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REVIEW

Sustainable winegrowing: current perspectives

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Abstract: The winegrowing sector worldwide is strongly committed to improving environmental and social sustainability. The aim of this work, based on a literature review, is to highlight current sustainability perspectives and the related main issues. There is a broad consensus that the challenge to achieve a greater spread of sustainable practices is to enhance environmental and social sustainability while maintaining economic viability. From the producers' point of view, the priority is to bridge the still substantial knowledge gaps in terms of perceived environmental benefits, economic benefits, and costs. Thus, an increased research effort focusing on the costs and benefits of different winegrowing practices and technical assistance with implementation might support their diffusion. Moreover, targeted marketing strategies are needed to: enhance consumers' involvement and their attitude toward sustainable wine; improve understanding and use of sustainable labels and claims; and raise awareness of some environmental credentials of wine packaging, mainly with reference to lightweight glass bottles.

Keywords: winegrower, sustainability, wine, consumer, marketing strategies

Introduction

The shift toward sustainable development has become a priority objective from a political, economic, and social point of view. Coming to an agreed definition of this concept has been a long, challenging process that dates back to the 1970s. In 1987, the United Nations Brundtland Report defined sustainable development as meeting the needs of the present without compromising the ability of future generations to meet their own needs. Moving forward, since 2005, the three main interrelated dimensions of sustainability, namely environmental, economic, and social, have been widely accepted and used.

These basic ideas are implemented in the Food and Agriculture Organization of the United Nations definition:[1] "Sustainable agriculture must nurture healthy ecosystems and support the sustainable management of land, water, and natural resources, while ensuring world food security. To be sustainable, agriculture must meet the needs of present and future generations for its products and services, while ensuring profitability, environmental health, and social and economic equity. The global transition to sustainable food and agriculture will require major improvements in the efficiency of resource use, in environmental protection and in systems resilience."

The winegrowing sector has a long history of commitment to promoting more sustainable development, and several initiatives are under way worldwide. The aim of this work, based on a literature review of the major and most recent studies on the subject, is to highlight current perspectives and main issues. To address these

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questions, the paper is organized into six sections that focus on the following aspects: progress with regard to the international definition of sustainable winemaking; main tools and programs available to implement sustainability; areas of environmental concern in the wine sector; environmental performance of the wine supply chain based on life cycle assessment (LCA); winegrowers' views on sustainability and their motivations; and consumer awareness and acceptance of wine with some environmental and/or social sustainability qualities (hereafter sustainable wine). In the final section, an overview is given of the main progress made and of the difficulties to be addressed for a more sustainable winegrowing industry worldwide.

International shared vision on sustainable winemaking

With a view to reviewing progress on the definition of sustainable winemaking, it is appropriate to refer to the work done by the two main organizations (most of the producing countries are members of one or both), ie, the International Organisation of Vine and Wine (OIV) and the International Federation of Wine and Spirits. The joint work of these organizations has led to the development of two respective, somewhat overlapping, guidelines for sustainability programs, namely, the Guidelines for Sustainable Vitiviniculture (production, processing, and packaging of products)[2] and the Global Wine Sector Sustainability Principles Project.[3]

Sustainable vitiviniculture is defined by the OIV[2] as a "global strategy on the scale of the grape production and processing systems, incorporating at the same time the economic sustainability of structures and territories, producing quality products, considering requirements of precision in sustainable viticulture, risks to the environment, products safety and consumer health and valuing of heritage, historical, cultural, ecological, and landscape aspects". The basic idea is that the triple bottom line of economic, environmental, and social sustainability should be promoted by implementation of appropriate environmental sustainability programs, applied to production, transformation, warehousing, and packaging.

Identification of environmentally sustainable activities should be based on an environmental risk assessment, and priority should be given to significant and unique risks in individual geographic regions where wineries and vineyards are located. According to OIV guidelines, environmental risk assessments should consider, amongst others, the following aspects: site selection (for new vineyards/wineries), biodiversity, variety selection (for new vineyards), solid waste management, soil management, energy use, water management, air quality, wastewater, neighboring land use, human resource management, and agrochemical use. In addition, the Global Wine Sector Sustainability Principles Project guidelines explicitly consider carbon accounting, transportation, and fossil fuels. A process should be introduced to plan for and implement environmentally sustainable activities, assess their effectiveness, and make adjustments to drive continuous improvements through "self-assessments" and other forms of evaluation of environmental performance. Moreover, promoting awareness through education and partnerships with stakeholders is reported as strategic supporting action to improve sector sustainability.

Implementing sustainability: main tools and programs

Various ways of implementing sustainability in the wine industry have been developed and used during the past 20 years, and are based on voluntary standards, management systems (with the relative certification system), and some industry-specific programs. A detailed survey of all of these methods is beyond the scope of this document, as there are many systems involved, several of which are local. We therefore focus on those that have international renown and recognition (Table 1).

Organic and biodynamic standards

Among the non-conventional production and transformation practices, using methods and materials that minimize the negative environment impact of agriculture and food production, the two main standards are organic and biodynamic. The International Federation of Organic Agriculture Movements, the worldwide umbrella organization for the organic movement, sets standards that include social and ethical aspects (the core principles are health, ecology, fairness, and care), while Demeter International is the main certification organization and trademark for products from Biodynamic Agriculture. For wine, as for food, there exists a large number of country-specific regulations, certification schemes, and logos.[4] In general, without considering differences across countries, organic vineyards are managed without the use of fertilizers and plant protection substances of synthetic origin, and use of genetically modified organisms is prohibited. While biodynamic agriculture has distinguishing features, it is founded on anthroposophic principles and a complex system of herbal sprays and composting techniques, known as "preparations", is used.[5] The basic requirement of organic winemaking is the use of organically grown grapes, but the

Table 1 Implementing sustainability: main tools and programs

Voluntary standards	Organic
	Biodynamic
	Fair trade
Management systems	ISO 14000 family, provides practical tools for companies and organizations looking to identify and control their environmental impact and constantly improve their environmental performance
	ISO 14001 and ISO 14004 focus on environmental management systems
	The other standards, eg, ISO 14040, ISO 14044, ISO 14046, and ISO 14067, focus on aspects such as life cycle analysis, communication, and auditing
	OHSAS 18001 (Occupation Health and Safety Assessment Series) is intended to help an organization to control occupational health and safety risks
	SA8000 (Social Accountability International) sets out the requirements to be met by organizations, including the establishment or improvement of workers' rights, workplace conditions, and an effective management system
Guidelines	ISO 26000 provides guidance on how businesses and organizations can operate in a socially responsible way. This means acting in an ethical and transparent way that contributes to the health and welfare of society
National programs	Integrity and Sustainability Certified (South Africa)
	California Sustainable Winegrowing
	Sustainable Winegrowing (New Zealand)
	Entwine Australia
	Certified Sustainable Wine of Chile
Programs in local areas or by groups of winegrowers	Wine Industry Ethical Trade Association (South Africa)
	FairChoice (Germany)
	Vignerons en Développement Durable (France)
	VIVA Sustainable Wine (Italy)

Abbreviation: ISO, International Standard Organization.

legal definition varies from country to country, with the primary difference relating to use (maximum content or non-use) of preservatives (eg, sulfites) during the production process. It should be mentioned that the European Union only recently (in 2012) approved an organic winemaking regulation, while organic viticulture has been regulated since 1991.

The differences in national regulations represent important non-tariff barriers to international trade, and hinder the potential for growth in organic and biodynamic exports.[6] To address this issue, in addition to mutual recognition agreements that many countries have already signed, it could be very useful to reach, within the OIV, a harmonized umbrella-like standard.

Fair trade

A benchmark for a comprehensive approach to sustainability, which includes economic, environmental, and social standards, is fair trade.[7] According to fair trade principles, wineries must provide a living wage and safe conditions for workers, and must pay growers a fair price for their grapes to cover the cost of environmentally friendly viticulture and a premium price to invest in social programs within the local community. Protecting the ecosystem and workers' health is a key requirement. Moreover, the large amount of information provided on the label, including allocation of revenue along the supply chain, promotes consumer awareness and willingness to pay a higher price. Globally, about 21 million liters of fair trade wine were sold in 2013 (27% growth compared with 2012), mainly produced in South Africa, Argentina, and Chile, and sold by retail chains.[8]

Management systems and guidance standards

The International Standard Organization (ISO) and some non-governmental organizations have developed standards that can help businesses and organizations to make progress in implementing sustainability and to support corporate social responsibility claims. The most widespread management standards, that can be certified, are: ISO 14000 for environmental management, Occupation Health and Safety Assessment Series (OHSAS) 18001 for health and safety in the work environment, and SA8000 for the ethical treatment of workers, whilst ISO 26000 is the main guidance for social responsibility. The benefits of these formal management systems include economic savings, risk reduction, and a good company reputation. However, the cost of implementing and certifying could prove unrealistic for small and medium enterprises, as is the case in many wine regions around the world that are populated predominantly by small and medium enterprises. Hence, such systems are mainly used by larger wineries with the scale to suit and absorb their costs.[9,10]

Sustainable winegrowing programs

Around the world, there are many different programs ongoing in sustainable winegrowing, pioneered especially by some of the New World wine-producing countries (South Africa, New Zealand, and USA), followed by Australia and more recently Chile. These programs, developed through collaborative efforts driven by national institutions and associations, are in accordance with the guidelines of the Global Wine Sector Sustainability Principles Project. Most of them make reference to the above-mentioned set of standards and tailor the principles of sustainability to individual operating environments and specific industry goals. Several initiatives are under way in the main European wine-producing countries,

primarily concerning single winegrowing areas or small groups of winegrowers.[11–13]

It is worth pointing out some specific traits of the programs in the New World wine-producing countries. The Integrity and Sustainability Certified program in South Africa (which is in the process of integrating the long-established ethical trade logo implemented by the Wine Industry Ethical Trade Association),[14] California Sustainable Winegrowing, and Certified Sustainable Wine of Chile integrate social sustainability aspects, while the other programs have, up to now, focused more on environmental aspects alone. For example, a report on the carbon footprint is only required by Entwine Australia. California tends, more than the other programs, to focus on education and training of producers as part of their continuous improvement, which is a main strength of this program.[9] Although each program is voluntary for producers, in South Africa it is mandatory to be a member in order to export wine, and New Zealand makes it a prerequisite for participation in national promotional events.

Environmental concerns in the wine sector

Environmental concerns and their impact are the most widely studied aspects of the sustainability concept. Analysis and quantification of environmental effects in the wine sector depend on the stage of the supply chain (viticulture, winemaking, and distribution), geographic location, and the scope and scale of wine organizations (ie, vertically/horizontally integrated). This often makes the results of environmental impact difficult to compare and the solutions not generalizable. The integrative literature review conducted by Christ and Burritt[15] is a valuable landmark for an indepth analysis of the main areas of environmental concern currently facing the wine sector. These authors summarized the following main points: water use and management; solid waste generation and management; energy use and greenhouse gas emissions (GHGs); chemical use; and land use issues. It is useful to quote some of their remarks.

Water use and management

The global scarcity of water makes it necessary to define benchmarks (eg, number of liters per ton of grapes or per bottle). Notwithstanding regional differences in resource availability, the evidence suggests that use of water in wine operations often falls short of best practice, with many managers unaware of how water is used within their operations. In particular, it has been shown that many wineries do not have the data control to identify the processes most responsible for production of wastewater.

Generation and management of solid waste

The winemaking process produces two types of solid waste, ie, organic and inorganic. Some organic waste streams and associated byproducts have a reuse market (eg, as an alternative fuel source) while for the inorganic components (eg, heavy and bulky packaging materials, used chemical containers, disused pallets), landfill and incineration are choices, where legally permissible, the environmental impact of which should be reduced through, for example, recycling programs.

Energy use and greenhouse gas emissions

A large amount of energy is consumed in winemaking, which generates a significant amount of GHGs. At the vineyard level, the use of nitrogenous fertilizers should be minimized, and where possible, substituted by fertilizers with low production-related global warming emissions. For bottling, the hot spots for energy consumption are represented by the production of glass and the mode of transport. For this reason, adoption of bottle reuse systems and use of recycled glass lead to an appreciable reduction of energy as well as alternative containers, such as cartons. At the transportation stage, the mode of transport is crucial for the aspect related to the energetic efficiency; in fact - given the same type of transport modality – a better energetic efficiency is given by: maintenance status, age and type of fuel used.

Chemical Use

Use of chemical products in vineyards and during the winemaking phase has raised numerous environmental concerns. Most of them are addressed in the section below.

Land use

Land resources are under pressure due to increased competitiveness in the global wine industry that encourages grape producers to look for new land, thereby creating conflict with local communities and having a major impact on the natural habitat. Due to climate changes, some vitivinicultural areas have moved to lands further north, looking for more favorable climatic conditions, especially for production of white grapes. In some cases, this means a shift to upland areas, with the resulting deforestation of areas that play a major role in combatting hydrogeological instability.

To measure environmental impact, several metric standards, such as the ISO 14040, ISO 14044, ISO 14046, ISO 14067, PAS 2050, and GHG Protocol Product Life Cycle accounting and reporting standards, are applied worldwide. Based on these metrics, synthetic impact calculators have been introduced. The carbon footprint is a worldwide standardized indicator of GHGs according to the Kyoto protocol because it is a manageable tool for identifying areas of reduction in emissions. For this reason, in the wine industry, as in other sectors, the carbon footprint is often used as the only indicator to communicate environmental life cycle performance through ecolabeling.[16] The impact of water use during the life cycle of winemaking is calculated using the water footprint, an indicator of the full embedded water volume in a product.[17,18]

Life cycle assessment of wine

In order to assess the environmental performance of the different stages of the wine supply chain, the methodology currently used most widely is LCA, given the multiple impact categories that can be considered. According to several surveys,[16,19,20] LCA methodology is able to separate out the environmental impact and analyze the contribution of each stage with respect to the impact categories shown in Table 2. Moreover, LCA methodology enables comparison of the effects of various potential changes in the life cycle of wine through application of different modeling hypothesis. In such a way, it is possible to establish the "best" industry scenario. One critical choice for application of LCA methodology relates to system boundaries for defining which stages of the life cycle have to be considered and the relative data inventory needed to quantify the inflows and outflows of energy and relative emissions.

In the case of winemaking, according to the extensive review by Rugani et al,[16] which considers 35 papers, the literature states the following boundary systems: gate to gate; cradle to gate; and cradle to grave. Their selection depends on the objectives of the study and data availability, and there are usually sufficient data related to viticulture and winemaking stages, while not enough information may be available for transportation or end-of-life stages. The gate to gate option is used when the analysis aims to examine a precise process/stage of the supply chain (eg, viticulture phase, transportation, or end-of-life). In the cradle to gate perspective, the boundary is set at the gate of the winery, while a cradle to grave perspective identifies the following main stages: vineyard planting, viticulture and grape growing, winemaking, packaging processes, and transport and distribution. To give a general measure, the estimated average global warming potential value per bottle of red wine in a cradle to gate scenario is 0.86 kg CO_2 eq, while in a cradle to grave perspective, it is 2.17 kg CO_2 eq per bottle.[16] With respect to the various stages, some impact evaluations are common to the majority of studies, while others are controversial, and the comparability of results is often affected by the different perspective of the analysis or by the influence of territoriality. In the following paragraphs, major results are discussed related to some of the main wine supply chain stages.

Table 2 Main impact categories of life cycle assessment

ADP	Abiotic depletion potential
AETP	Aquatic ecotoxicity potential
AP	Freshwater acidification potential
CED	Cumulative energy demand
EP	Eutrophication potential
GWP	Global warming potential
HTP	Human toxicity potential
ODP	Ozone depletion potential
POCP	Photochemical ozone creation potential
POP	Photo-oxidant formation potential
TETP	Terrestrial ecotoxicity potential
WD	Water demand

Viticulture and grape growing

Viticulture has a large impact on global warming potential mainly due to the emissions arising from the management of pesticides and fertilizers and from fuel use. Amienyo et al[20] calculated that within the worldwide value of global warming potential, the joint contribution of pesticides and fertilizers is 82% while the impact of fuels accounts for the remaining 18%. As regards nutrient management, the impact of nitrogenous fertilizers (provision and application) dominates all the others.[19] Alternative agronomic managements, such as precision viticulture based on farming practices closer to crop requirements, are an efficient solution applied increasingly widely. The impact of synthetic fertilizers is not reduced if *ceteris paribus*, an organic viticulture scenario, is introduced. The alternative use of manure does not produce a reduction in emissions since it is associated with higher release of nitrous oxide, ammonia, and nitric oxide than an equivalent amount of synthetic fertilizer. Nevertheless, improvements are identified with the exclusion of wood preservative chemicals on vineyard posts along with a significant reduction in terrestrial ecotoxicity potential. That said, this type of farming has a positive impact on biodiversity. Finally, the environmental

impact of biodynamic viticulture is the lowest in terms of energy use and GHGs (ie, diesel production and consumption, and fertilizers) with respect to conventional farming and a mixed biodynamic-conventional farming. Nevertheless, in biodynamic production, the economic relevance of decreasing productivity during the conversion period of vineyard should be not underestimated.[21]

Winemaking and packaging processes

Winemaking processes are influenced, first of all, by the technology used followed by the type of wine (red versus white), high versus low quality wines, and grape variety. Point et al[19] argue that the impact of LCA at the winery stage, for production of one 750 mL bottle of wine produced and consumed in Nova Scotia, is given by the energy used that has a major impact on photo-oxidant formation potential (23.5%) that is formed mainly by the reaction of sunlight with emissions from fossil fuel combustion. Moreover, during the winemaking stage, the use of chemicals, primarily from cleaning operations, impacts on water quality and on the cost of water treatment systems. Evidence internationally suggests that up to 70% of a winery's total water intake becomes wastewater.[15]

The glass bottle production stage has a major impact in terms of water quality and cumulative energy demand, and, as emerged in the case study by Amienyo et al,[20] selenium emissions are responsible for 40% of the potential for human toxicity in the whole life cycle. Alternative scenarios are taken into account in assessing solutions, at the bottle production and packaging stage, with less environmental impact, ie, light bottle weight recycled glass content, refillable glass bottle, and carton containers. A lighter bottle scenario, ie, 30% of the weight (380 g), implies an overall impact reduction of 2%–15% due to a reduced demand for energy and material for manufacturing and fuel during transport.[19,20] The use of recycled glass leads to an appreciable reduction in energy use during bottle production, as in the previous scenario, and a smaller amount of waste to be landfilled.[20] Refillable glass bottles and packaging in cartons lead to an impact reduction of all the environmental indicators due to energy savings during container manufacturing and reduction of emissions during transportation by a lighter load.[22] However, economic and social factors such as consumer perception, shelf-life, and impact on the glass bottle industry have to be considered to complete the evaluation.

Transport and distribution

The impact of the "food miles" indicator is unquestionable and is proportional to the distance covered. However, the transportation mode, in particular its efficiency, must also be considered.[23] Each geographical situation has a more efficient mode than others with respect to the final market.[24] For example, the shipment of bulk red wine from Australia to the UK has a lower impact with respect to its bottled counterpart.[20] The use of a larger truck, due to efficiencies gained, reduces the majority of environmental indicators.[19]

The benefits of a local food supply are rapidly lost if consumers use their cars to reach the local market. In the above study, a shift of 5 km to reach the retail outlet has a greater impact in terms of GHGs than that given by the sum of grape growing and winemaking.[19]

Winegrowers' views and motivations

Several surveys have focused on winemakers' opinions about the sustainability, drivers, and barriers to voluntary adoption of sustainable practices through country and cross-country analysis. The picture that emerges is rather complex and differentiated mainly between the European producers and those in the New World wine-producing countries.

Differences in vision and priorities between countries

A recent study found that European producers, compared with those in California, seem to have a narrower idea of what sustainability means, focusing mainly on the environmental dimension of viticulture, and seem to think that sustainable winegrowing in fact entails no more than organic or biodynamic farming.[25] These results may be due to more widespread organic vine growing in Europe, as illustrated in Figures 1 and 2.

Other surveys, mainly but not exclusively focusing on New World wine producers, have found that winegrowers believe that it is important to follow a sustainable development model, and they perceive that ecological health, economic viability, and social equity are inextricably interconnected.[26] In particular, Californian winemakers stated that economic viability is a necessary condition to enable management of viticulture to support ecological health and social equity, and for generational succession; yet, in the reverse direction, healthy ecosystems and equitable treatment of employees are necessary for economic viability. However, up to now, the focus has been primarily on environmental sustainability and economic survival, with less recognition of the social side of sustainability.[27]

Some differences related to current conditions, regulations, and competitive strategies that accentuate or minimize the consideration of priorities appear to exist between countries. According to the Jones survey,[28] confirming the

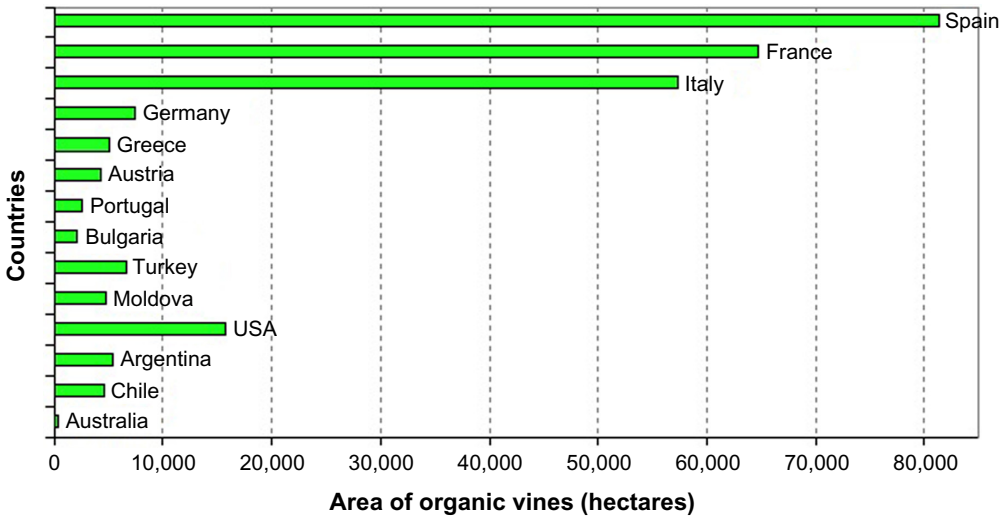

Figure 1 Area of organic vines in hectares, 2012.

results of other research on the topic, the highest responses for the importance of environmental sustainability came from Australia/New Zealand, followed by the USA, Europe, and Argentina/Chile. Overall, the actions with the highest priority are energy-saving practices, reducing use of pollutant products, reducing waste, and production of sewage. However, water-saving practices are ranked higher in Portugal, Australia, and New Zealand, while waste treatment and improving quality of life for employees are ranked higher in Argentina and Chile and supporting the local community is ranked higher in the USA.

Drivers and barriers to adoption of sustainable practices

Multiple drivers with varying degrees of contribution could explain voluntary adoption of sustainable practices by vineyards and wineries and their participation in industry-led sustainability programs. Several authors[29–34] agree that internal drivers, such as managerial attitudes, concern about environmental impacts and employee safety, company culture, protection of land, and social responsibility, play a much larger role than external motivators. Among the external drivers, the most important seem to be compliance with regulations, especially pre-emption of future trade regulations and requirements for export, and pressure from large retailers (in the more export-oriented countries like New Zealand and South Africa).[35]

Strategic drivers, such as competitive advantage, differentiation, product quality, marketing benefits, brand reputation, public image, and cost savings, do not seem to be perceived[10] or play a less influential role, although the evidence is conflicting. Research has highlighted an enhanced reputa-

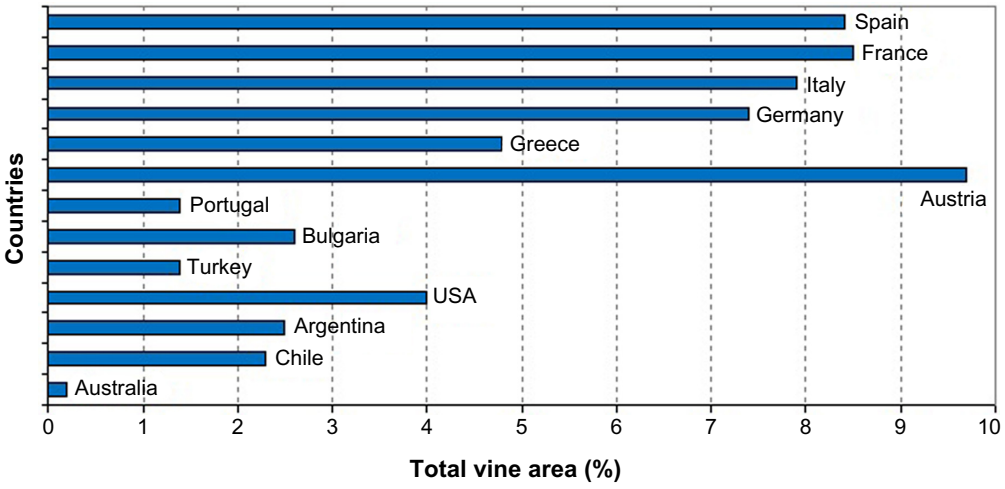

Figure 2 Organic share of total vine area (%) 2012.*
Note: *Share for Moldova is not available.

tion, image, and working environment,[26,36] improved product quality,[31] and, only for wineries that have implemented a formal environmental management system, cost benefits deriving from supply chain optimization, lower legal and regulatory risk, and greater operational efficiency.[37]

All in all, economic and marketing benefits, in terms of price and loyalty, are not perceived, mainly because of the lack of positive recognition from consumers. Besides the issue on the demand side, which are analyzed in detail below, other potential barriers have been identified, namely high costs and an administrative burden related to the certification process and the lack of knowledge, information, and skills.[38,39] While there are some sustainable practices for which winegrowers have enough information and clearly state that the economic benefits exceed the costs, for others they perceive a high level of uncertainty about their effectiveness and benefits. Moreover, some sustainability practices could ensure high environmental, social, and economic benefits to the broader community, with or without private benefit, but only if adopted by a substantial number of growers. Such practices, which are adopted out of a sense of civic responsibility and the desire to create a regional reputation for sustainability, need to be supported by community-based participatory strategies, in which growers come together as an industry group or in a multi-stakeholder partnership.

Consumers and sustainable wine: major issues

As mentioned above, one aspect that slows down the introduction of sustainable practices in the wine industry is the lack of value attributed to this effort by consumers. The process of wine purchasing is quite complex. Pleasure is the rationale behind consumption, and consumers rely on many attributes, whether intrinsic (eg, sensory characteristics, type, and color of wine) or extrinsic (eg, price, region of origin, brand, label information, and packaging features) to evaluate the characteristics of the product and make their choices.[40] Like other aspects related to the production process, the environmental and social quality of products are credence attributes that consumers cannot ascertain during purchase or use. Therefore, extrinsic cues are used as tools to reduce information asymmetry between producers and consumers. Label claims and logos are the extrinsic features most commonly used to signal sustainable attributes of wines to consumers; in addition, environmental sustainability can be communicated with a combination of several packaging attributes such as lightweight bottles.

Studies of the sustainable attributes of wine have burgeoned rapidly in recent years, investigating consumer awareness, understanding, acceptance, and willingness to pay (for sustainable wine and logos), mainly focusing on a broader vision of sustainability related only to organic and environmentally friendly production practices.

Lack of knowledge and awareness

According to research based on asking consumers directly about their interest in sustainable wines,[41,42] the overwhelming majority of respondents in California and New Zealand stated they would prefer to drink wines that had been produced using environmentally sustainable practices. Although it must be stressed that consumers have been found to be less concerned and informed about the effects of wine production practices on their health and the environment than for other food products,[43] they do not seem to be aware of the difference between sustainable practices (often linking the concept of sustainability only to organic production).[26,44] Further, a large segment reported that they did not know how wine was produced and thus had not, as yet, formed either positive or negative views about the effects of wine production practices.[45]

Sustainability is ranked after other attributes

Direct questioning could result in social desirability bias by making consumers show themselves as positively as possible. A more effective evaluation may be obtained if sustainability is positioned as one of a set of attributes in the wine purchase decision. In the context of food choice, sustainability is an issue of increasing general interest for consumers, although other product attributes, mainly safety, nutrition, taste, and price, are the main drivers.[46] For wine, there is considerable evidence to suggest that taste consistently influences preference, and information on environmentally friendly production practices would increase demand and lead to higher price premiums for the products only if consumers' sensory expectations were satisfied.[47,48]

With reference to organic food, for regular consumers but even more for the occasional, egocentric value related to personal well-being (health, nutrition, taste, product safety, curiosity, and fashion) appear to be stronger motivators for purchase than altruistic value such as protection of the environment and animal welfare.[49–52] For wine, the benefits of sustainable practices on quality are controversial, and there is still little evidence on the impact on health.[26,36] Some consumers negatively associate organic and even more so biodynamic wine with lower quality, and are still confused about the difference between wine made from organically grown grapes and organic wine.[26,53,54] Without

clear benefits of eco-wine with regard to quality and health, marketing communications may appeal only to the altruistic values of environmentally aware consumers.

Loveless et al[55] measured the relative importance in wine purchasing of three claims related to credence attributes, ie, sustainability (sustainable grape growing and wine making), quality control and traceability, and other attributes (taste, region, brand, and price promotion) across five countries (UK, Ireland, USA, Canada, and Sweden). This research confirms that taste is the most important attribute across all countries, and the other attributes are only up to one third as important as taste. Sustainability is less important to consumers than quality control and is ranked differently between countries (sixth in Ireland and second in Sweden). However, as research has documented for food,[56] Loveless et al[55] identified a substantial segment (29%) across countries in which sustainability has greater resonance. This segment has a higher share in Sweden and the west coast of the USA (36%), followed by Canada, and has the smallest share in the UK and Ireland. A survey of German wine consumers identified the same average appreciable segment. Such consumers, known as sustainable connoisseurs, buy more expensive wine and buy more often than the other clusters.[57]

Understanding and use of label claims and logos

For wine, as for food,[58] a major issue is that consumers have a low level of understanding of sustainability label claims and logos, and as a result, these extrinsic cues fail in their mission to communicate and bridge the information gap between seller and buyer. The many competing sustainability logos and claims create confusion; consumers do not necessarily understand the meaning of the different labels and their associated message is not successfully conveyed.[44] Credibility of the labeling process is also important for consumer choices, and trust is jeopardized when labels issued by independent organizations that have developed transparent criteria and are verified by a third party coexist with others that merely represent claims made by producers.[36]

Substantial differences have been found in consumers evaluation among sustainability claims and among countries.[44,59,60] The willingness to pay estimated by Mueller-Loose and Remaud[61] provides valuable insights.

Overall, the organic claim reports the higher willingness to pay and indicate an increasing trend in consumer' positive evaluation of organic wine. In particular, the willingness to pay account for around 14% of the average price, the highest value are observed for Germany and France (around 26%), followed by the USA and Anglophone Canada (around 11%). The willingness to pay for environmental and social responsibility claims on average are lower, respectively 6.6 % and 2.3%, but they result higher in North American Anglo-Saxon cultural markets, where corporate social responsibility has its traditional roots, and in Germany. By contrast, in France and Francophone Canada, the social responsibility claim has a negative evaluation. The carbon zero claim is strongly disliked by French and German consumers and the reduced glass weight claims by all consumers (except in USA). Consumer concerns about a higher probability of glass breakage[61] and the trend to associating the weight of the bottle with its quality[62] seem to be the main reasons for consumers' rejection of this claim.

Overall, consumers do not seem to pay attention to packaging visual and haptic features, such as bottle weight and shape, type of closure, and capsule material, when determining how environmentally friendly a wine is.[63] In particular, there is a large information/communication gap about lightweight glass, which is strongly disliked by consumers, but is considered a priority action by retail chains, standard setting bodies, and government agencies in some major import markets. To increase the efficiency of their logistic processes and create a distinct environmentally friendly image, the main international retailers are focusing increasingly on reducing the CO_2 emissions generated across their supply chains and have significantly reduced the average glass weight for wine bottles. Moreover, in the UK, following the guidelines of the GlassRite Wine project devised by the Waste and Resources Action Program, importing bulk wine and lightening of wine bottles are promoted as strategies that could deliver significant benefits in terms of reduced carbon emissions, transportation costs, and glass waste, while boosting the local market for recycled green glass.[64,65] The Liquor Control Board of Ontario, in purchasing wines, is setting standards on bottle weights and types of closure (screw caps).[63]

Conclusion

In the wine industry worldwide, a large number of small and medium enterprises operate in very different natural and social contexts. Thus, a one-model-fits-all approach to implementing the three dimensions of sustainability (environmental, social, and economic) is not realistic. In international wine markets, competition among companies/countries for market share is fierce, and the information provided to consumers, through logos and claims, plays an important role as a means of differentiation. In this context, it is useful to develop a shared set of guiding principles to

be applied in a targeted manner in the different contexts. Further, it is essential to have uniform criteria for measuring environmental and social performance, which can be used to give consumers accurate and reliable information.

In this direction, great steps forward have been made in recent years by leading industry-specific international organizations, such as the OIV, the International Federation of Wine and Spirits, and the ISO, but much remains to be done, especially with regard to the social aspects of sustainability. Moreover, it is widely recognized that the issue of sustainability needs to be addressed with respect to the entire life cycle of the product from cradle to grave, given that processes (mainly packaging and transport) have a significant impact on overall sustainability. This broader perspective has paved the way for opportunities to collaborate, many of which have not yet been explored, along the supply chain to find and implement shared environmental, social, and economic improvements.

At the operational level, it is critical for future developments in the wine sector to address the challenge of environmental and social sustainability while maintaining economic viability. Achieving this goal requires, on the one hand, action to support the implementation of sustainable practices by producers, and on the other, consumer awareness needs to be raised and suitable marketing strategies designed to encourage consumers to choose sustainable wines.

To promote a greater spread of sustainable practices among winemakers it is a priority to bridge the still substantial knowledge gaps in terms of perceived environmental benefits, economic benefits, and costs. Thus, an increased research effort focusing on the costs and benefits of different winegrowing practices and technical assistance with implementation might support their diffusion. A wider use of community-based and participatory strategies would also be desirable, whereby growers come together as an industry group or in multi-stakeholder partnerships to promote practices conferring high environmental, social, and economic benefits to the broader community.

It is currently acknowledged that a large number of consumers do not hold any views regarding the effects of wine production on the environment and on their health. Better knowledge of the environmental benefits of sustainable practices and higher perceived consumer effectiveness (including the belief that personal effort can contribute to solving the problem) could enhance consumer involvement and their attitude toward sustainable wine. Specifically, additional research and evidence for the impact of environmental practices on health could motivate consumers to buy sustainable wine. Otherwise, the marketing effort may only appeal to the altruistic values of environmentally aware consumers.

Overall, sustainability is not deemed an important attribute by consumers. However, an appreciable segment across countries in which sustainability has greater resonance has been identified, and more research on customer profiles (demographic, socioeconomic, and psychographic characteristics) is required to better target this segment with wines that meet the expected sensory characteristics and with claims that combine information on quality control and sustainable practices. Significant efforts are needed to make communication with consumers more effective, as the large number of competing sustainable labels and claims is leading to confusion and mistrust among consumers, and to raise awareness on some environmental credentials of wine packaging, mainly lightweight glass bottles. Last, but not least, a major issue is use of the carbon footprint as a logo to communicate the environmental impact of wine to consumers. It is critical to standardize a single wine carbon footprint calculation method and form of labeling to allow consumers worldwide to make conscious purchases.

Disclosure

The authors report no conflicts of interest in this work.

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