STRATEGIES FOR PACKAGING OPTIMIZATION IN THE WINE INDUSTRY

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Abstract

This study addresses significant aspects of the wine industry, focusing on wine packaging and analyzing the environmental impact of materials used by producers. The circular economy, applied to waste minimization through the integration of sustainable solutions into the production cycle, along with innovations in this sector, represents important components in developing and ensuring a sustainable future. Identifying materials with a reduced environmental impact, such as recycled glass, biodegradable cardboard, or innovative materials like bioplastic, constitutes the first step in conducting a customized study aimed to create sustainable packaging. The second essential aspect is the analysis of the direct impact of these materials on the greenhouse gas emissions of the wine industry. The next step is validating the logistics chain to identify partners that use renewable energy sources in the production process, in order to ensure that indirect emissions do not negatively influence the company's carbon footprint. The final step involves the integration of the new packaging into the production cycle and optimizing it to foster consumer loyalty. Designing sustainable packaging for the wine industry requires careful analysis, integrating innovation, renewable energy sources, and eco-friendly materials. It is important to consider the entire product life cycle, from production to recycling, to ensure minimal environmental impact. Only by adopting these practices can the wine industry contribute to environmental protection and promote responsible consumption.

Keywords: sustainability, wine industry, eco-friendly packaging, circular economy

Packaging plays an essential role in the food supply, protecting and containing food from processing and manufacturing, through distribution, handling, and storage to the final consumer. Without packaging, food distribution would be inefficient and much more costly. Packaging functions may be described as protection and containment, preservation, information, and convenience and service. For most food products, the protection afforded by the package is an essential part of the preservation process.

Wine packaging, influences not only the quality, safety, and shelf life of the product but also consumer perception and behavior. However, traditional wine packaging poses significant environmental challenges, generating substantial waste and greenhouse gas emissions throughout its life cycle. This article explores the current state of wine packaging, the environmental impacts, and the potential benefits of adopting sustainable practices.

Traditional wine packaging, primarily glass bottles, has a considerable environmental footprint. The production and transportation of glass bottles are energy-intensive processes that contribute to greenhouse gas emissions. Additionally, the disposal of glass bottles generates significant waste, as recycling rates are often low.

The concept of a circular economy (CE) provides a framework for addressing these challenges by promoting the reduction, reuse, and recycling of packaging materials. Implementing CE principles in the wine industry can help minimize waste and reduce the environmental impact of wine packaging. The concept of circular economy (CE) is intensively discussed and addressed by different actors of value chains, politicians, and academia. It is frequently depicted as a combination of reducing, reusing, and recycling activities. It is recognized that CE requires a systemic shift and a transition from the traditional linear patterns of production, consumption, and disposal (Kirchherr J. *et al,* 2017). Barriers to this transition have been studied, focusing on specific geographies, business types, or industry sectors. They can be categorized as regulatory, technical, and economic barriers (Bening C.R. *et al,* 2021). These barriers are not independent, and cultural barriers, namely lack of consumer interest and awareness, hesitant company culture, and lack of synergistic governmental interventions, are considered important together with technological limitations (Kirchherr J. *et al*, 2017). However, limited

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progress has been accomplished regarding CE implementation, and only 8.6% of the total material used is cycled (Wit M.D., 2022). Between 2015 and 2021, the global economy consumed an additional half a trillion tons of virgin materials, namely minerals, ores, fossil fuels, and biomass. In only 50 years, global use of materials has nearly quadrupled—outpacing population growth, despite initiatives settled as the Club of Rome, Paris Agreement (COP21) (COP21, n.d.), and Glasgow Climate Pact (COP26) (COP26, n.d.). Rising waste levels accompany the rapid acceleration of consumption: over 90% of all materials extracted and used are wasted, and most environmental problems, from biodiversity loss, global warming, and air pollution to plastic soup, are connected to waste (Waste Report, 2022). This report indicates 21 measures (interventions) to allow the world to achieve the COP21 goal of keeping at 1.5°C of warming by 2032. One of these measures focuses on reducing excess consumption, and using less packaging on food products (Waste Report, 2022).

This involves using materials with a lower environmental footprint, such as recycled glass, biodegradable cardboard, or innovative materials like bioplastic.

Several innovative packaging solutions have emerged as alternatives to traditional glass bottles. Aluminum cans and plastic-lined boxes, for example, are gaining popularity due to their lower carbon footprint and ease of recycling. Bag-in-Box (BiB) and Tetra Pak are also viable options, significantly reducing carbon emissions compared to glass bottles. These alternatives not only offer environmental benefits but also cater to the growing consumer demand for sustainable products.

The adoption of sustainable wine packaging is influenced by regulatory frameworks that govern packaging materials and waste management. Compliance with these regulations is essential for market access and competitiveness. Wine producers must stay informed about the evolving regulatory landscape and adapt their packaging strategies accordingly.

The research aims to explore the direct correlation between the raw materials used in the production of wine packaging, the carbon footprint of the supply chain, and the market acceptance of the new packaging solutions. By examining the environmental impacts and market dynamics, the research seeks to identify sustainable packaging alternatives that not only reduce the carbon footprint but also meet consumer preferences within the regulatory requirements.

MATERIAL AND METHOD

Wine packaging is subject to various regulations and standards, which aim to ensure the quality, safety, and sustainability of the product and the packaging material. Regulations and standards can vary across different countries and regions, depending on the legal and institutional frameworks, the market conditions, and the consumer preferences. Some of the main regulatory aspects of wine packaging include the labeling requirements, the recycling schemes, and the criteria for recycled content. Labeling requirements specify the information that must be displayed on the wine packaging, such as the origin, the ingredients, the alcohol content, the allergens, and the environmental claims. Recycling schemes regulate the collection, sorting, and processing of packaging waste, as well as the responsibilities and obligations of the producers and consumers. Criteria for recycled content define the minimum percentage of recycled material that must be used in the production of new packaging material. These regulatory aspects can have significant implications for the wine industry, as they can affect the market access and competitiveness of wine products, the environmental performance and innovation of wine packaging, and the consumer awareness and behaviour (Van den Bosch M., Sang Å.O., 2017).

The Common Market Organization (CMO) is a regulatory framework established by the European Union (EU) to manage the production, marketing, and trade of agricultural products, including wine. The CMO aims to balance supply and demand, ensure market stability, and promote sustainable and competitive development within the EU wine sector.

The CMO for wine is governed by Regulation (EU) No 1308/2013, which establishes a common organization of the markets in agricultural products (Wine Legislation, n.d.). This regulation covers various aspects of the wine sector, including production rules, quality standards, labeling requirements, and trade measures. The CMO also includes measures to support wine producers, such as financial aid for restructuring vineyards, promoting wine in third countries, and supporting innovation and research in the wine sector (Eur Lex, n.d.). In addition to Regulation (EU) No 1308/2013 (Regulation EU, n.d.) the CMO for wine is also influenced by other EU regulations, such as Regulation (EU) 2021/2117, which amends the rules governing the common market organization in agricultural products and introduces changes to the EU quality schemes and support measures for remote regions (Eur Lex, n.d.). The CMO plays an important role in ensuring the quality and competitiveness of EU wines, as well as promoting sustainable practices within the wine sector. By adhering to the CMO regulations, wine producers can access financial support, improve their production processes, and

enhance their market presence both within the EU and internationally.

To be eligible for financial aid under the Common Market Organization (CMO) for restructuring vineyards, wine growers must meet certain criteria, such as purpose, support measures and sustainability. The purpose is for improvement of competitiveness and sustainability of vineyards. The support measures: is mainly integrated through national support programs (NSPs) in the wine sector. For sustainability offering support to improve sustainable production systems and the environmental footprint of wine growing (Green Vineyards, n.d.).

The article thoroughly investigates the regulations and standards that oversee wine packaging, including labeling requirements, recycling programs, and criteria for recycled content, emphasizing their substantial influence on market access, competitiveness, and environmental performance. Life Cycle Assessment (LCA) (Rajagopal D., 2023) methods to evaluate the environmental impacts of wine packaging throughout its life cycle (Ferrara C., De Feo G., 2018), focusing on key indicators such as carbon footprint, energy consumption, and waste generation associated with different packaging materials. The market analysis (sustainable packaging market report, n.d.) reveals a growing consumer preference for eco-friendly packaging solutions like aluminum cans, plastic-lined boxes, Bag-in-Box (BiB), and Tetra Pak, which reduce the carbon footprint while maintaining product quality and safety. Additionally, the supply chain analysis delves into the complexities of the wine packaging supply chain, examining environmental impacts at each stage from raw material extraction to end-of-life disposal, and identifies key areas for implementing sustainable practices to reduce the overall carbon footprint (Global Eco friendly packaging market, n.d.). The study emphasizes the importance of a holistic approach involving collaboration among various stakeholders, including suppliers, manufacturers, distributors, and consumers, to achieve a sustainable supply chain.

RESULTS AND DISCUSSIONS

The environmental impacts of wine packaging can be assessed by using life cycle assessment (LCA) methods, which measure the environmental burdens associated with the production, use, and disposal of packaging materials. LCA studies have shown that the main environmental impacts of wine packaging are related to the extraction and processing of raw materials, the transportation and distribution of packaged wine, and the end-of-life management of packaging waste. The choice of packaging material, size, shape, and weight can significantly affect the environmental performance of wine packaging, as well as the energy and water consumption, and the carbon footprint of the wine industry. According to Life Cycle Assessment studies, glass bottles are the most widely used and the most environmentally intensive packaging option for wine, accounting for up to 30% of the wine's carbon footprint (Rugani B. *et al*, 2013).

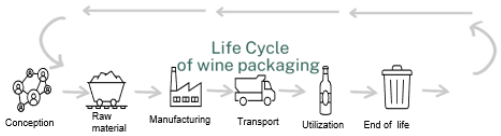

Figure 1 **Life cycle of wine packaging (adaptation after Rajagopal D., 2023)**

Glass bottles require large amounts of energy and resources to produce, and their weight and volume increase the fuel consumption and emissions during transportation. Glass recycling can reduce the environmental impacts of glass bottles, but it depends on the availability and efficiency of recycling facilities and consumer behavior. Other packaging options, such as plastic bottles, aseptic cartons, bag-in-box, and cans, have lower environmental impacts than glass bottles, mainly due to their lighter weight, smaller volume, and lower energy requirements.

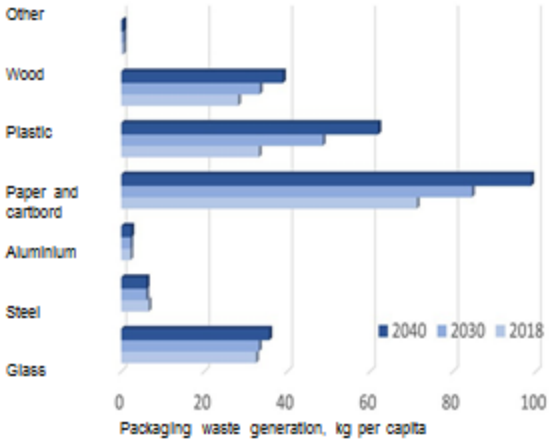

Figure 2 **Packaging waste generated in Europe per capita, for each packaging material and the estimates for 2030 and 2040 (Eurostat Waste packaging statistics, n.d.)**

However, these alternatives also have some drawbacks, such as lower recyclability, shorter shelf life, and potential quality and safety issues. Therefore, the environmental sustainability of wine packaging depends on a comprehensive and holistic evaluation of the advantages and disadvantages of each packaging option, considering the specific context and conditions of the wine supply chain (Alternative packaging, n.d.).

As an additional response to the environmentally conscious consumers, the wine industry has focused in all components of the packaging, exploring various alternatives for wine stoppers and their sustainability profiles

Cork is, an ideal material is cork, as it is harvested from the bark of the cork oak tree, which regenerates after each harvest, making it a renewable resource. The harvesting process is environmentally friendly, as the trees are not cut down being biodegradable and recyclable. Its natural properties, such as elasticity and impermeability, make it an ideal material for wine stoppers, ensuring a tight seal and preserving the quality of the wine.

Diam has developed a sustainable agent derived from plants to ensure that its corks are free of cork taint, a significant issue in the wine industry. This innovation guarantees that even organically farmed vineyards do not experience cork taint. Diam corks, made from natural granulated cork, are processed using revolutionary technology to maintain cork elasticity and control oxygen penetration during wine bottling and aging. This process ensures that the corks are free of cork taint, providing a consistent and reliable closure for wines.

Nomacorc is known for its plant-based closures (Normacorc, n.d.) produces engineered synthetic corks that manage the oxygen transfer rate for wine, reducing the risk of cork taint, offering various options such as Ocean cork, made from marine plastic waste, addressing environmental concerns while providing a reliable closure for wines.

Synthetic corks are typically made from food-grade polymers. They are designed to mimic the properties of natural cork while eliminating the risk of cork taint. Synthetic corks provide a consistent seal and are an alternative for producers looking for a reliable and uniform closure.

Screw Caps are made from aluminum, screw caps provide an airtight seal, preventing any oxygen ingress. They are recyclable and have gained popularity for their convenience and ability to preserve the wine's freshness. However, their sustainability can vary depending on the recycling practices in place.

Glass stoppers: are reusable and recyclable, offering a premium look and feel. Glass stoppers provide an airtight seal and are often used for high-end wines. Their environmental impact is relatively low, especially when reused multiple times.

Each of these options contributes to the sustainability efforts in the wine sector, offering varied solutions to the issue of packaging waste.

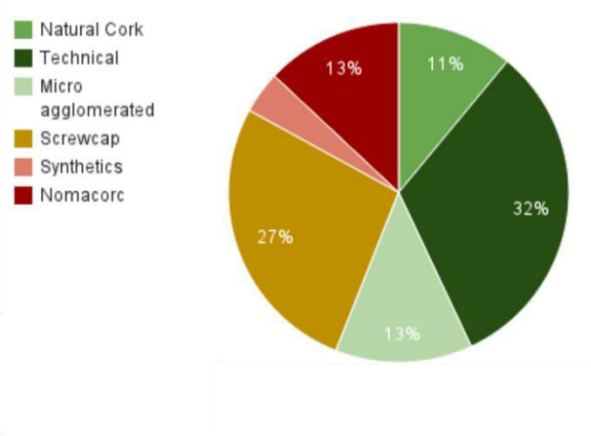

Figure 3 **Marketshare of wine stoppers per raw materials (source: Charts wine market shares, n.d.)**

The transition to sustainable wine packaging faces several barriers and challenges, which can be categorized as regulatory, technical, economic, and cultural. Regulatory barriers refer to the lack of harmonized and consistent policies and standards for packaging sustainability, which can create confusion and uncertainty among producers and consumers. For example, different countries and regions may have different labeling requirements, recycling schemes, and criteria for recycled content, which can affect the market access and competitiveness of wine products. Technical barriers refer to the limitations and difficulties of developing and implementing innovative and sustainable packaging solutions, which can meet the functional and quality requirements of wine packaging. For example, some alternative packaging materials may not provide adequate protection and preservation for wine, or may not be compatible with existing packaging equipment and infrastructure.

Green energy sources are known to play an important role in making wine packaging more sustainable, efforts not only contribute to environmental sustainability but also align with the growing consumer demand for greener products. In a German case study, a combined average of the total energy requirement from each study was used to analyze the energy mix of Germany. The study highlights a clear trend indicating that as the electricity mix increasingly originates from renewables and less from coal, and as more overall energy comes from electricity rather than heat, the overall environmental impact is reduced. The breakdown of German electricity includes renewables, natural gas, coal, lignite, and nuclear,, conducted under two models: one where most of the total energy used for production came from electricity and the rest from natural gas, and another where the energy split was half electricity and half natural gas, it was found that an additional 135,408 kg CO_2 would be added to the kg of CO_2,

significantly increase the product's Global Warming Potential.

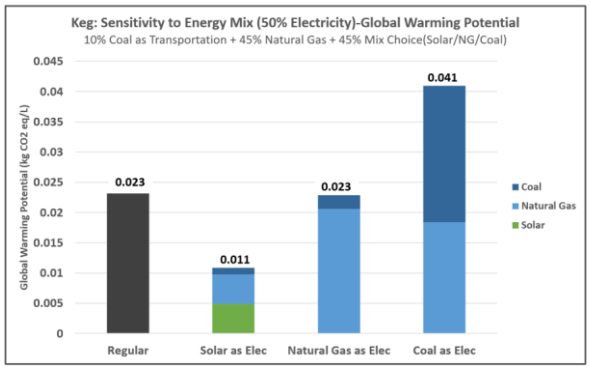

Figure 4 **Energy mix (source: Rajagopal D., 2023)**

Economic barriers refer to the costs and risks associated with the adoption of sustainable packaging practices, which can affect the profitability and viability of wine producers. For example, some sustainable packaging options may have higher initial or operational costs, lower consumer demand, or lower perceived value, which can reduce the economic incentives for wine producers (Martínez-Falcó J. *et al,* 2023).

Cultural barriers refer to the attitudes and behaviours of consumers and industry stakeholders, which can influence the acceptance and adoption of sustainable packaging practices. For example, some consumers and industry stakeholders may have strong preferences and traditions for glass bottles, or may have negative perceptions and misconceptions about alternative packaging options, which can hinder the diffusion and innovation of sustainable packaging practices (Amienyo D.G., 2013).

The adoption of sustainable wine packaging practices can offer several opportunities and benefits for the wine industry, as well as for the society and the environment. Sustainable wine packaging can reduce the environmental impacts and resource consumption of the wine industry, by minimizing the waste generation, energy use, and greenhouse gas emissions associated with packaging materials and processes (Wagner M. *et al,* 2023).

Another aspect is that through the packaging system the wines can also improve the quality and safety of wine products, by enhancing the protection and preservation of wine, extending the shelf life, and preventing the contamination and degradation of wine. Sustainable wine packaging can also increase the consumer satisfaction and loyalty, by meeting the consumer expectations and preferences for environmentally friendly and socially responsible products, providing more convenience and functionality, and conveying a positive image and reputation of the wine brand.

As important as the wine quality, the sustainable packaging can also create competitive advantages and new market opportunities for the wine industry, by complying with the regulatory requirements and standards for packaging sustainability, reducing the operational and transportation costs, and differentiating the wine products from the competitors.

Sustainable wine packaging can also contribute to the social and economic development of the wine industry and its stakeholders, by creating new jobs and businesses, supporting local communities and suppliers, and enhancing the innovation and collaboration among the wine industry actors.

CONCLUSIONS

The packaging of wine in a sustainable manner represents both challenges and opportunities for the wine industry. By embracing circular economy principles and exploring innovative packaging solutions, the industry can reduce its environmental impact and meet the growing consumer demand for sustainability. As the regulatory environment continues to evolve, wine producers must remain proactive in adopting sustainable practices to ensure long-term success.

Wine packaging is a key factor that affects the environmental, social, and economic sustainability of the wine industry. The concept of circular economy provides a framework to improve the sustainability of wine packaging, by promoting the reduction, reuse, and recycling of packaging materials, as well as the adoption of alternative, more sustainable packaging solutions. However, the transition to sustainable wine packaging faces several barriers and challenges, which require a comprehensive and holistic approach, involving the collaboration and coordination of all the wine industry actors, including producers, consumers, policy makers, and researchers. By implementing sustainable wine packaging practices, the wine industry can achieve multiple benefits and opportunities, such as reducing the environmental impacts and resource consumption, improving the quality and safety of wine products, increasing the consumer satisfaction and loyalty, creating competitive advantages and new market opportunities, and contributing to the social and economic development of the wine industry and its stakeholders.

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