide. Recent discoveries and innovations have been put into practice in many companies already, but the room for improvement is still considerable. Furthermore, since product sustainability is turning into a crucial feature also affecting daily decisions, the implementation of a circular economy (CE) with a small footprint on the environment is requested by the consumer itself. The by-products of this sector cover a wide range of possible re-uses.

For instance, researchers recently showed that grape bagasse, i.e. the fibrous part of a bunch of grapes, has promising properties for the mercury removal in the water treatment (Zúñiga-Muro et al., 2020). Other sustainable measures involve territory exploitation and the performances of a sustainable vineyard (Borsato et al., 2020). Finally, several studies showed relevant improvements which apply to the bottle filling process within the wine industry. All these different opportunities demonstrate the variety of measures that can be introduced to accomplish sustainable goals in this industry.

In this research, we only refer to the wineries where the grapes are transformed into wine, leaving apart viticulture and distribution. Our aim consists in providing a comprehensive literature review on the sustainable actions within this "window". Next to this, we develop an agent-based framework. Through the agent-based model we address the following questions: 1) How is it possible to implement industrial symbiosis (IS) measures in the winemaking process? 2)What advantages can be obtained by introducing CE within the winemaking process?. This report is based on bibliographic research carried out at the beginning of October 2020. Therefore, the publications are up to date until the 1st of October, 2020. The first step to create our literature database was documents collection. Google Scholar has been used for our preliminary research and it was useful to identify main keywords that could have been crucial for our SLR. Papers have been drawn,

screened and selected from the following portals: Scopus, Science Direct, Web of Science and Springer Link. In all of them, the same string of keywords and filter settings have been used.

MATERIALS AND METHODS

Phenomenon and process description: In order to assess where to act to obtain a circular business model, we believe it is important to have briefly explained the processing phase of winemaking. For the purposes of our research, we decided tofocus mainly on the winemaking process, starting from the grapes already harvested up to bottling, packaging and distribution. This choice allows us to focus on those processing steps where it is easier, more effective and immediate to apply the principles of CE. The cycle of winemaking starts with the harvested grapes being taken to the winery or factory. At the winery, the grapes are unloaded into a crusher and a manual selection of the grapes could be carried out, depending on the quality of the desired wine. The crushing may be accompanied by pressing, according to the variety of grapes.

Skins and seeds are then removed from the juice, depending on the type of wine, immediately after crushing or left in contact with the juice for 12 to 24 hours to increase flavour and colour extraction. When separated one from the other, the solid is called "must", a term also used to refer to the unfermented grape juice.

After the separation of the two, the pressed mass remaining after the extraction of the juice from the grapes, so-called "pomace", can be distilled to produce spirits. The juice is usually turbid and cloudy and must be filtered, centrifuged, pasteurized, or added with chemicals to facilitate clarification. After this step, yeast (Saccharomyces cerevisiae) can be added as a starter for the fermentation; some grape varieties do not require any additions and will start the fermentation autonomously. The alcoholic fermentation process is accurately controlled, and temperature and unwanted bacteria are carefully regulated. Also, air is restricted to prevent oxidation, whilst carbon dioxide is emitted. Since this process may last days or weeks, a cap of skins and pulp floating on top of the juice may create and this could bring unwanted results; it is therefore broken or submerged frequently. When the wine-to-be has reached the desired alcohol content, the fermentation is completed. To stop it, chemicals can be added, or temperature may be altered. Lastly, clarification is carried out by removing suspended material through filtration, centrifugation, refrigeration, and heating. The wine is then set to ageing until it reaches the desired textures. Wines are usually aged in wooden containers to favour oxygen access and facilitate water and alcohol evaporation. Before bottling in a low oxygen environment, many wines are filtered and added with chemicals to prevent microbe development. Finally, the wine can be sold in bottles to distributors or in tanks to bottlers, according to the market needs and to the position of the winery in the production chain.

Theoretical framework: As stated in the previous sections, our study phenomenon concerns the winemaking process and the possibility to implement CE and IS practices in it. For this purpose, five agents were distinguished and considered:

I. Raw material suppliers: It considers all the actors at the very beginning of the process, such as farmers who grow wine grapes, but also chemical and additives suppliers. Also machinery providers can be included in this category.

II. Wine producers: these are the processing companies themselves. They use grapes as main input and produce consumable wine as output. Most of the CE and IS actions will be evaluated and implemented by these agents.

III. Policymakers: these actors encourage the implementation of CE and IS through legislation and, therefore, through obligations.

IV. Distributors: these agents buy the final output in the form of bottled wine or barrels; in the latter case, the wine will be transported and bottled by the distributors. They will also be responsible for the logistic part of the chain, transporting the final product to the consumer.

V. Waste buyers: in this category, all actors willing to buy waste from the winemaking process are included.

To implement CE and IS measures, these agents will modify their production process to incorporate waste as a substitute for their primary inputs.

Agents and actions

I. Raw material suppliers

Characteristics and drivers: raw material suppliers for wine production can be broadly classified into two: feedstock suppliers and chemicals/additives suppliers. Feedstock suppliers include farmers and vineyard owners who practice viticulture to supply grapes to wine producers. Other than the biological raw material, wine production also needs certain chemicals and additives such as bleaching and deacidification agents, yeast etc (Šperková & Hejmalová, 2011), which are provided by chemical and additives suppliers. For the raw material suppliers, one can generally classify the drivers to adoptcircular economy principles into two: internal drivers and strategic drivers. According to the literature (Gabzdylova et al., 2009; Sehnem et al., 2020; Brown et al., 2015; Marshall et al., 2005), the most important drivers for raw material suppliers to adopt CE principles are internal, such as the realization of corporate social responsibility initiatives, farmland and surrounding environment protection, sustainable and organic viticulture practices implementation. Besides, another internal driver concerns the longevity of the vineyard, i.e. the benefits sustainable and organic viticulture will provide to the land, such as improving land quality and reducing plant diseases, which increases the functional life of

the vineyard. Strategic drivers, such as competitive advantage creation, corporate image improvement and increasing profit and efficiency, also motivate the suppliers to adopt sustainability measures (Gabzdylova et al., 2009). This mainly counts for the chemical and additive suppliers, as the increasing popularity of sustainable wine threatens their existence; in fact, they are likely to succumb if they don't adopt the required practices and provide sustainable materials called for by the wine producers. Recognitions such as organic viticulture, biodynamic and vegan wine certifications increase the corporate value of the suppliers, thus providing them with an upper hand in the industry. Literature also suggests that sustainable and organic viticulture attracts tourists (Abad et al., 2014) and enhances real estate value (Ouvrard et al., 2020) acting as additional incentives for the suppliers.

Actions: raw material suppliers can adopt several measures to incorporate CE principles into their processes:

- Specific investments in the vineyards and chemical factories: these investments are aimed at incorporating sustainability and circularity measures within organisations and their processes. Changes in the vineyards architecture/location or aimed at developing and introducing new grape varieties can have huge impacts on the sustainability of the crops (Carroquino et al., 2019). Chemical producers can invest in technological innovations to improve process efficiency. Investments in renewable energy are also crucial.
- Adopting efficient crop and soil management methods: feedstock providers should focus on adopting greener crop management methods, such as organic and biodynamic viticulture, as they will result in lower environmental burdens when compared to conventional viticulture (Rey et al., 2013; Mariani&Vastola, 2015). Adopting innovative soil management techniques (e.g. green covers) can have significant impacts on sustainability, such as CO2 uptake, soil erosion reduction, rain infiltration, increase in soil organic carbon etc (Tezza et al., 2019).
- Adopting sustainable irrigation and proper wastewater management methods: vineyard owners can adopt measures to reuse the water for irrigation and to manage the usage of water. In some dry areas, water usage in viticulture sometimes accounts for as high as 70%-90% of the total water usage (Costa et al., 2020), underlining the need for substantial measures. Some examples of such efforts can be found in optimised irrigation techniques, use of cover crops, installation of water basins to collect rainwater and wastewater (Costa et al., 2020). Same counts for the chemical producers too which, by adopting various wastewater treatments, can reduce their water footprint to a minimum.
- Adopting renewable energy in vineyard and chemical production: feedstock suppliers and chemical suppliers can adopt renewable energy in the vineyard machinery and chemical production machinery respectively, which helps to reduce the use of conventional

fuels as well as the emissions of greenhouse gases. Feedstock suppliers can also produce biomass with pruning, whilst adopting solar and wind energy to power their machinery, significantly reducing their environmental impact (Carroquino et al., 2019).

II. Wine producers (wineries)

Characteristics and drivers: wine producers are the companies who process raw materials and turn them into consumable wine. These actors are the ones with the actual power to decide whether to implement CE principles or not and, consequentially, have an impact on the whole chain. Internal drivers could be identified in the reduction of the environmental impacts, protection of surrounding land, and achievement of CSR targets.

Moreover, strategic reasons could boost CE implementation, in order to gain more profit compared to those companies who do not have CE measures. In fact, such firms may attract more customers, especially those who also have concerns on environmental matters, working as a marketing tool.

Actions: possible actions for the wine producers to adopt to implement CE are:

- Circularity-based technology investments: investments in technological innovation may support the company's movement towards CE. For instance, wine producers can introduce new technical machinery that significantly reduces emissions compared to the previous equipment.
- Renewable energies and water reuse: by switching to or own-producing renewable energy, emissions of the winemaking process will be compensated. Also reusing wastewater in other process intra-company or inter-companies may significantly reduce the impact on the environment (Carroquino et al., 2019).
- Circularity surveillance: having to comply with certifications or labels of sustainable production may improve internal performances; also informal self-assessment could be useful for identification of weaknesses. Wine producer may have to perform energy audits, calculate their carbon footprint and the amount of waste and by-product to get certificates of organic and sustainable winemaking.
- Usage of ICT synergy identification systems: the IS identification app introduced may help wine producers to find partners interested in buying winemakers' waste. In this app, companies need to fill their industry profile and choose their role in the Industrial Symbiosis relationship, which in this case is "waste producers". The app will show which firms in their area might be interested in that waste product, allowing to contact them and negotiating a potential partnership.

III. Policymakers

Characteristics and drivers: policymakers have the power to incentive an entire sector or the whole economy of a region/country towards IS implementation; in this case,

they can help the wine production chain in overcoming barriers. Main drivers of these agents mainly concern the improvement in the environmental performances of companies within a certain region or country, for the good of society as a whole.

Actions: this section provides examples of several tools that policymakers can make use of to encourage CE implementation in companies.

- Encourage companies to adopt circularity-based management systems: companies with certified Environmental Management System are committed to improving their environmental management and performance recurrently and over time (Ardente et al., 2006).
- Provide incentives for companies who agreed to implement CE: even though profitability and economic benefits are the main drivers, the triple bottom line approach suggests to include the social and environmental spheres too. However, when it comes to implementing CE actions, companies may assume that there are no additional advantages apart from the environmentally-related ones and therefore they will decide not to implement any measure. Policymakers can help overcome this barrier by providing incentives such as financing infrastructure that are needed to perform IS exchanges (e.g. in the form of underground utilities) (Hein et al., 2017), and subsidies to make IS and CE more profitable under the economic viewpoint (Marildo et al., 2018).
- Free of charge support from public institutions: public institutions may act as facilitators in IS relationship between companies. Their role is to support companies by providing adequate tools. While a private party will provide paid-consulting, public institutions are funded by the government and comply with policymakers guidelines.
- Educating companies about IS benefits: many companies have a lack of knowledge about IS benefits, how to discover opportunities and partners and how to implement it. Providing substantial knowledge in these areas, but also presenting cases of companies that already succeed in IS partnering, will trigger companies towards CE implementation.

IV. Wine Distributors

Characteristics and drivers: wine distributors buy wine in barrels from wine producers and are responsible for the bottling and distribution process. A significant amount of energy consumption in the wine process comes from the production of the glass wine bottles and the transportation phase. Therefore, adopting bottle reuse or glass recycling systems, introducing alternative containers and designing more efficient glass bottles can lead to a reduction of energy consumption and a reduction of wastes to be landfilled (Mariani&Vastola, 2015; Acampora et al., 2017). A decreased energy consumption in bottle production and transportation to the final consumer is translated into a reduction of costs, increasing economic benefits for the wine distributor companies.

Actions: this section delineates several possible actions that the wine distributors

can adopt to become more sustainable and CE oriented.

- Implementation of efficient bottle collection systems: implementing such system will increase the use of reused bottles in the distribution phase. Due to geographical distance and transportation costs, the reuse program is a convenient alternative mainly for local markets (Ferrara & De Feo, 2020).
- Efficient maintenance of transportation means: regular maintenance of the transportation equipment and vehicles, as well as investments in lowering fuel consumption, will result in lower costs in the long run and a significant reduction of the environmental footprint.
- Improvement in packaging design: investments in improving bottling and packaging design will result in lighter wine bottles and optimised storage and transportation. Reduced demand for energy and raw materials in wine bottles production is not the only benefit: having more lightweight bottles will eventually lower fuel consumption during transportation.
- Transporting bulk wine and bottling it at final destination: wine producer countries such as France and Italy are used to export their wine to other EU and American countries by shipping bulk wine and bottling it once at the final destination. This is a great alternative to reduce the transportation cost and environmental impact since a bulk container has a lower weight, greater storage efficiency and suffer from lower potential damage incidence compared to wine bottles (Aranda et al., 2005). This option could be combined with local reused bottle collection systems, allowing maximisation of benefits and enhancing local market partnerships.

V. Waste buyers

Characteristics and drivers: waste buyers are companies that are willing to modify their demands for materials and inputs, to include waste as a substitute of traditional feedstock in their production processes (Fraccascia et al., 2018). There are several internal and external drivers for the waste buyer to include the wine by-products in other production processes; as an example: reduction of input purchase cost, new products development and production diversification within a firm, increase in consumer perceived value and business reputation. In the wine industry, food, pharmaceutical and cosmetic companies are potential waste buyers (Malindretos et al., 2016; Acampora et al., 2017The processed-food industry is the major waste buyer since this IS can offer them natural colourants, preservatives and antioxidants that do not compromise the stability of the final product compared to traditional ones (Garcia-Lomillo& Gonzalez San Jose, 2016).

Actions: several actions given to wine waste buyers can be considered for adoption:

- Renovation of business models to include IS: to be able to include wine waste into their production processes, industries must broadly rethink their business model.

- Implementation in handling and treatment processes: due to the seasonal availability of waste, waste buyers need to implement judicious handling and treatment procedures to achieve economic feasibility and efficiency (Zacharof, 2016). Moreover, waste buyers need to find potential partners even outside their usual area or sector of operation, to continuously ensure inputs of sufficient quality and minimise disruptions in their production activity.
- Expand IS studies to increase wine waste incorporation in industrial processes: further investigation is required to identify other possible inputs that can be replaced by wine waste. Waste buyers need to identify potential symbiotic opportunities and innovation is a way of doing so. Moreover, waste alternatives should be explored and investigated not only from a technical perspective but also under a legal one.

RESULTS AND DISCUSSION

In this paper, we have outlined an agent-based model in the wine production industry from the wine producers' perspective. As already mentioned, our interest was in the big firms, where the steps of wine production are carried out by different stakeholders, in order to have as many actors in the model as possible. However, this decision does not compromise the accessibility of smaller companies to IS. We believe that any player who is involved in the wine-production process can recognise its role in one of the actors aforementioned. It is evident that the bigger the business and the extent of the supply chain, the higher the benefits and chances for the establishment of symbiotic relationships. This paper has shown several applications of CE in the wine sector, identifying benefits, drivers and actions that can lead towards more sustainable business models. However, we cannot exclude from our analysisbarriers that may arise while implementing IS. One of the significant problems that emerge is the seasonality of grape cultivation. This activity has a one-year cycle and fruits are usually harvested in autumn, depending on the quality of the grape. As a result, all the by-products of winemaking can only be exchanged and transformed in this period. Companies that might consider IS implementation have to take into account this drawback and examine if their productions can be modelled accordingly in such short period. Geographical circumstances also impact in different ways the wine supply chain: such issues may concern water and waste management (Miglietta et al., 2018) as well as partnership opportunities with local industries since geographical proximity maximize IS benefits (Vergamini et al., 2019). As previously stated, many by-products can be reused in the cosmetic and chemical industry. However, most government regulations do not authorize chemical industries to settle in agricultural regions to prevent pollution or groundwater’s poisoning. Hence, IS becomes harder in such contexts. Lastly, due to the high health standards required in the food industry, quality controls of wine waste are needed to avoid microbial contamination (Musee et al., 2005). In essence, some barriers are relevant to all actors, whilst others depend on the operative sector.

At the beginning of the report, 2 questions were advanced:

1. How is it possible to implement IS measures in the winemaking process?
2. What advantages can be obtained by introducing CE within the winemaking process?

The answer to the first question lies in the different actions the agents can adopt to obtain IS. These specific measures were discussed mainly for the wine producers and waste buyers, but a comprehensive framework has been provided also for other actors. This paper defined some actions that could work as guidance for CE and IS adoption. It is interesting to observe that investments in innovative technologies and renewable energy can yield to a higher value for products and organisations; thus, agents must be motivated enough to make these investments or should get support from policymakers in order to have a swift transition to a CE business model.

Concerning the second question, this is answered by the different drivers that motivate agents to adopt CE principles. It has been observed that the most critical factors that drive towards CE principles adoption are economical, such as lower production costs, higher efficiency, and achievement of strategic competitive advantages. Other internal drivers, such as CSR targets accomplishment can also motivate agents to adopt such measures.

Since this study has not addressed external factors, such as communication between companies and barriers, it leaves room for future researches. Moreover, it is recommended to conduct a detailed study on the impacts of the barriers and an in-depth assessment of the economic viability of the activities suggested, considering that characteristics of the wine industry vary from country to country. Thus, it is also of sublime importance to make sure the specified actions are fit for the country or region on focus.

REFERENCES

Abad, G., Huertas-García, J., Vazquez-Gomez, R., & Casas, M.(2014), Drivers of Sustainability Strategies in Spain's Wine Tourism Industry. Cornell Hospitality Quarterly, 56, 106-117

Acampora, A., Preziosi, M., Merli, R., &Lucchetti, M.(2017), Environmental Management Systems in the Wine Industry: Identification of Best Practices toward a Circular Economy.

Aranda, A., Zabalza, I., &Scarpellini, S.(2005), Economic and environmental analysis of the wine bottle production in Spain by means of Life Cycle Assessment. CIRCE Foundation - Centre of Research for Energy Resources and Consumption.

Borsato, E., Zucchinelli, M., D'Ammaro, D., Giubilato, E., Zabeo, A., Criscione , P., & Pizzol, L.(2020), Use of Multiple Indicators to compare Sustainability Performance of Organic vs Conventional Vineyard Management. Science of The Total Environment.

Carroquino, J., Garcia-Casarejos , N., &Gargallo, P.(2019), Classification of Spanish wineries according to their adoption of measures against climate change. Journal of Cleaner Production, 244, 0959-6526.

Costa, J. M., Oliveira, M., Egipto, R. J., Cid, J. F., Fragoso, R. A., Lopes, C. M., & Duarte, E.N.(2020), Water and wastewater management for sustainable viticulture and oenology in south Portugal- A review.

CiênciaTéc. Vitiv. Ferrara, C., & De Feo, G.(2020), Comparative life cycle assessment of alternative systems for wine packaging in Italy. Journal of Cleaner Production. Florida.

Fraccascia, L., van Capelleveen, G., Yazdanpanah, V., & Murat Yazan, D.(2018), A Framework of Instrustrial Symbiosis Systems for Agent-based Simulation.

Gabzdylova, B., Raffensperger, J. F., &Castka, P.(2009), Sustainability in the New Zealand wine industry: drivers, stakeholders and practices. Journal of Cleaner Production, 17, 992–998.

Hein, A. M., Yannou, B., Jankovic, M., &Farel, R.(2017)Towards an Automatized Generation of Rule-Based Systems for Architecting Eco-Industrial Parks.

Malindretos, G., Tsiboukas, K., &Argyropoulou-Konstantaki, S.(2016), Sustainable wine supply chain and entrepreneurship. The exploitation of by-products in a waste management process, Int. Journal of Business Science and Applied Management, Volume 11, Issue 2.

Marildo, G. F., Lumi, M., Hasan, C., Marder, M., Leite, L., &Konrad, O.(2018), Energy recovery from wine sector wastes: A study about the biogas generation potential in a vineyard from Rio Grande do Sul, Brazil, Sustainable Energy Technologies and Assessments 29, 44-49.

Marshall, R. S., Cordano, M., & Silverman, M.(2005),Exploring Individual and Institutional Drivers of Proactive Environmentalism in the US Wine Industry, Business Strategy and the Environment, 14.

Miglietta, P., Morrone, D., &Lamastra, L.(2018), Water footprint and economic water productivity of Italian wines with appellation of origin: Managing sustainability through an integrated approach, Science of The Total Environment, 1280-1286.

Musee, N., Lorenzen, L., & Aldrich, C.(2007), Cellar waste minimization in the wine industry: a systems approach.” Journal of Cleaner Production 15, 417-431.

Ouvrard, S., Jasimuddin, S. M., &Spiga, A.(2020), Does Sustainability Push to Reshape Business Models? Evidence from the European Wine Industry, Sustainability,12.

Santiago-Brown, I., Metcalfe, A., Jerram, C., & Collins, C.(2015), Sustainability Assessment in Wine-Grape Growing in the New World: Economic, Environmental, and Social Indicators for Agricultural Businesses, Sustainability, 7 , 8178-8204.

Sehnem, S., Ndubisi, N. O., Preschlak, D., Juarez, R., Bernardy, & Junior, S. S.(2020),

Circular economy in the wine chain production: maturity, challenges, and lessons from an emerging economy perspective, Production Planning & Control, 31:11-12, 1014.

Šperková, R., &Hejmalová, H. (2011), Supplier in the Wine sector, Acta Univ. agric. etsilvic. Mendel. Brun.,Vol LIX, No. 7, 439–446.

Tezza, L., Vendrame, N., &Pitacco, A (2019), Disentangling the carbon budget of a vineyard: The role of soil management, Agriculture, Ecosystems and Environment, 52-62.

Vergamini, D., Bartolini, F., &Prosperi, P. (2019), Explaining regional dynamics of marketing strategies: The experience of the Tuscan wine producers, Journal of Rural Studies, 136-152.

Villanueva-Rey, P., Vázquez-Rowe, I., Moreira, M. T., &Feijoo, G. (2013). Comparative life cycle assessment in the wine sector: biodynamic vs. conventional viticulture activities in NW Spain, Journal of Cleaner Production, 65, 330-341.

Zacharof, M.-P.(2016), Grape Winery Waste as Feedstock for Bioconversions: Applying the Biorefinery Concept, Waste Biomass Valor (2017) 8:1011–1025.

Zúñiga-Muro, & N.M. & Bonilla-Petriciolet. (2020), Recovery of grape waste for the preparation of adsorbents for water treatment: Mercury removal. Journal of Environmental Chemical Engineering.

Received: 20th November 2020; Accepted: 11th March 2021; First distribution: 12th May 2022.