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Innovative Packaging for Wine

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Abstract
The wine packaging industry is evolving rapidly, driven by technological advancements, sustainability concerns, and consumer preferences. Classic glass bottles, while still predominant, are being supplemented by innovative packaging such as Bag-in-Box, cans, polymer/biopolymer-based bottles, single-serve pouches, and kegs. These alternatives offer some benefits like lower carbon footprints and enhanced convenience, although they also face challenges related to consumer perception and acceptance. Smart packaging is enhancing wine quality preservation by controlling oxygen levels and monitoring product freshness, thereby extending shelf life and ensuring safety. Recent trends indicate a growing demand for eco-friendly and aesthetically innovative packaging solutions, aligning with consumer preferences and emphasizing the industry's dynamic nature and potential for continued growth. This paper offers an overview of different innovative wine packaging.

Keywords: wine packaging innovation, smart packaging, sustainable packaging.

1. Introduction

Drinks constitute a complex category encompassing non-alcoholic beverages, which include non-carbonated options (fresh fruit juices, ready-to-drink fruit nectars, coffee, tea, syrup), as well as carbonated beverages (cola, mineral waters); alcoholic beverages (beer, wine, brandy, whisky); and water. To ensure their quality and safety, drinks (beverages) require packaging materials that protect against various deteriorative factors. Beverages necessitate distinct barrier properties compared to foods (Stoica, 2020). Beverage packaging must consider the final application and characteristics of the bottled product, such as colour, aroma, flavour, vitamin C content, enzymes, acidity (for fruit juices), moisture vapour ingress, O_2 permeability, CO_2 and volatile component egress, grease resistance (for coffee), and factors like O_2, CO_2, H_2O vapour, light, UV-light, flavour, migration, permeation, and scalping (for carbonated beverages), as well as CO_2 and O_2 barrier properties, clarity, and CO_2 pressure (for beer) (Stoica, 2020). Beverage packaging must also be economical, eco-friendly and user-friendly (Stoica, 2020a). To date, the vast majority of packaging used in the wine industry are classic glass bottles, which offer an elegant presentation and preserve the wine's flavour. However, traditional choices coexist with innovative and sustainable alternatives of packaging are gaining ground, being driven by advancements in wine packaging technology, consumer demands, environmental sustainability and cost-efficiency. From Bag-in-Box and canned wines to single-serve pouches and kegs, these innovative options are redefining the packaging, distribution, and consumption of wine, creating positive impact of the wine value chain (Alternative wine packaging, 2024; Wine Packaging Market Analysis, 2024).

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2. Methodology

The objective of this article is to consult a database necessary to provide up-to-date information on different innovative wine packaging. Data was collected from various databases (e.g. Web of Science and Scopus), such as ISI/BDI articles, book chapters, and websites.

3. Results

3.1. Types of innovative wine packages

Over the last few years there is a proliferation of innovative wine packages come to market (Table 1).

Table 1. Innovative wine packages, benefits and drawbacks (Alternative wine packaging, 2024; Stoica, 2020, 2020a).

Types description	Benefits	Drawbacks
Bag-in-Box	stopping wine's oxidation, retaining wine's freshness (for a long time after package opening), lighter than glass, minimizing transportation costs, low carbon footprint	quality perception can be a downside, some consumers associate boxed wine with inferior quality, despite the package has no influence on the attributes of the wine
Cans	convenience, lightweight, single-serve portions, recyclable, lower carbon footprint	due to concerns regarding quality perception among consumers, these packaging options are not suitable for wines requiring ageing
Aluminum bottles	lightweight and recyclable, high protection from light and O_2	added appeal of mimicking the traditional wine bottle shape, which can facilitate consumer acceptance
PET-based bottles (PET – polyethylene tereftalate)	resistance to breakage, lighter weight than glass, lower shipping costs, perfect for outdoor events (camping, picnics, beach outings, poolside sipping) mimic the shape and feel of classic wine bottles, convenience and practicality	the global recycling rate remains relatively low, and there is an issue with the perceived quality of wine in polymer-based bottles
Plant-based bottles	based on renewable resources, decreasing dependence on fossil fuels, similar properties to PET bottles with a reduced carbon footprint	production process still requires scaling up, potential impact on food resources is a concern
Reusable bottles	Innovative and sustainable packaging solution, reduces single-use packaging waste	implementation and logistics can be complex, requiring consumer buy-in

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Paper bottles	Minimizing the environmental influence of wine packages, based on sustainably sourced paper, lighter than glass, low carbon emissions, 100% recyclable, wine's taste and quality remain unaffected by the packaging	preliminary consumer perception and acceptance influence the future of this packaging format in the wine industry
Tetra Paks	lightweight, unbreakable, easy to transport, economical alternative to glass, package with extensive surface area for branding and information, recyclable	consumer perception can be an issue
Pouches	modern and portable solution, lightweight, unbreakable, ideal for on-the-go consumption, protect wine against oxidation	may be perceived as lower quality, not all components of a wine pouch can be easily recyclable
Kegs	sustainable packaging option particularly suitable for on-premise consumption in bars/restaurants, maintain the wine's freshness for up to six months, substantially reduce packaging waste, cost savings in packaging and shipping	require specialized equipment for serving and are unsuitable for retail distribution

3.2. Smart packaging

Smart packaging integrates intelligent packaging and active packaging, and is primarily employed to facilitate the handling, transportation, storage, and shipment of foods and beverages, while also preserving their inherent attributes (Matthes and Schmid, 2024; Upadhyay *et al.*, 2024). Intelligent packaging monitors the quality of packaged foods and beverages such as freshness, storage time and temperature, and aids in tracking foods and beverages across the production line and supply chain without direct product interaction, while active packaging enhance conventional packaging by intentionally integrating functional compounds (enzymes, antimicrobials, natural extracts, etc.) within the package, or polymer/biopolymer-based matrix or on its surface, primarily designed to adsorb (oxygen, carbon dioxide, ethylene, off-odors, off-flavors, moisture) or release compounds from or into the packaged foods or beverages, as well as the packaging headspace, to prolong the shelf life of the foods or beverages (de Oliveira Filho *et al.*, 2024; Du *et al.*, 2023; Fadiji *et al.*, 2023; Golmakani *et al.*, 2024; Gupta, 2023; Jain *et al.*, 2024; Jayakumar *et al.*, 2024; Jiang *et al.*, 2023; Kuchaiyaphum *et al.*, 2024; Matthes and Schmid, 2024; Mkt Nova, 2024; Nasution *et al.*, 2024; Ribeiro *et al.*, 2024; Tregnago Cunha and Mazieri, 2024; Upadhyay *et al.*, 2024; Vasile and Baican, 2021; Young *et al.*, 2023; Zhang *et al.*, 2024).

3.2.1. Commercially innovative smart packaging for wine

Global smart packaging industry is driven by several players, who through their focus on the use of advanced tehnology for safer wine for a long time have significantly contributed to the growth of the smart packaging market in the upcoming years (Table 2).

Table 2. Examples of key players in innovative wine packaging

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Manufacturer	Package
Checkpoint Systems	**BottleID™** exceptional detection capabilities that ensure full traceability of individual products from the moment they are bottled through to purchase. This system incorporates Checkpoint's RFID labels inside bottles containing liquids. (https://checkpointsystems.com/blog/euroshop-2023-roundup/; https://checkpointsystems.com/industry-solutions/food-beverage-solutions/)
Amcor	**Blue Bin (100% rPET Wine Bottle)** a premium-wine packaging solution, the coated rPET with SiOx wine is protected against oxidation, it retains its intended flavor profile (https://www.plasticstoday.com/packaging/amcor-ron-rubin-winery-launch-100-rpet-wine-bottle)
Constar International	**MonOxbar** Oxygen-scavenging technology for PET containers (https://www.packaging-gateway.com/contractors/packaging-sundries/constar/)
Thinfilm	**Smart wine bottle, NFC OpenSense tags** winemakers and wine consumers can authenticate bottles throughout the supply chain, ensuring they are packaged, shipped, stocked and purchased in their original factory-sealed state (https://www.labelsandlabeling.com/news/interactive-technology/thinfilm-and-g-world-unveil-smart-wine-label-china)
PakSense	**PakSense shipping label** track the temperature of wine, information from the label can be downloaded into computer, letting wineries track their shipments to the shelves (https://www.packworld.com/home/news/13344988/smart-packaging-tells-you-if-your-wine-is-hot)
Toppan Printing	**Cachet-Tag** an NFC1 tag designed to prevent relabeling, detect gray market and other types of fraud; results are displayed on the smartphone to enable easy verification (https://www.holdings.toppan.com/en/news/2018/11/newsrelease181116e.html)
DAKLAPACK	**Winepouch** laminated stand-up pouch with a very handy tap, ensuring a good seal (https://www.daklapack.eu/doypack-spouted-pouches/pouches-for-wine/wine-pouch-215-mm-x-300-mm-silver/8712963003869)
Crown Holdings	**Can** metal packaging solutions extends beyond beverage (https://www.crowncork.com/)

3.3. Overview of the wine packaging market

Global wine packaging market (dominated some key players such as Amcor) is strong, with an estimated size of approximately $5.6 billion in 2024. Geographically, North America leads with a 35% market share, closely followed by Europe at 30%. According to market analysis, glass

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remains the primary material for wine packaging, constituting 70% of the market, while plastic and paper packaging each hold 15%. Recent trends indicate a 20% increase in demand for eco-friendly packaging materials, reflecting a shift toward sustainable practices. Additionally, there has been a 15% rise in demand for innovative and aesthetical packaging solutions, aligning with consumer preferences and emphasizing the importance of packaging in purchasing decisions. This industry is expected to continue growing, with a projected annual increase of 5.48% in the coming years, underscoring the dynamic nature of the global wine market (Alternative wine packaging, 2024).

4. Conclusions

The wine packaging industry is experiencing significant innovation, with a shift from classic glass bottles to alternative packaging solutions (Bag-in-Box, cans, single-serve pouches, polymer/biopolymer-based bottles, kegs), which offer various benefits (reduced transportation costs, lower carbon footprints, enhanced convenience), while also posing challenges related to consumer perception and market acceptance. The integration of smart packaging enhances the preservation of wine quality by controlling some factors (oxygen levels, product freshness), thereby extending shelf life and ensuring product safety throughout the wine supply chain. The wine packaging industry is poised for continued growth, being fueled by advancements in packaging technology and consumer demands.

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