beverages

Review

An Overview on Sustainability in the Wine Production Chain

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Abstract: Despite the great relevance of sustainable development, the absence of a shared approach to sustainable vitiviniculture is evident. This review aimed to investigate sustainability along the entire wine chain, from primary production to the finished wine, with specific attention to three key dimensions of sustainability (environmental, social, and economic) and relating measures. Therefore, it was decided to: investigate the ways in which sustainability is applied in the various stages of the production chain (wine growing, wineries, distribution chain, and waste management); analyse the regulations in force throughout the world and the main labelling systems; provide numerical information on sustainable grapes and wines; study the objective quality of sustainable wines and that perceived by consumers, considering that it affects their willingness to pay. The research highlighted that rules and regulations on organic production of grapes and wines are flanked by several certification schemes and labelling systems. Although sustainable wines represent a niche in the market, in recent years, there has been an increase in vineyards conducted with sustainable (mainly organic and biodynamic) methods, and a consequent increase in the production of sustainable wines both in traditional and emerging producing countries. Although (or perhaps precisely for this reason) no significant differences in quality are found among sustainable and conventional wines, consumers are willing to pay a premium for sustainably produced wines. This finding should encourage wineries to both put in place environmental activities and intensify their communication.

Keywords: biodynamic; consumer preference; organic; natural wine; purchase behaviour; wine market

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1. Introduction

Nowadays, the term 'sustainability' is frequently used, and a variety of definitions are available. According to the definition given by the United Nations in 1987, "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [1]. In 2005, the United Nations stated the three-dimensionality (environmental, economic, and social) of the sustainability concept [2]. Three years later, Ohmart specified that sustainability in agriculture "involves everything that can be done on the farm, including economics, environmental impacts of everything done on the farm and all aspects of human resources, including employees and the surrounding community" [3]. In 2019, Peano et al. investigated the priorities declared by consumers among 12 definitions of sustainability retrieved from the scientific literature [4]. According to the results, the respondents preferred definitions concerning the environment, ethics, and health/safety, as, for example, "preservation of natural resources", "decent working conditions" and "accessibility for everyone to healthy and safe food". Five clusters of consumers were then identified: man–nature balance, social welfare sensitive, relationship with the territory of production, environmental sensitivity, and local ecosystem preservation.

The concepts of "sustainability" become less clear when applied to grape and wine products. The initial absence of a common definition of sustainable viticulture and winemaking, and the actual absence of a common vision on the methods to be applied to achieve sustainability cause confusion, both among wine companies and consumers [5]. In order to define the concept of sustainability applied to viticulture and wine production, both the International Organisation of Vine and Wine (OIV) and the International Federation of Wine and Spirits (FIVS) developed sustainability guidelines, the guidelines for sustainable vitiviniculture (OIV 2008), and the Global Wine Sector Sustainability Principles (FIVS 2016), respectively [6,7]. According to OIV (2008), the sustainable vitiviniculture is 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" [6].

According to Gilinski et al., the main priority for practitioners in the wine industry is leaving the land in better conditions than the current ones for the next generation [8]. Szolnoki et al. performed a study aimed to understand how wine makers defined sustainability in different countries (namely, France, Germany, USA/California, Hungary, Italy, Greece, and Spain) [5]. They found that the definition given by almost all of the U.S. and French wineries contains the three aspects of sustainability stated by the United Nations. Differences were observed as a function of the size of the wine companies, with small wineries, especially those certified as organic or biodynamic, focused on the environmental aspect, with the bigger companies more prone to consider the economic and social principles. Another finding of this research was that several wine makers did not distinguish between organic and biodynamic management systems.

Another important topic concerns the challenges that producers should face when marketing their wines by underlining their orientation towards sustainability. Casini et al. observed that the marketing challenges varied according to the chosen strategy, and elaborated a descriptive matrix that framed winery strategy based on the degree of implementation of sustainable practices (orientation), and the degree of communication (exposure) of the sustainable orientation [9]. They described the four following profiles: devoted (wineries that strongly implement sustainable practices and communicate them as much as they can); unexploiters (wineries that apply sustainable practices, but do not communicate their orientation); opportunists (wineries that do not have interest in sustainability, but heavily communicate the few sustainable practices introduced); laggards (wineries that are neither interested in sustainability nor consider that benefits can arise from communicating sustainable orientation). According to Bonn and Fisher, regardless of the debate on corporate social responsibility and environmentalism, sustainability is not considered a priority in strategy making [10].

Although the actual overall consensus on the need to achieve an equilibrium among the enhancement of environmental and social sustainability and the maintaining of an economic viability (the so-called triple bottom line approach), the main challenges are: to bridge the knowledge gaps in terms of perceived environmental benefits, economic benefits, and involved costs; and to orient their strategies toward the development of an integrated sustainability system [11,12]. The main environmental issues include land use, water use and management, energy use and management, chemical use, greenhouse gas emission (GHGs), and waste generation and management. The social aspects of sustainability are the less explored in the wine sector, although they are progressively gaining importance, thus leading to a proliferation of initiatives. The same OIV stated that "Companies will have to consider the impact of their activities on the socio-economic context and their involvement in the socio-economic development of the territories (or areas)" with specific concern to working conditions (respect, equality, safety, health, training, and stability), integrations in the socio-economic and cultural context, consumer safety, and health [13].

The great interest of researchers for sustainable viticulture and wine production is proven by the high number of scientific publications on these topics. The search of the "sustainable viticulture" keyword in Scopus and WoS (Web of Science), two of the most accessed databases, gave 334 and 262 papers, respectively, while 979 and 763 documents, respectively, resulted from the search of "sustainable wine" [14,15]. The acceleration undergone by research activities on sustainable viticulture and wine is proven by the fact that over 60% of the articles have been published in the last 5 years. In addition, an increasing number of both private and public sustainability programs has been launched in recent years, although the differences in the objectives and methodologies risk to undermine the positive aspects of these initiatives [16].

Based on these assumptions, the present work is aimed to give an updated overview on sustainability in the wine sector, describing the following aspects: categories of sustainable wines; sustainable practices along the wine supply chain; sustainable certification schemes; market of the sustainable wines; and consumer attitude towards sustainable wines.

2. Types of Sustainable Wines: Regulatory Issues, Certifications, and Labelling Systems

The first sustainable winegrowing program was accomplished by the Californian Lodi Winegrape Commission in 1992. In that year, the Commission launched a grassroots farmer education program with the aim of reducing the amount of pesticides used by acquiring skills concerning the entire vineyard ecosystem; thus, applying the concept of integrated pest management. In 2005, thanks to the feedback coming from farmers, viticulturists, and leading environmentalists, this program turned into the "Lodi Rules Sustainable Certification Program". Today, over 1000 vineyards are certified under the Lodi Rules program in California and in Israel. In fact, in addition to the Lodi Rules usable by wineries in Lodi, two new seals were created for wineries outside of Lodi, namely "California Rules" and "Universal Rules". The three seals, based on the rigorous application and verification of a scientifically-sound sustainable farming, emphasize environmentally and socially responsible practices, while keeping in mind economic feasibility for long-term business success [17].

Since then, many other organizations of different countries have created their own rules or have accepted already existing guidelines to practice sustainability. Currently, the presence on the market of several categories of "green" wines (natural, organic, biodynamic, sustainable wine, etc.) and the resulting large number of country-specific regulations, certification standards, and logos creates confusion among the consumers and affected their choices [11]. The aim of this paragraph is to provide an overview of the main regulatory frameworks, certification standards, and labelling systems related to the various aspects of sustainability.

2.1. Organic Viticulture and Wine Production

Beyond the differences across regulations/certification standards in force in the various countries, organic vitiviniculture is managed without the use of substances of synthetic origin and forbids genetically modified organisms and ionizing radiations. This paragraph contains a brief overview of the legislation in force in some of the main countries in the world.

In the European Union (EU), organic production, labelling, and controls are currently regulated by Regulation (EC) 834/2007, which defines the general principles of this type of production, and by two other regulations, namely Regulation 889/2008 and 1235/2008, which specify the rules that underlie organic production, import, processing, official controls, and labelling of all the existing organic foods, including those deriving from grape and wine processing, but with the exclusion of collective catering [18–20]. The new Regulation (EU) 2018/848 on organic production will apply from 1 January 2022 [21].

In the USA, the National Organic Program (NOP) of the Department of Agriculture (USDA) has the task to of developing the regulations for production, handling, and labelling of all the organic products. The regulatory references are represented by the following documents: The Title 7, Subtitle B, Chapter I, Subchapter M, Part 205; a program handbook; the Organic Foods Production Act of 1990; and the NOP preamble [22].

Canadian organic foods must be certified according to the Canadian Organic Standards, which include the following standards: CAN/CGSB-32.310-2020 "Organic Production Systems: General Principles and Management Standards"; CAN/CGSB-32.311-2020 "Organic Production Systems: Permitted substances lists"; CAN/CGSB-32.312-2018 "Organic Production Systems: Aquaculture—General principles, management standards and permitted substances lists" [23].

In Brazil, organic wines are regulated by the following rules: the organic system of agricultural production with certification under Law 10,831 of 2003; the Joint Normative Instruction N° 18 of 2009 concerning processed organic foods. The certification bodies are accredited by the Brazilian Ministry of Agriculture, Livestock and Supply [24].

The (currently in force) Chinese standard on organic products is represented by GB/T 19630-2019, which cover mandatory requirements for production, processing, labelling, and management of organic products. The Chinese organic regulations also includes organic certification rules, and an eligible product catalogue [25].

In Japan, organic food production is regulated through the Japanese Agricultural Standard (JAS) system, which covers general and specific standards for food, non-alcoholic beverages, and forestry products. Specific JAS organic standards cover plants, processed foods, organic feeds, and organic livestock products [26].

Since January 2020, the Russian federation regulated manufacturing, storage, transportation, labelling, and marketing of organic products through the Federal Law No. 280-FZ [27].

Indian organic foods are regulated by the Food Safety and Standards Organic Foods Regulations [28]. These Regulations includes the following two certification systems: Participatory Guarantee System (PGS) of the Ministry of Agriculture and Farmers Welfare; National Programme for Organic Production (NPOP) of the Ministry of Commerce and Industry.

Differently from the above mentioned countries, there is no mandatory requirement for certification of organic product in Australia where organic standards are generally owned and managed by private organisations. The majority of Australian organic products is sold under the Australian Certified Organic Standard, which is published by Australian Organic, an organic industry not-for-profit representative group [29].

To help consumers in identifying organic products, their label generally includes a specific logo or seal. Figure 1 shows some of the logos/seals established by organic rules and regulations in the world, but a lot of private standards and logos can also be found on food packages.

2.2. Biodynamic Viticulture and Wine Production

The biodynamic movement was funded in 1924 by Rudolph Steiner, who also invented the term "biodynamic". The concept behind biodynamic is that everything in the universe is interconnected and that the human being is in the middle (anthroposophy theory), between the earth and cosmos rhythms, bridging the gap existing between the spiritual and material world [30]. The biodynamic farm is a closed system, able to produce all of the necessary stuff for vineyards, wineries, and the lives of the farmers–winemakers.

There are no official rules for the biodynamic sector, but a biodynamic company must first be certified as organic before transitioning to biodynamic, and, if located in the European Union, it must respect the regulations regarding the 'organic agriculture'. This means that, in any case, the biodynamic wines have a double certification: the first, concerning their 'organic' nature, which is released by independent certification bodies; the second, referred to their 'biodynamic' characteristics, which has been guaranteed by the Demeter Association since 1927. Demeter is the only official certifier of the biodynamic products and Demeter International provides a set of standards for: food production and processing, the use of Demeter, Biodynamic® and related trademarks, and labelling [31].

The standards for biodynamic winemaking were approved for the first time in 2008 and, since then, have been submitted to periodic revisions in order to improve their application in vineyard and in cellar. Only wineries that strictly apply the wine processing standards can have certified Biodynamic® wines. Otherwise, they can choose to use the labelling category referred to wines made with Biodynamic® grapes if wines are made with 100% Biodynamic® grapes, but the manipulation of grapes during vinification does not comply with the vinification standard. A network of Demeter National Associations has been developed worldwide. Each of them is responsible for the control of the application of the International Demeter Standards, while the International Certification Office is responsible for the certification in countries that do not have an independent National Association [30].

Figure 1. Organic logos/seals in force in (from left to right and from top to bottom) Brazil, USA, Canada, European Union, China, Japan, India, Russia, Australia.

2.3. Other Sustainability Standards and Labelling Systems

Labelling is the main way to supply consumers with information concerning the characteristics of food products. Nevertheless, according to the European regulation for wine labelling (Regulation EU No. 1308/2013), only some compulsory (category of the grapevine product, designation of origin, actual alcoholic strength by volume, indication of provenance, of the bottler or importer) and optional information (vintage year, name of grape varieties, indication of certain production methods) can be reported on the label [32]. As a consequence, there is a discrepancy between the consumer demand for information regarding the impact of wine consumption on both human health and the surrounding environment and the information supplied.

As an example, a category of wine not yet regulated is that of “natural wines”, i.e., the wines obtained by applying traditional organic farming techniques and the production specification of “VinNatur”—an association constituted by over 170 winemakers from nine countries (Italy, Austria, Germany, Spain, France, Portugal, Slovenia, and the Czech Republic)—which include the following requirements: exclusive use of native vines and indigenous yeasts in the cellar; no additives; uneven control of the fermentation temperatures; quantities of sulphites lower than those used for organic wines [33,34]. Nevertheless, the absence of regulation does not allow the application of a certification system and, of course, the term natural cannot be reported on label. This means that consumers can only infer the naturalness characteristics of a wine from the information allowed on the label.

The carbon footprint (CF) of a product is the sum of GHG emissions and removals in a product system, expressed as CO_2 equivalent. It is particularly useful to both evaluate the environmental impact of wine production and supply a true emission account since, according to the OIV GHG protocol (Resolution OIV-CST 503AB 2015), it follows a from-cradle-to-grave approach including the following phases: grape production; wine processing and packaging; distribution and retail; and end-life-phase (use phase, disposal and recycling) [35]. The OIV GHG protocol consider the four greenhouse gases (carbon dioxide—CO_2, methane—CH_4, nitrous oxide—N_2O, sulphur hexafluoride—SF_6) and the two groups of gases (hydrofluorocarbons—HFCs, perfluorocarbons—PFCs) considered under Kyoto Protocol.

The VIVA label derives from the certification to technical specifications developed by the Italian Ministry for the Environment, Land, and Sea with the collaboration of other authorities for calculating sustainability performance in vineyards and wine production [36]. It works through the analysis of four indicators: air, which reflects the total greenhouse gas emission expressed as kg of CO_2 equivalents, directly or indirectly associated with the production of a 0.75 litre bottle of wine; water, which expresses the potential environmental impacts resulting from the use of fresh water, and takes into account the litres of water directly consumed and polluted in the vineyard, and in the cellar, for the production of a 0.75 L bottle of wine; vineyard, which measures the agricultural practices impact expressed on a scale from A to E (A = minimal environmental impact; E = strong environmental impact); and territory, assesses the impact of winery's activities on surrounding biodiversity, local workforce (both in terms of job creation and job quality), and local communities (producers and consumers).

The standard Fairtrade has a comprehensive approach to sustainability. According to this benchmark, wineries must provide workers with living wages and safe conditions, and must pay growers a fair price, i.e., a price that is able to both cover the cost of environmentally sustainable viticulture and include a premium price to invest in social programs within the local community. This standard includes a specific label with information regarding allocation of revenue along the supply chain [11].

3. Statistics and Market Analysis

It is quite difficult to supply statistics in this fields, due to the coexistence of several categories of sustainable wines, the differences among regulatory frameworks in force in the various countries (for example, differences concerning the maximum amount of SO_2 than can be used during vinification), and the absence of regulatory frameworks for some categories of sustainable wines. This section provides a collection of literature data referred to the surface of sustainable vineyards and the amount and/or value of the sustainable wine produced.

3.1. Organic Vineyards and Wines

Interesting data relate to the percentage of organic vineyards across the world in 2016: Europe 8.5%; New Zealand 7%; America 4.1%; Chile 3%; Argentina and South Africa, 2%. However, the overall percentages of vineyard certified as sustainable were very high in some countries. For example, in New Zealand and South Africa, they are 100 and 95%, respectively. In 2014, the countries having the largest surfaces dedicated to organic vineyards were Spain (~84,000 ha), Italy (~72,000 ha), and France (~66,000 h ha), with increases of +413, +128, and +307%, respectively, during the period 2003–2014. In 2016, Spain, Italy, and France represented 73% of all organic vineyard in the world [37]. In 2017, the biological vineyard surface in Italy exceeded 83,000 ha and the three Italian regions with the largest biological surfaces were Sicily (with more than 39,000 ha), Puglia, and Tuscany (SINAB 2018). Concerning wine, in 2016, the value of the French organic market was €792 million, while it was significantly lower in UK, being around €6.8 million for all the organic alcoholic beverages [37]. In 2017, four out of five bottles of organic wine were sold in Europe and the top three countries were Germany (162 million bottles; 23.9% of world market), France (111.6 million bottles; 16.4%), and the United Kingdom (68.4 million bottles; 10.2%). Other important markets were USA (50.4 million bottles; 7.4) and

Japan (34 million bottles, 6%), while in Italy only 15.6 million bottles (2.3% of the world market) were sold [38]. Regardless of its small numbers, the Italian organic wine market shows interesting signals of growth. In fact, between the first semester of 2017 and the first semester of 2018, the global value of wine sold in supermarkets increased by 4.5%, while the value of organic wine sales increased by 49.3% [39]. In Italy, in 2018, the channels for the purchase of organic wine were large-scale retail channel (33%), the direct purchases from producer (23%), wine bars (19%), shops specialised in organic products (18%), and the online selling (6%). In 2018, the sales of organic wine reached 21.6 million euros only in the GDO and the market share of organic wine was equal to 1.2%. Red organic wines were the most consumed ones (49% of the sales organic wine in the GDO). Abruzzo was the first region of Italy for sales of organic wine in the GDO (4 million euros), followed by Veneto, Tuscany, and Sicily with sales higher than 3 million euros [40]. The market for organic wine should grow rapidly in the period from 2017 to 2022, even if the share of organic wines will remain relatively low (3.6%) [41]. The world sale of organic wine should reach 1 million bottles in 2022 (they were 676 million in 2017). The highest increase (+14%) should occur in the USA.

3.2. Biodynamic Vineyards and Wines

Biodynamic grapes intended for winemaking are produced worldwide by 639 biodynamic farms that account for about 11,000 hectares. Three hundred of them are located in France (with about 4700 hectares) and over 70 farms are located in Italy (more than 1000 hectares). One thousand hectares of biodynamic vineyards are also managed in each of the following countries: Spain, USA, and Chile [30]. The average surfaces of biodynamic farm producing grapes greatly change from a country to another one: up to 10 hectares in The Netherlands, Hungary, Greece, Portugal, Germany, Switzerland, UK, Slovenia, Austria, and Mexico; around 16–19 hectares in France, Italy, and Brazil; about 23 hectares in the USA; 30–35 hectares in Spain, Argentina, South Africa; about 53 hectares in Czech Republic; 72 hectares in Chile [30]. Instead, it was impossible to find statistic data on biodynamic wines for the reason that biodynamic production is often included in data concerning organic production.

3.3. Fairtrade Vineyards and Wines

In 2014, about 22 million litres of Fairtrade certified wines were sold worldwide. They derived from about 9800 hectares of certified vineyards. Forty-five producer organisations and wineries are globally involved in making Fairtrade wine, mainly in South Africa, Argentina, and Chile. The main sales markets are the UK, which accounts for half of the overall Fairtrade wine sales, followed by Germany, with around 3 million litres, Sweden, and the Netherlands. The main sales channel for these wines is represented by the retail chains [42].

4. Sustainability in Viticulture

The aim of this section is to describe the different environmental impacts of conventional and sustainable vineyard managements and the effects of the various sustainable management systems on the microbial mass and chemical characteristic of the soils and on the above-ground grapevine microorganisms. Measurements of soil-borne microbial communities are good indicators of soil quality since microorganisms are intimately linked with the cycling and stability of soil organic matter and, as a consequence, are sensitive to changes in soil management.

4.1. Effects of Conventional and Sustainable Management on Soil

Probst et al. analysed the effects of conventional and organic management on chemical and microbiological characteristics of soil in eight Alsatian vineyards [43]. They found that the management systems did not exert significant effects on the contents of organic C, total N, total P, total S, and on the contents of the heavy metals Zn and Cu. The content of Pb was higher in conventional vineyards while the contents of Ni, Co, and Cd were higher in the organic ones. The microbial biomass and activity indices (microbial biomass C and N, ATP, ergosterol, and CO_2 production) were significantly higher in the soils under organic management. Likar et al. analysed the fungal and bacterial rhizosphere communities and related them to the type (conventional and organic) of soil management [44]. There were significant differences among the vineyards under the two types of soil management in particular for bacteria. In a previous work, the copper-detoxifying fungus *Aureobasidium pullulans* was shown to make the difference between conventional and organic viticulture since it was enriched in the organically managed plants where showed a higher indigenous anti-phytopathogenic potential [45].

4.2. Environmental Impacts: A Comparison among Conventional and Sustainable Viticulture

Life cycle assessment (LCA) supplies the appropriate methodology to evaluate the environmental impacts of viticulture activities and, for this reason, it has been extensively used to evaluate the impact of different vineyard managements. As an example, a comparison among biodynamic, conventional, and an intermediate biodynamic-conventional wine-growing plantation was performed within the same wine appellation (Ribeiro, Spain). The results of that study showed that the biodynamic management exerts the lowest environmental impact as a consequence of a lower application of pesticides/fertilisers and the substitution of mechanised work with the manual type but its highest impact was also highlighted in terms of land competition. In fact, the shift towards biodynamic practices implies substantial yield decreases and, consequently, noticeable increases of land use. This aspect could be a limiting factor to the diffusion of the biodynamic viticulture in appellation areas, since they are strongly constrained by land availability [46]. A work on the environmental footprint of grapes grown in the island of Cyprus confirmed that organic grapes have the lowest values for most of the impact categories, with the exception of respiratory inorganics, whose highest value derive from the stocking of manure prior to application and the use of machinery and fuel for its transport and application [47].

4.3. Indicators of Environmental, Economic, and Social Sustainability

Despite the wide literature available on the environmental impacts of various categories of viticulture, there is a gap regarding the simultaneous evaluation of both economic and environmental aspects of sustainability. Borsato et al. (2020) performed a comparison between the environmental and economic performances of organic and conventional vineyard management systems by applying a multi-criteria approach [48]. The considered environmental indicators included water footprint, carbon footprint, and vineyard management indicator. The total water footprint is the sum of the following three components expressed as volume per unit of surface (m^3 ha^{-1}) or vine grape yield (m^3 ton^{-1}): the green water footprint, which considers the volume of water from precipitation consumed by plants through evapotranspiration; the blue water footprint, which includes the water used for irrigation, dilution during pesticides treatments, and cleaning of the equipment; the grey water footprint concerns freshwater pollution as a consequence of pesticide and fertiliser use. The carbon footprint indicator evaluates the greenhouse gas emissions as a unit of carbon dioxide equivalent emissions (kg CO_2-eq). The Vineyard Management Indicator, based on the "Vigneto" indicator in the VIVA calculator, consists of six sub-indicators concerning pest management, fertilization management, soil organic matter, soil compaction, soil erosion, and landscape quality.

The economic indicator used was the net income, i.e., the difference between the gross marketable income and the costs. According to the results, the conventional vineyard management showed the higher total water footprint, due to the higher contribution of blue and grey water footprint, and the greater GHG emissions. Concerning the indicator of Vineyard Management, there was not a significant difference between the two management practices. The analysis of the economic balance highlighted that conventional vineyard management generally had higher costs. As a consequence, organic vineyard management did not compromise the economic productivity and reduced the environmental impacts.

The lack of homogeneity of the methods and indicators used to assess sustainability is an issue not easy to solve. The main effect of this inhomogeneity is the impossibility of making comparisons between different regions, farms, and crops. Santiago-Brown et al. (2015) applied the Adapted Nominal Group Technique (ANGT), i.e., a hybrid interview and discussion group method, for developing a set of indicators usable by wine-grape growers as a decision tool in agricultural business [49]. The ANGT sessions produced 507 indicators, divided into economic (161), environmental (171), and social (175) indicators. After a merging work, the list comprised 76 indicators (27 economic, 26 environmental, and 23 social), ranked by the so-called 'importance index', calculated by multiplying the number of groups that mentioned a specific indicator by the average score of that indicator. The histograms in Figure 2 summarize the main sustainability indicators according to their Importance Index values.

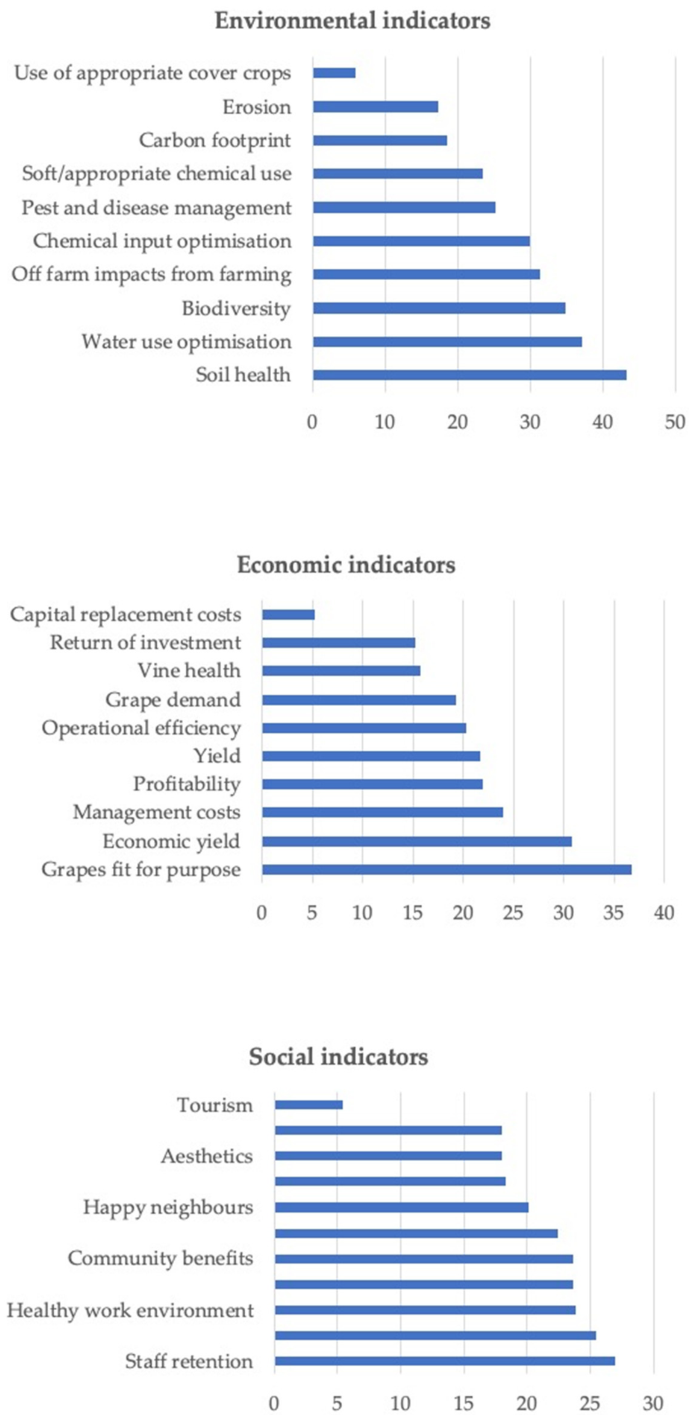

Figure 2. The main environmental, economic, and social sustainability indicators ranked according to their Importance Index (adapted from Santiago-Brown et al. [49]).

5. Sustainability in Wineries

An interesting research by Moggi et al. identified the key (environmental, social, and economic) dimensions and the relating practices of sustainability in Italian wineries, while Jeffery identified the main environmental sustainability achievements of three wineries chosen as case studies [50,51]. The results, summarised in Table 1, can be extended to the wineries of all the world, since they are attributable to the following issues: recovery of water, energy (in all its forms), and waste; use of renewable resources and innovative materials; protection of health and safety; exploitation of local resources; ethical reputation and identity.

Table 1. Measures related to the three key (environmental, social, economic) dimensions of winery sustainability (our elaboration of information from Moggi et al. and Jeffery [50,51)].

Key Dimensions	Measures and Actions
Environmental	Recovery of rainwater
	Reduced production of wastewater and recycle wastewater
	Recovery and recycle of wastes
	Waste-to-energy
	Recovery of energy and heat
	Use of renewable resources
	Acquisition of green cars and delivery trucks
	Use of low-impact innovative materials for packaging
Economic	Reduced consumption of water
	Reduced consumption of energy
	Sequestration and reuse of CO_2 produced with fermentation
	Recognisability on the market
Social	Protection of health and safety
	Ethical reputation
	Exploitation of local resources, workers, and growers
	Corporate welfare

5.1. The Main Impacts of Wineries

In order to verify the measurement and size of some cellar parameters related to sustainability, Gubiani et al. performed a survey in the area of Friuli Venezia Giulia and Eastern Veneto [52]. According to the results, electricity consumption (expressed as Wh/L of wine) was very high, especially during the harvesting period, due to the need to cool grapes and/or musts. Furthermore, there was a direct correlation between the average temperature of the harvest and the global energy consumption of a winery. In small to medium wineries, such as the Friuli wineries (about 2000 hL/year of wine), the electricity consumption was around 250–350 Wh/L. These values decreased considerably in larger wineries, although they also depend on the type of grapes (white grapes need much more refrigeration than the red ones), and the type of processing. Concerning water, most of the consumption was realised to the vineyard. In cellar, the water consumption was around 4 litres per litre of wine and the largest share was used in the operations occurring after fermentation since they included many washing cycles.

5.2. Winery Approach to Sustainability

Wineries can adopt effective measures to increase sustainability of the entire wine sector also taking into account the various expressions of climate change (hotter summers, warmer winters, droughts, and extreme events, such as freak hailstorms, spring frosts, flooding and forest fires), as well as their impacts on grape and wine production. The increasing risk of frosts occurring after budburst could cause serious damage: Warming is sometimes responsible for early harvesting to maintain the acidity required for the wine aging. The greatest expression of climate change is represented by global warming, i.e., the increase of the Earth average temperature, whose impacts vary significantly with vineyard location since global warming is not uniform, but it is greater at the higher latitudes, especially in the Northern Hemisphere [53]. The shift of warmer temperatures poleward will lead to significant changes in the geographic distribution of wine production with movement of premium grape growing areas out of the traditionally devoted territories, placing of vineyards at higher altitudes (previously considered inhospitable), and changes of grape variety cultivation [54]. A work by Carroquino et al. classified Spanish wineries on the basis of implementation of mitigation and adaptation measures towards climate change [55]. Although all wineries were aware of the existence of climate change, four different winery profiles were individuated according to their actions towards climatic change: wineries making structural changes in the vineyard to ensure its long-term sustainability; wineries that operated a systematic and professional management of sustainability through the use of renewable resources, surveillance of sustainability, attention to efficiency and recycling; wineries whose mitigation measures were focused on energy through changes in the contracted power to obtain economies in the electricity bills; wineries that did not implement any sustainability actions. The Canadian winegrowers show different levels of adaptability depending on the type of weather events and the company size. First of all, they are more capable of coping precipitation and drought than extreme weather events. Furthermore, the greater winegrowers are more likely to adapt themselves to events associated with climate change [56]. Based on the considerations reported above, the adoption of specific measures to combat climate change should be carefully investigated to help institutions in the design of promotion policies.

An important issue is represented by the costs of sustainability and by the way wineries perceive the ratio among costs and benefits of sustainability measures. An exploratory research that involved 14 wineries, representing more than 50% of the wine certified according to the California Sustainable Winegrowing scheme, showed that environmental and economic benefits of reducing and recycling practices outweigh the economic costs. Reversely, the activity of planning and monitoring goals and results is perceived as the practice whose economic costs outweigh the economic benefits without supplying consistent environmental benefits [57]. Furthermore, wineries consider sustainable programs and certifications as a way to contribute to the social and economic well-being of the territory where the winery is located [58].

Wineries generally approach sustainability according to two different points of view: 'green business', where the decision of being sustainable is not moved by ethical awareness, but by the benefits deriving from this status, including the positive image feedback that the green companies obtain; 'green–green business' in which wineries configure themselves as sustainable companies since their creation [59,60].

6. Sustainability in the Wine Supply Chain

As the wine supply chain is increasingly globalised, a growing number of researchers are focusing their studies on its environmental sustainability. The most widely used system approaches include analyses of greenhouse gas emissions (GHG), environmentally extended input-output analyses, and life cycle assessment (LCA). In particular, GHG emissions are the most frequently used environmental indicator while LCA allows the assessment of the environmental impacts of a product/service, focusing on the resources used and the substances emitted in each steps of its lifecycle. LCA is a useful instrument to orientate organization and policy decision making.

6.1. Contribution of the Wine Supply Chain to the Environmental Impact

According to Rugani et al., the contribution of the wine supply chain to the global GHG emissions is 0.3%, i.e., a non-negligible percentage for a single type of product [61]. Postein et al. analysed the GHG emissions related to the Finnish wine supply chain by applying LCA [62]. The study is particularly interesting since all wine consumed in Finland is mainly imported from eight countries (Australia, Chile, France, Germany, Italy, Spain, South Africa, and the United States); and many types of packaging are considered (glass bottle, Bag-in-Box, PET bottle, beverage carton, and pouch). Furthermore, the results could be extended to countries, such as Sweden and Norway, which are in similar conditions. The authors found an average value of 1.23 kg CO_2 for 0.75 L wine consumed in Finland, ranging from 0.59 for French wine packed in bag-in-box to 1.92 kg CO_2 for

Australian wine in glass bottles. Since logistics, packaging, and energy consumption are among the main emission sources in a supply chain, the authors explored the implications of their variations by supposing four scenarios: (1) import of bulk wine, bottling in Finland; (2) changes in glass bottle weight; (3) change in packaging type by increasing the share of bag-in-box; (4) increase of energy efficiency. The potentials for reducing GHG emission depended on exporting country. Scenario 3 showed the greatest potential for reducing GHG emission (−12%) followed by Scenario 4 (−8%), where the impact was greatest for wine from countries with a high emission factor for electricity such as South Africa and Australia. Scenario 2 would have avoided 6% of the GHG emissions, but the effects were interesting only for wine imported from countries with a high share of bottled wine (France, Italy, Germany, and Spain). Scenario 1 would have allowed the lowest reduction of GHG emission (−2%) since it would have reduced the GHG emissions from wine from overseas countries, but not from European countries.

Petti et al. (2006) analysed the progressive adoption of a life cycle approach by a small Italian organic winery [63]. For most impact categories, the more impacting phase was that of primary packaging, involving the following operations: bottling of wine in glass containers previously washed with water and soda; sealing of the filled bottle with a cork and a PVC (polyvinyl chloride) capsule at the neck; labelling; and packing of the bottles in cardboard boxes. The major environmental hot spots were: airborne emissions and use of energy and water in the distribution phase; airborne emissions, use of energy and water and solid waste generation in the packaging life cycle; airborne emissions, use of energy and water in the agricultural phase. The winery decided to improve the impact of primary and secondary packaging, since they are easier to be changed. Bottles, corks, and cardboard boxes were replaced with lighter ones. These actions allowed the reduction of raw material and energy required for the production of glass, but also of waste to process. Furthermore, transportation efficiency was improved.

6.2. Sustainability Promotion Tools

In the last years, a proliferation of projects, protocols, and tools occurred with the aim of promoting sustainability in the wine industry. Regardless of the three dimensions of sustainability (environment, economy, and society), most of these initiatives only concern the environmental aspect of sustainability. Merli et al. examined the main protocols concerning sustainability used in the wine sector through a series of indicators of performance and created an evaluation framework to test these indicators and provide a tool assisting decision makers in the selection of more suitable metrics [64]. The protocols analysed were two projects specifically applied in the wine sector, namely Italian VIVA Sustainable Wine project, California Sustainability Winegrowing Alliance (CSWA), and the Eco-Management and Audit Scheme (EMAS) proposed by EC Reg. No. 1221/2009. CSWA provides growers and winemakers with a tool allowing the management of natural resources through indicators, such as water consumption, energy consumption, emissions of greenhouse gases, and the use of nitrogen. VIVA Sustainable Wine project is an Italian initiative launched in 2011 by the Ministry for the Environment that allows participants to quantify their environmental, social and economic impact. The application of EMAS led to the use of indicators different from a company to another, but they were generally referred to energy and material efficiency, water, waste, biodiversity, and emissions. According to the evaluation framework, only the VIVA set of indicators considers all of the aspects of sustainability of the wine industry, but EMAS is the only standards that covers most of the critical environmental aspects. In fact, CSWA and VIVA do not consider raw materials efficiency and waste management. Furthermore, the examined protocols do not include specific indicators for packaging and transport that, instead, are significant contributors to the environmental impacts of wine production. In conclusion, the integration of the various indicators in a unique protocol could supply wine industry with a tool suitable to evaluate and manage all its sustainability aspects. Martucci et al. investigated the available social sustainability assessment tools [12]. More specifically, they compared the social life cycle assessment (S-LCA) with the VIVA requirements for Italian wine supply chain. The S-LCA works in the same way that the better known environmental LCA, but is specifically projected to analyse the social impacts throughout the product life cycle. The comparison between VIVA and S-LCA highlighted that the second tool is more complete and allows a better evaluation of the social issues of the wine supply-chain. The main defect of S-LCA is that only 8 of the 189 indicators proposed refer to a direct evaluation of the social performance of the product, while the other 127 and 69, respectively, refer to organizational and geographical area assessments. As in the work of Merli et al., the authors concluded that integration of the indicators of the two tools could be useful to broad the analyses of the socio-economic impacts [63].

An interesting proposal was forwarded by Valero et al. [65]. They developed a Sustainable Wine Scoring System (SWSS), i.e., a single numeric index of the sustainability of a bottle of wine constituted by multiple normalised indicators, starting from different environmental impact categories quantified through a life cycle assessment approach. They found that grape growing greatly contributes to the ecotoxicity, non-carcinogenic, and eutrophication impact categories, while transportation mainly contribute to global warming, smog, and ozone layer thinning. The calculated SWSS results vary from 279 (scenario with the highest environmental impact) to 350 (scenario with the lowest environmental impact).

7. Environmental Impacts of the Wine Life Cycle from Viticulture to Distribution

This section is aimed to give an overview of the environmental impacts of the whole wine life cycle and of the specific contribution to such impacts of each stage of the chain. The better approach to the analysis of the environmental impact associated with a product is LCA studies as that described in this section.

Neto et al. applied an LCA study for the assessment of the supply chain of *vinho verde*, a white wine produced in the northern part of Portugal [66]. The authors collected data referred to the campaign in 2008–2009 and fixed a 0.75 litre bottle as the functional unit. The system boundary includes materials, water, and energy used in the activities taking place during viticulture (grape growing), wine production (from vinification to wine storage), bottle production, and wine distribution, also including transportation of grapes, must, wine and other products. Figure 3a shows the contribution of the considered stages to each impact category. As can be inferred, viticulture contributes by more than 50% to all the environmental impacts, followed by bottle production, while distribution had a relatively lower impact regardless the worldwide distribution. Point et al. used LCA to quantify the environmental impacts of a 0.75 litre bottle of wine in Nova Scotia (Canada) [67]. The difference, with respect to the study by Neto et al., was that the system boundary included both production and consumption, but the results were the same, i.e., that viticulture gave the greatest contribution to the wine total impacts (Figure 3b) [66]. The second major contribution to environmental impacts was found for consumer transport.

Finally, an LCA study by Zhang and Rosentrater analysed the environmental impacts of red winemaking supply chain in USA, by including the stages of viticulture, winemaking, bottle manufacture, and distribution [68]. They obtained the following results: bottle manufacturing and wine making gave the greatest contribution to energy consumption (35% and 31%, respectively) and solid waste disposal (32% and 59%, respectively); winemaking accounted for 91% of all water consumption; viticulture and bottle manufacturing was the major contributor to GHG emissions.

Bandinelli et al. individuated the 19 main sustainable practices, classifying them according to both the stages (viticulture, wine production, bottling and distribution) of the wine supply chain that is involved and the elements (air, water, plants, and soil, landscape and society) on which these practices mainly exert their impact [69]. As can be inferred from Table 2, eight of these practices concerns viticulture, six are related to wine production, and five can be applied in bottling and distribution. Furthermore, they mainly affect the quality of air, while landscape and society are only marginally considered.

Table 2. Environmental practices in the wine sector (adapted from Bandinelli et al. [69]).

Stage of the Chain	Sustainable Practices	Effects on			
		Air	Water	Plant/ Soil	Landscape/ Society
Grape production	Promote the use of organic substances		√	√	
	Promote the use of a high level of automation	√	√		
	Implement actions to protect soil			√	
	Promote the more efficient micro-irrigation		√		
	Promote the use of precision agriculture			√	
	Preserve and promote biodiversity			√	√
	Promote the production of compost starting from pruning residues			√	
	Reduce the use of fertilizing and agrochemicals	√	√	√	
Wine production	Reduce the use of chemical substances				√
	Promote the use of bio-materials to realise the cellar structures	√			√
	Promote the recovery of waste to produce energy		√	√	
	Promote the use of the so-called clean energy	√			
	Construction of hypogeal or partially buried structures	√			
	Promote the recovery and use of rainwater		√		
Bottling and Distribution	Use of recycled or alternative materials to produce bottles	√			
	Replace paper communication with digital communication	√			√
	Use of recycled materials to produce labels	√			
	Use of recycled materials to produce packaging	√			
	Favouring 0 km production by bringing production sites closer to sales markets	√			

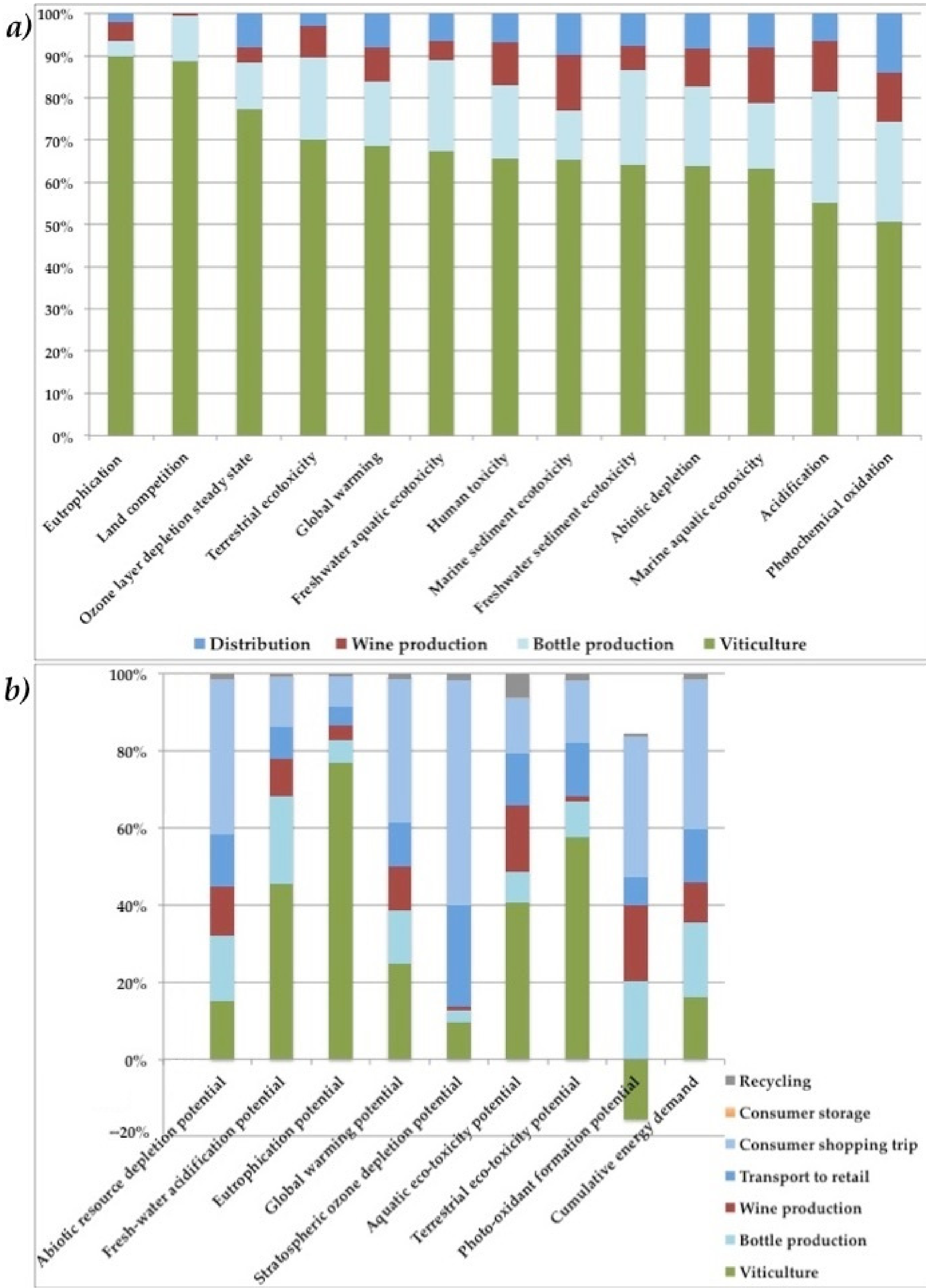

Figure 3. Percentage contribution of the stages of the wine supply chain to the various impact categories in life cycle assessment (LCA) studies applied to (**a**) *vinho verde* Portuguese wine (adapted from Neto et al.) and (**b**) a Canadian wine made with locally grown grapes (adapted from Point et al.) [66,67].

8. Sustainability in the Waste Management

8.1. Amount and Characteristics of Wastes

Wine making produces a large amount of organic and inorganic wastes. During cultivation and harvesting, about 5 tonnes of solid waste per hectare per year are generated [70]. Concerning processing, it has been estimated that wineries globally produce around 13 million tonnes of solid waste, consisting of seeds, skins, and stems (grape marc) each year. Large amounts of wastes, in the form of wastewater are generated during the further stages of processing, as a result of washing and clarification. The winery wastewater ranges from 650,000 m^3 to over 18,000,000 m^3 per year, according to the production size [70]. It has been calculated that 26,000,000 to 100,500,000 hectolitres of water are consumed globally per year, although according to less conservative calculations, the water consumption reaches 1,000,000,000 hectolitres per annum [71,72]. Finally, there are wastes known as lees, composed of solid and liquid fractions.

The characteristics of winery wastes are the following: low values of pH (3.8–6.8) and electrical conductivity (1.62–6.15 Ds/m); high content of organic matter (669–920 g/k or g/L), and phenolic compounds (1.2–19.0 g/kg or g/L); low concentrations of micronutrients and heavy [73]. This implies a great number of uses for their exploitation.

8.2. Treatments of Wastes

Conventional treatments of wastes are expensive, since they require considerable amounts of economic and energy resources for their safe discharge into the environment. Furthermore, the growing attention towards environmental concerns is leading to a tightening of legislations regarding waste disposal throughout the world. In Europe, for example, the Waste Framework Directive highlights the priority of the different methods of managing waste that in a descending order proposed the following actions: waste prevention, re-use, recycling, other recovery (e.g., energy recovery), and, lastly, disposal [74]. Thanks to both, the development of an environmental awareness and the more stringent legislation, in recent years, the transition from the dominant "take-make-dispose" economic model towards the so-called circular economy occurred [75]. Circular economy is aimed to replace the traditional linear supply chains with networks in which materials are recycled or, better, are upcycled. Upcycling is a term used to include any process able to transform waste into higher value products by making them the input for other products. Summarizing, circular economy allows to make "someone's waste the resource of someone else" [76,77]. The circular economy idea is strictly related to the biorefinery concept that means recycling of wastes through bioconversion. Wastes generated by beverage, food, feed, and agricultural factories are the best candidates for the biorefinery approach, since they satisfy criteria such as size, continuity of supply, and nutritive content. Based on these findings, it is necessary to develop innovative practices for the by-product exploitation [78].

Liquid and solid (lees, vinasses, marc) winery wastes can be used as feedstock in chemical/biochemical biorefineries for the production of biofuels, gases, cell biomass, enzymes, acids, and other valuable products, such as antioxidant and dietary fibres. Leaves and pomace are feedstocks for the so-called green biorefineries to produce biogas, heat, electricity, and chemical substances such as proteins, enzymes, amino acids, and ethanol. Finally, lignocellulosic (LCF) biorefineries use stalks, peels, seeds, trimming vine shots, pips, and pomace to produce fuels, gas, and a variety of chemicals [70]. The high content of bioactive molecules, such as phenolics and vitamins makes lees a suitable substrate for the production of extracts useful in the food, nutraceutical, and pharmaceutical industries ([78]. Grape seeds have already important uses in food industry, since they provide an edible oil, but further applications in cosmetics and pharmaceutical industries can be planned. For example, grape seed flours, which are known to contain both phenolics and fibres, can act as prebiotics since they dramatically change gut microflora, thus resulting in lower cholesterol and liver fat, and maintaining the right body weight [79]. Finally, winery wastewater, which is known to have environmental impacts due to its high content of organic and inorganic substances, could find an interesting use in xanthan bioproduction [80].

9. Characteristics of Conventional and Sustainable Wines: Similar or Different?

Literature on chemical, physical, microbiological, and sensory characteristics of conventional and sustainable grapes and wines is somewhat contradictory since some researches highlight significant differences while others consider the various types of wine identical from a qualitative point of view.

A research on sensory differences between Merlot wines obtained from biodynamically and organically grown grapes was performed by Ross et al. [81]. They found that the effects of the vineyard management system were year-dependent. In fact, in 2003, the biodynamic wines were higher in bitterness and musty/earthy aroma while, in 2004, the organic wines were higher in astringency, bitterness, musty/earthy aroma, and had a longer finish. Moyano et al. investigated the sherry wines obtained from Pedro Ximenez organic and conventional grapes and were able to distinguish between the two types of wines by profiling their aromatic compounds [82]. In fact, wines from organic grapes had similar aromatic profiles, but with lower intensities, with respect to the conventional ones.

Phenolic composition and antioxidant activity were studied in conventional and organic Monastrell grapes and wines [83]. The researchers found that both the indices were higher in the organic grapes than in the conventional ones a month before harvesting but that the difference disappeared at the harvesting time. Furthermore, the higher phenolic concentrations and antioxidant activity of organic wines were not significant. Tassoni et al. analysed the concentrations of biogenic amines, anthocyanins, polyphenols, and the antioxidant activity value of white (Pignoletto) and red (Sangiovese) grape berries and wines obtained through conventional, organic, and biodynamic vineyard managements and oenological practices [84]. They did not find a significant difference among the samples deriving from the different agricultural and winemaking practices.

Kecskeméti et al. investigated the epiphytic microbial communities in the carposphere of grapes [85]. They did not find significant differences among, conventional, organic, and biodynamic management systems, with the exception of *Alternaria alternata* and *Pseudomonas* spp., which were more abundant in the carposphere of conventional berries than in the biodynamic ones, and of *Sphingomonas* spp., which was significantly less abundant in conventional than in organic berries.

A work by Picone et al. on the application of ^{1}H-NMR foodomics to organic and biodynamic Sangiovese grapes highlighted lower sugars, and coumaric and caffeic acid contents, and a higher amount of γ-aminobutyric acid (GABA) in biodynamic grapes [86]. Laghi et al. performed a successive study aimed to discriminate red wines obtained from Sangiovese grapes produced under organic and biodynamic vineyard management and vinification protocol by means of proton nuclear magnetic resonance (^{1}H-NMR) and metabonomic investigation [87]. More specifically, trans-caffeic acid concentration was always higher in biodynamic wines, while glutamine, tyrosine, and resveratrol contents were higher in organic wines. In the work by Parpinello et al., the organic wines showed higher total acidity and lower volatile acidity and pH, while the concentrations of anthocyanins, phenolic and cinnamic acids, and flavonols, and the colour components did not significantly differ [88]. Trained panellists highlighted differences in astringency and odour complexity between organic and biodynamic wines, while consumers did not show preference.

Regarding ochratoxin A contents, Gentile et al. found comparable levels between organic and conventional wines and Vitali Čepo et al. did not observe significant differences between organic and conventional wines [89,90].

10. Sustainable Wines: Consumer Perception, Preferences, and Willingness to Pay (WTP)

10.1. Consumer Approach to Sustainability

Several researchers agree that consumers can actively contribute to the overall sustainability by choosing healthy foods that are both able to produce positive effects on the environment and in agreement with socially ethical standards [91,92]. According to Zucca et al., many consumers do not have a clear idea of the meaning of sustainability and of what sustainable practices are [93]. Nevertheless, other authors stated that consumers like the concept of sustainable wine and would be willing to pay more for it than for a conventional one [94]. One of the main motivations behind the choice of several agro-food companies of incorporating the principles of environmental, economic, and social sustainability into their business, seems to lie in the change in consumer behaviour [95]. Especially in the last years, consumers are basing their purchasing decisions not solely on the product quality characteristics, but also on the influence that these products have at the environmental, health, and social levels. Many theoretical approaches have been applied to understand the green purchasing behaviour, but only psychological criteria have been shown to be strongly correlated with green purchasing behaviour and consequently very effective in profiling environmentally conscious [96]. Sogari et al. investigated the consumer perception of sustainable wine and grouped the Italian wine drinkers in clusters based on three factors (belief about environmental protection, beliefs about sustainable wine certification, and attitude towards sustainable-labelled wine) and willingness to pay. They identified the four groups of consumers: well-disposed; not interested; sceptical; and adverse. Consumers with positive attitude towards sustainable wine and higher beliefs of environmental protection (belonging to clusters 1 and 3) showed higher willingness-to-pay for sustainable wine. [97]

An interesting concept is that of 'perceived consumer effectiveness' (PCE) that corresponds to the extent to which the consumers believe that their own efforts can contribute to solving a social and environmental problems [98]. Ghvanidze et al. (2016) performed an online survey in the U.S., UK, and Germany to investigate five consumer behavioural factors—namely, perceived consumer effectiveness (PCE), environmental conscious behaviour, concerns for ethical food production, health-conscious lifestyle, and healthy dietary patterns [99]. The results shown that information on food labels concerning environmental and social issues represents a value for consumers with higher levels of PCE, while health and nutrition information on food labels do not get the same consideration. Other important findings included the highest levels of PCE of U.S. consumers and the low sensitivity of both younger people and consumers with lower levels of education towards environmental and ethical aspects of food production.

10.2. Consumer Attitude–Behaviour Gap and Willingness to Pay for Sustainable Wines

Despite the different values between green and conventional consumers (the first one seems to be more altruist and universalist than the latter), the attitude towards environmental protection is not always followed by the corresponding purchasing behaviour [100,101]. Price is one of the reasons of this "attitude-behaviour gap" [102]. To define the right price, the price premium that consumers are willing to pay for a sustainable product, when compared to a traditional alternative, should be considered [103]. Sogari et al. proposed the following three different consumer perception profiles based on the level of involvement in sustainability and their WTP for sustainable wines: interested, i.e., people with a high understanding of sustainability issues and high WTP for sustainable wines; cautious, i.e., people highly concerned with environmental issues but with low WTP for sustainable wines; adverse, i.e., people with low involvement in sustainability issues and low WTP for sustainable wines [104]. Authors concluded that, although the eco-labelled wines might capture the interest of consumers, it is not said that they could be attractive to purchase if considered of low quality or too expensive.

According to the European Commission, three-quarters of the European citizens are willing to pay premium prices for environmental-friendly [105]. Other factors, such as convenience, quality, ingredients, and brand familiarity could be responsible for the "attitude-behaviour gap" [98]. The paper of Remaud et al. explored the importance that Australian wine consumers gave to the organic attribute in comparison with other three attributes: price, region of origin, and another eco-friendly claim [106]. The research was focused on Shiraz varietal wines. Results showed that price was the most important attribute, followed by region (17%), environmentally responsible claims (14%), and organic attribute (3%). Thus, organic wines are less valued (9%) compared to wines with environmental claims (30%). In addition, only a minority of Australian wine consumers (14%) did value organic wines. The consumers belonging to this group were willing to pay a price premium of $4.99 (22% premium compared to a conventional wine) for an organic wine, for a special occasion. Instead, the average Australian wine consumer would only pay a price premium of $0.25 (1% premium) for an organic wine. A similar research was performed by Tait et al. [107]. They applied a discrete choice experiment involving California Sauvignon Blanc consumers to assess the importance of several sustainability attributes in wine choice against other attributes such as country of origin, price, and quality (expressed as score out of 100). They found that critic score of 95/100 was at the first place in the willingness-to-pay rank, followed by the attributes 'Made in USA' and 'Made in New Zealand'. The attributes '100% organic' and 'Made with organic grapes' were at the fourth and fifth positions. The successive positions in the rank are occupied by the following attributes: 'Made in France', 'Pest and Disease Management', 'Water management', 'Made in Chile', 'By-product management', 'Social responsibility', 'Made in South Africa', 'Greenhouse Gas Management', 'Energy Management', and 'Biodiversity Management'.

In the wine sector, the growing attention of consumers towards sustainability in general and environmental aspect in particular is highlighted by the increase in the sales of organic wines, which was equal to +88% in 2018 respect to the previous year. In the same period, the increase in the sales of wine in general increased only by +3% [108].

Galati et al. performed a survey aimed to profile the Italian consumers of "natural wine", to evaluate their willingness to pay for this type of wines, and to understand the effects of label information on the consumer purchasing choice [109]. The authors administered a questionnaire to 286 wine consumers and submitted their responses to an ordered logistic estimation. According to their results, consumers were willing to pay a premium price for "natural wine" (€2.32 more than a bottle of conventional wine), and that this WTP was higher in consumers that: showed high interest in natural products; gave high importance to label information; and chose the convivial occasion as main consumption occasion. Concerning the sociodemographic variables, the younger consumers (18–35 years old) were more likely to pay a high premium price for "natural" wine than the elder ones. The willingness to pay was higher in consumers declaring higher education levels. Lanfranchi et al. applied an ordered probit sample-selection model to evaluate the willingness to pay of Sicilian consumers for sustainable wine [40]. The results showed that women were more likely to pay a surplus for a sustainable wine. Furthermore, the willingness to pay a premium price was positively influenced by age, by how much the consumer spent for traditional wine, and by certifications. Occasional consumers were more likely to pay a higher price than the usual consumers. The knowledge of sustainable production methods increased the premium price that consumers were more likely to pay for sustainable wines.

Vecchio investigated the willingness-to-pay for sustainable wines of young Italian adult wine drinkers [110]. Four wines were submitted to the attention of participants: a conventional wine, a wine with a carbon neutral logo (indicates the reduction of greenhouse gas emission in the supply-chain), a wine including a Libera Terra logo (a label used to commercialise wines produced by a Cooperatives that work on lands confiscated from the criminal organization called Mafia), and a wine with the Wine for Life logo (an initiative of the Community of Sant'Egidio, with producers paying half a euro for each label and the collected money used to combat AIDS in Africa). The author applied the Vickrey fifth-price full bidding auctions and, to analyse the factors affecting willingness-to-pay, the bid functions estimated with Tobit models were compared to the premium functions estimated with ordinary least squares. According to the results, consumers positively evaluated sustainability attributes and the willingness-to-pay for each of the 3 sustainable wines was significantly higher that for the conventional wine. The average premium that young people were willing to pay for a sustainable wine was equal to 23% (Libera Terra), 30% (Carbon-neutral wine), and 57% (Wine for Life) of the average price of the conventional wine, depending on the main feature considered (social, environmental, or solidarity, respectively). Furthermore, female and older participants tend to bid higher for the sustainable wines.

Ginon et al. investigated the way in which Burgundy wine consumers perceived 12 logos available in the French market and indicating environmental sustainability in wine production [111]. Three logos were specific to wine and delivered by French non-public organizations (TerraVitis, Biodyvin, Vignerons en développement durable). Nine logos were nonspecific to wine and, among them, two were delivered by French public organizations (French AB, Haute valeur environnementale), three were delivered by French non-public organizations (AgriConance, L'abeille sentinelle d'environnement, NF Environnement), two were delivered by European public organizations (former European AB, new European AB), and two by European non-public organizations (Demeter, Nature et Progrès). Large differences were observed in how consumers perceived the logos. Biodyvin, the former European AB and the French AB organic logos most successfully conveyed their messages, since they were strongly associated to organic wine. Instead, most logos did not communicate a message related to environmental sustainability. A segmentation analysis on lifestyle aspects of sustainable wine consumption among German people was performed by Klohr et al. [112]. They identified four clusters: "unconcerned non-experts", not interested in wine and sustainability, who buy only cheap wines; "concerned non-experts", interested in environmental concern, but not in wine, who are in the medium-priced mass market and react to sustainability characteristics in their buying decisions; "phlegmatics", with an average interest in wine and in the in the medium-priced mass market, but not interested in sustainability; "sustainable connoisseurs, very interested in wine and showing a sustainable lifestyle, who are interested in products with higher prices if they are of both high quality and sustainable. Producers and retailers of sustainable wines should be focused on the last group, which includes about 29% of German population, to increase the market share of this type of wine.

Abraben et al. examined the price premiums associated with organic production and certification of Tuscan red wines on both the Italian and American markets [113]. The results were very interesting, since they observed that for wines with low quality ratings, the application of organic practices without certification, and the certification without labelling as organic wine exerted a positive effect on price. Instead, as the wine quality rating increases, the positive effects of organic practices and certification on price decreased and, for wine with higher quality ratings, the application of organic practices and the organic certification became a penalty and their prices were lower than those of comparable conventional wines. Sellers evaluated the premium price that Spanish consumers are willing to pay for a sustainable wine with respect to the price of a similar conventional wine [114]. The author found that 77.9% of participants would pay a premium price for a sustainable wine and the average premium price was 12.87%. Furthermore, both willingness to pay (from 87.2% to 61.6%) and average premium price (from 18.72 to 5.08) decreased as consumer knowledge of wine culture increased from to so-called "beginners" to the "experts". The authors also individuated six market segments (Traditional, Urban, Trendy, Routine, Occasional, and Social) and observed that the highest and the lowest percentages of participants available to pay a premium price were found in the Urban and Routine groups while Trendy and Traditional consumers would pay the highest and the lowest premium price, respectively.

A recent survey by Capitello and Sirieix explored the perceptions of consumers from Italy and France (both with a long tradition of wine consumption and production) [115] about product attributes of six categories of sustainable wine (organic, biodynamic, wine with no added sulphites, natural or sustainable-development wine, Fairtrade wine, and carbon-neutral wine), and one conventional wine. French respondents were slightly more able to associate attributes with the proposed wines than the Italian ones, but both groups were able to distinguish the sustainable wines from the conventional wine and wine with no added sulphites from other sustainable wines. Organic wine was evaluated as harmless to the environment, trendy, good for health, and more expensive. Biodynamic wine was considered as more expensive and innovative, but not able to support local production. Wine with no added sulphites was considered as good for health. Natural or sustainable-development wine promoted by producer organisations was considered as respectful of ethical values. Fairtrade wine was considered as able to support local production and respectful of ethical values, while carbon neutral wine was perceived as harmless to the environment and innovative. Conventional wine was evaluated as traditional, with good value for money, pleasurable and fun. These results could be useful for wine producers, marketers, and public institutions by increasing their knowledge on the attributes that consumers associate with different types of sustainable wine and on the way to ensure consistency between attributes of sustainability and consumer perceptions of the product through more effective communication policies.

The so-called millennial generation represents an increasingly important segment of the global wine market. Sogari et al. investigated the role of social media in the consumer purchasing behaviour for wine of Italian millennial and non-millennial generations [116]. According to their results, social media had the power to increase sustainability awareness and influence the consumer's buying behaviour for wine in terms of willingness-to pay. This implies that if wineries would increase their market share, they should increase the communication of their environmental activities through social media. Gallenti et al. performed a choice experiment to investigate Italian millennials (18–34 years) preferences toward "carbon footprint claim" and "winescape aesthetic", respectively, an aesthetic and an environmentally sustainable attribute of wines [117]. According to the findings of this research, the majority of respondents were interested in the carbon footprint claim, and a part of them preferred to pay a premium price for high-quality wines. Winescape aesthetic was not an important attribute in driving respondent choices.

One of the last studies performed on consumer willingness-to-pay for Cabernet sauvignon wine, and how it is affected by two different ecolabels (a sustainable and an organic claims), was performed by Lim and Reed [118]. They found that consumers were willing to pay a premium for both organic wine and sustainably produced wine, but that the willingness-to-pay for organic wine was higher than that of sustainable wines. Furthermore, the willingness-to-pay for the ecolabels was appellation-dependent since it was higher for ecolabels applied to appellations of origins of lesser prestige.

10.3. Consumer Perception of the Quality of Sustainable Wines

According to Annunziata et al. (2016a; 2016b), both U.S. and European consumers of wines would perceive a higher quality level if health warning and nutritional information should be reported on the label [119,120]. On the contrary, Mueller et al. found that the presence of ingredient information on the label had a negative impact on about a third of Australian consumers [121]. The European Regulation on food labelling established the mandatory indication of any ingredient or processing aid causing allergies or intolerances that is used in the manufacture or preparation of a food and is still present in the finished product [122]. These ingredients include substances generally (but not always) used in wine production, i.e., sulphur dioxide and sulphites at concentrations of more than 10 mg/kg or 10 mg/litre in terms of the total SO_2. A generally higher willingness to pay for wines without added sulphites was found within Spanish and Italian consumers and was related to the consumer attitudes towards health [123]. However, the willingness to pay was higher for Italian men and Spanish women and younger people [124]. Opposite to this finding, American consumers showed lower WTP for wines without added sulphites, especially if they were informed about wine sulphites [125].

A curious study was performed by Parr et al. in New Zealand [126]. They investigated a principle of biodynamic philosophy, according to which wines taste different on different days of the lunar cycle. Nineteen wine professionals performed a blind taste of 12 Pinot noir wines from conventional, organic, and biodynamic producers, both in fruit days (days of the biodynamic calendar considered as favourable for wine tasting) and in root days (considered as unfavourable), and evaluated them using 20 descriptors. The results demonstrated that judgments were little influenced by tasting day. Furthermore, the type of wine, namely conventional, organic, or biodynamic, was not a factor in determining the influence of fruit and root days on wine evaluation. Further, the type of wine was not a factor in overall quality ratings of the Pinot noir wines.

11. Conclusions

A great number of sustainable wine types are available on the market as a result of the different regulations (rules on organic wines) and certification schemes (biodynamic, VinNatur, Fairtrade, etc.) in force in the various countries. This heterogeneity makes difficult the recognition of sustainable wines by consumers, however, especially millennials, who demonstrate a greater willingness to pay for wines produced with procedures that respect the environment and the principles of social ethics. This matter is of great importance since, often, sustainable wines are indistinguishable from the corresponding conventional ones from a qualitative point of view. The market of sustainable wines is currently a niche, and will likely remain so, but it is undeniable that the overall percentage of vineyards certified as sustainable is high in countries such as New Zealand and South Africa, and increased in the traditional producer ones.

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