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REVIEW

An overview of the biodynamic wine sector

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Abstract: The wine industry is currently shifting toward more sustainable production practices. Due to the growing globalized wine market and the increasing environmental impacts, producers have begun to pay more attention to organic and biodynamic products. Using a systematic literature review, this review aims to investigate the biodynamic production system in the viticulture and winemaking process. In particular, the review examines, 1) the biodynamic practice and its main characteristics including the certification system; 2) the biodynamic market characteristics and the recent trends, the production costs and the marketing strategies adopted by wineries; 3) the demand attributes and wine consumers' perception on sustainable practices and "green products" such as biodynamic products; and 4) the association between the biodynamic wine chain and the environment. The review highlights the research progress in this field and reflects on the potentiality and needs of the biodynamic viticulture and wine sector. The literature clearly indicates the lack of knowledge regarding, mainly, the biodynamic farming concept and the label. Moreover, while it is clear that consumers are willing to spend more for an organic wine than for a conventional one, there are no data about the willingness to pay for biodynamic wines. Finally, the review concludes with implications and suggestions for further research.

Keywords: biodynamic, viticulture, wine, environment, market analysis, consumer

Introduction

The shift toward sustainable production of the food and wine sector is not a recent event. Sirieix and Remaud[1] stated that since the early 1990s concerns about environmental and sustainable practices and consumption acquired increasing popularity. The reasons for this are many, as follows: the growing public concern over climate change; an even more "green" consumer; the increasing competition on the market and the consequent industries' necessity of differentiation strategy and positive corporate image and reputations.[1–6] The attention toward environmentally friendly practices and green products is increasing in the worldwide consumers' choices (organic- and/or biodynamic-labeled food or showing claims on sustainability or other bio-sounding expressions and characteristics). Environmental values also represent important drivers for winegrowers and industry, because they could represent a credential to offset an environmental impact of wine chain (ie, high food miles or a large carbon footprint caused by long transports).[2,6,7] This is even more important if we consider that viticulture and wine industry have a strong connection with environment and a mutual influence is widely recognized not only in the phase of cultivation but also during the vinification stages.[6,8] A recent survey on consumer's perceptions describes

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the Italian wine market of the future as addressed toward organic-labeled, carbon-free, vegan or other environmentally friendly products.[9] These characteristics appear to be common in the evolution of wine consumption in the Old World countries as on the New World wine markets (ie, the USA, Chile, Australia, New Zealand and South Africa) even if the consumers' sensibility and interests are different.[3,5,7,10]

The biodynamic movement has strong connections with sustainability approach and is sometimes considered as an extreme evolution of organic agriculture. Organic and biodynamic techniques are strictly linked but with an important difference: organic viticulture is regulated by an official set of rules (ie, in EU Council Regulation EC No 834/2007 and EC Reg No 203/2012) while biodynamic regulation is still founded on a "voluntary" basis, without any public intervention. It is worth remembering that for a long period only grapes could be called organic and wine could only be labeled as "derived from organic grapes", and this happened until 2012. The retard on the organic wine regulation probably could be one of the most important reasons for the lack of a biodynamic wine regulation at a global level.[11]

Currently, on the market, the presence of several competing "green" categories with different logos and claims (natural, organic, biodynamic, sustainable wine, etc) has created confusion among the consumers who are not well informed about these product specifications or properties; this fact has increased the consumers' uncertainty and affected their choices.[10]

The aim of this work is to provide an overview of the biodynamic wine sector based on the available literature and recent data. The analysis of the materials is performed according to the following steps: first the biodynamic movement is explained in its main characteristics, and the certification system is included. A market analysis of the supply side dimensions and behavior and about the demand attributes (a large part of the surveyed literature is focused on the biodynamic wine consumers) represents the main part of the work together with a review on the association between biodynamic wine chain and some environmental issues. Finally, some short considerations about the potentiality and needs of the biodynamic wine sector are made.

It should be noted that the literature about biodynamic viticulture and winemaking is not abundant; often biodynamic is considered as a branch of sustainable approach to agriculture, and the literature mainly focuses on organic or green practices (including biodynamic but not specifically on it). To gain an idea about the available bibliography on biodynamic winegrowing, a concise keyword-based research has been performed in two academic search engines in April 2016 (Scopus and Web of Science™). The results have been quite a disappointment in terms of completeness and variety; three keyword-based searches, with "biodynamic viticulture"/"biodynamic vine"/"biodynamic wine", showed that Scopus produced the largest number of records overall (43 totally, 23 only for "biodynamic wine") and Web of Science had 28 total records (seven records for "biodynamic viticulture", 14 in Scopus). Scopus classification of these documents by subject area is interesting because it shows that beyond agriculture, biodynamic viticulture and wine represent fields of work for several different disciplines such as engineering, business and management, chemistry, medicine, arts and humanities (Figures 1 and 2).

The biodynamic viticulture and wine production: definition and regulations

> The concept behind biodynamic is that everything in the universe is interconnected and gives off a resonance or "vibe". […] Biodynamic viticulture is the practice of balancing this resonance between vine, man, earth and stars. Essentially, biodynamics is a holistic view of agriculture. (Interview with M Benziger – Benziger Family Winery is one of the most representative US wineries with organic and biodynamic certification).[12]

Biodynamic agriculture is founded on the anthroposophy theory, which states that the human being is in the middle between the earth and cosmos rhythms, bridging a gap between spiritual and material world. Soil, man, plants and all the natural and cosmic elements take part in a holistic view typical of biodynamic agriculture. Growers embrace this philosophical approach and it guides them in daily agricultural practices. Considering this vision of agriculture and the role of biodynamic farmer in the universe, it is clear why biodynamic discipline sometimes appears more as a belief than as a cultivation technique.[13–15]

The biodynamic movement was funded in 1924 by R. Steiner (the term "biodynamic" was invented by him followers[16]), who was the father of anthroposophy and pioneer of a holistic vision. In 1924, Steiner[17] conducted eight lectures (in Koberwitz, Poland, June 1924) explaining the concepts of biodynamic agriculture as an answer to the increasing development of chemicals in agriculture.

Biodynamic agriculture is considered not only an economic activity but also a cultural and creative action, and the farmer should play a role in all these areas. The farm must become a self-sustaining organism, ie, a closed system producing all the necessary stuffs for vineyards, winery and the life of the farmer–winemaker.[16]

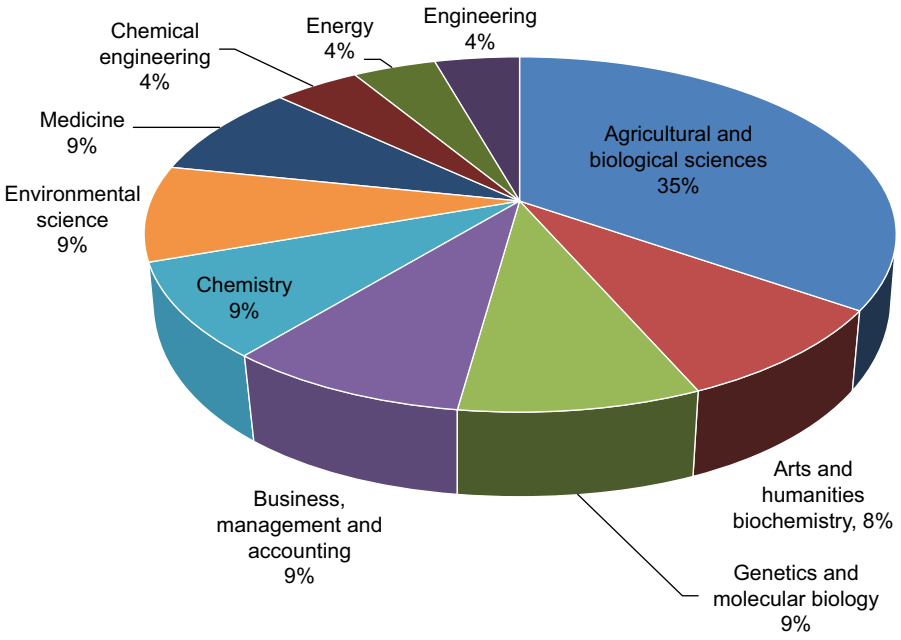

Figure 1 Scopus results by subject area: keyword "biodynamic viticulture" (July 2016; %).

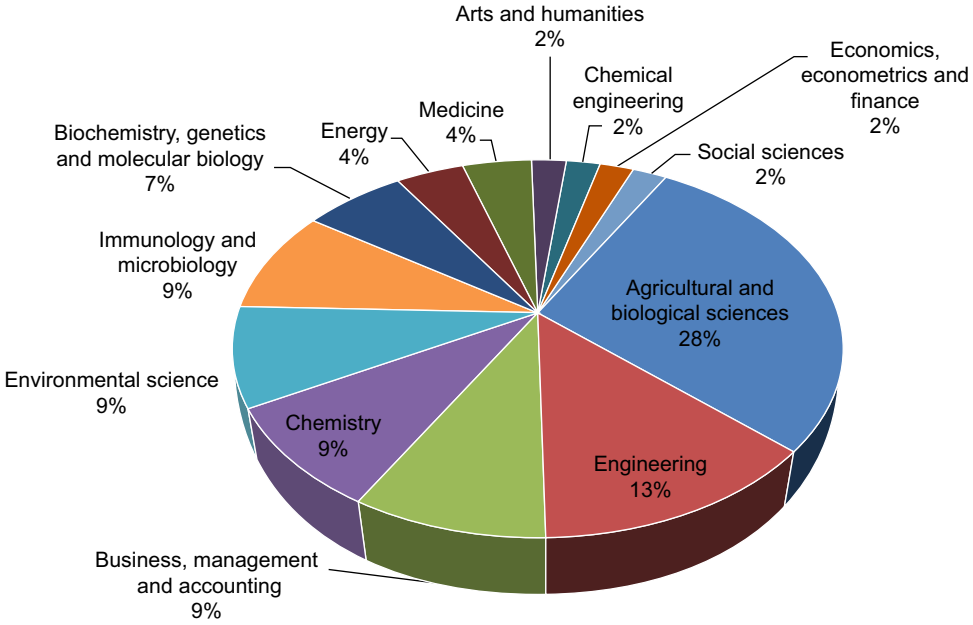

Figure 2 Scopus results by subject area: keyword "biodynamic wine" (July 2016; %).

Special natural preparations (the so-called Steiner preparations, currently well-known as biodynamic preparations) are available for growers because synthetic substances are not admitted; they must be distributed in keeping with the rhythms of the nature. Moreover planting, harvesting and all the operations are regulated by a special calendar (based on lunar and planets cycles).

"Biodynamics occurs primarily in the vineyard before winemaking even happens";[12] after this, the biodynamic wine is considered nearly a human being; it preserves in itself the power of the original grape and the wine passes down this energy to the consumer (Demeter-International, 2016).[18]

Regulatory issues and certification for biodynamic viticulture and wine

There are no official rules or regulations for the biodynamic sector, and EEC Reg 834/2007, 889/2008 and 203/2012 about organic agriculture are the only current legal requirements because being organic is a minimum step to be biodynamic.

So biodynamic wines have a double certification: one declares that they are organic and it is released by independent monitoring bodies and the second (biodynamic) could be guaranteed by Demeter.

Since 1927, Demeter is the most important association in biodynamic agriculture and it is the only official certifier of these products at the international level. Demeter-International provides a set of standards for production and processing in agriculture for the use of Demeter, Biodynamic® and related trademarks and for labeling.[19–21] In 2008, Demeter approved the first standards for biodynamic winemaking, but their impact has been assessed only after the publication of EEC Reg 203/2012 on organic wine. Standards are subject to continuous improvement; practitioners are required to research and try to improve continually the processes in vineyard and in cellar.

Demeter has built up a network of individual certification organizations worldwide, which includes 18 members and five guest members from Europe, America, Africa and New Zealand. Each Demeter National Association adopts the "Mother-House" International Standards and must adapt them to its current situation; each association is responsible for Demeter certification in its own country. The International Certification Office of Demeter-International is responsible for the certification of products and enterprises in countries that do not have an independent Demeter certifying organization.

Demeter can certify different types of products as biodynamic; there are no limits of category. In a farm, every production can be certified usually within a biodynamic farm, which must live as a "self-contained entity", and there are several different raw materials and products.[16]

Only those vineyards and wineries that comply with Demeter standards are permitted to use the Demeter certification logos; they are certified as Demeter®/Biodynamic® "made from biodynamic grapes" or Demeter®/Biodynamic® "biodynamic wine" as wine production is concerned. Demeter claims that

> Ideally, Demeter/Biodynamic® wine helps the development of nature and man, speaking to the senses and speaking to the mind. Demeter/Biodynamic® winegrowing is not a means to an end. Its purpose is to enrich the world and to celebrate the beauty of landscape and life.

The second certification is more binding than the first because it provides that during vinification stages any kind of additive (tannins, sugar, yeasts, etc) should be avoided (i.e. sulphur dioxide is to be used to the minimum) and physical methods are preferable to chemical methods (flavoring from oak chips, osmosis, etc).

Worldwide biodynamic wine market: size and characteristics

There is a relationship between organic and biodynamic growing; most of the producers that use biodynamic practices are also organically certified. For this reason, it is interesting to begin with a brief overview related to the organic market. Over the past decades, the organic market has continued to grow.[22] According to Forschungsinstitut für biologischen Landbau (FiBL; or Research Institute of Organic Agriculture) data, in 2014, 43.7 million hectares of agricultural land were managed organically with approximately 2.3 million farmers. In the same year, the global sales of organic food and drink reached 80 billion US dollars.[23] The regions with the largest organic areas are Oceania (17.3 million hectares, 40% of the global organic farmland), Europe (11.6 million hectares, 27% of the global organic farmland) and Latin America (6.8 million hectares, 15%).[23] Globally, the organic vineyards represent 4.5% of the total organic surface; at the EU level, this percentage grows up to 7.8%.[23] The countries with the largest surfaces are Spain (84,381 hectares), Italy (72,361 hectares) and France (66,211 hectares), which during the period 2003–2014 registered a significant increase, respectively, of +413%, +128% and +307%. In France, wine constitutes an important part of the organic market, ie, more than 10%.[24]

In addition, biodynamic techniques are steadily increasing in most countries, as shown in Figure 3.

The number of farms has grown from 2,785 in 1997 to almost 5,000 in 2016 and the surface, during the same period, from 87,000 to 164,000 hectares.

As regards grapes for wine, biodynamic production is represented worldwide by 639 farms certified as Biodynamic® with the largest number in France (~300) and Italy (>70). The vineyards are ~11,000 hectares; France with 4,700 hectares is the country where biodynamic viticulture is mostly spread. Four countries register more than 1,000 hectares; two are traditional wine producers (Italy and Spain) and the others belong to the "New World" (USA and Chile).

The average surface of a biodynamic farm with grapes (for wine) varies from 4 to 30 hectares depending on the country (Table 1). According to Meissner,[25] currently, biodynamic wineries have varied sizes, ranging from small winemakers that give the grapes in the consortium to small and medium businesses and to get to big companies with hundreds of hectares.

Organic wine is a growing business but relatively small if compared with the wine industry in general; the biodynamic market is much smaller than the organic one and most wineries are small-scale, family-oriented businesses.[26,27] In addition, Castellini et al,[8] indicate a smaller size for Italian biodynamic wineries (<3 hectares) compared to the average

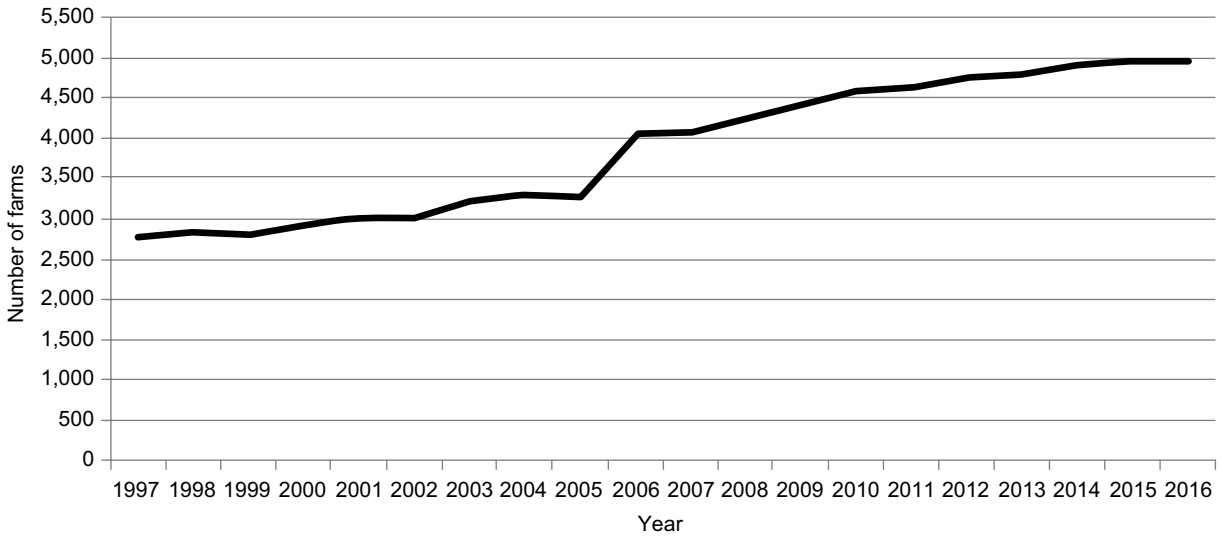

Figure 3 Worldwide trend of Demeter-certified farms (number of farms).
Note: Data courtesy of Demeter-International data.

size of the sample surveyed in that study (10.4 hectares), which also includes organic wineries. Hence, the biodynamic wine segment can be considered as a niche within a niche;[28] producing wine in a niche is a widely diffused strategic behavior among small wineries.[29]

Moreover, the producers consider biodynamic wine more balanced and complex, providing increased aromas and authenticity.[30] In some cases, wineries choose green orientation as a strategic lever for achieving product differentiation and to be more competitive on the market.[26,30,31]

Biodynamic food and wine consumption are becoming more popular among consumers, and consumption level has increased throughout the world. Organic/biodynamic wine consumption has increased in both production countries (such as Italy, France and Spain) and large importers (Northern Europe, Japan and the USA).[32,33] It is important to underline that given the prejudice of bio-food consumers against alcohol and wine (considered unhealthy products), the most interesting targets for organic/biodynamic wine are "ordinary" consumers.[32,33]

Production costs of biodynamic grapes and wine

The production costs include both the cost of vineyard operations and those of vinification. The economic amounts are difficult to assess because they depend on different variables including, for example, the size of vineyard, planting density, climatic conditions and consequently the grape and wine quality.[34] Costs may differ from conventional or organic viticulture mainly because of the nutrition, weed and pest and disease management of the cultivation.

The vineyard cost includes operations, harvest and any assessment and/or certification fees. According to Delmas et al,[35] the cost of growing organic wine grapes is from 10% to 15%, which is higher than that for conventional grapes, and the cost of growing biodynamic grapes increases again by 10–15% compared to that of the organic product.

Table 1 Demeter-certified vineyards worldwide

Country	Number of farms with grapes for wine*	Area (hectares) with grapes for wine	Average hectares/farm
Certified by DI members			
Austria	34	348	10.2
Belgium	1		
Brazil	1	19	
France	286	4,706	16.5
Germany	54	218	4
Italy	74	1,303	17.6
The Netherlands	2	1	0.5
New Zealand	8	241	30.1
Slovenia	9	69	7.7
Spain	33	1,014	30.7
Switzerland	37	215	5.8
UK	6	35	5.8
USA	58	1,314	22.7
Certified by DI (ICO)			
Argentina	9	312	34.7
Chile	17	1,224	72
Czech Republic	1	53	
Greece	1	5	
Hungary	3	11	3.7
Mexico	1	4	
Portugal	1	3	
South Africa	3	93	31
Total	639	11,188	

Notes: *Demeter certification and "in conversion" certification. Data courtesy of Demeter-International data. Statistics of biodynamic winegrowers worldwide. Not all farms included here are certified as biodynamic. Some of them are in conversion.
Abbreviations: DI, Demeter International; ICO, International Certification Office.

The cost of winemaking includes the costs of oak barrels, storage, bottling, labeling, marketing, sales and overheads. It is estimated that the overall cost of winemaking is similar for conventional, organic and biodynamic wines.[35]

Santiago and Johnston[34] confirm this result with a survey designed and conducted in Australia during the 2009–2010 growing season. In that study, operational costs were divided into vine practices (that are more expensive than conventional) and canopy management (in this case, the costs were reduced). Only the costs that were potentially different between the two systems were considered and it was assumed that other operational costs (ie, for harvesting or pruning) were similar within the same grape quality range. The average total increase in operational costs between conventional and biodynamic vineyards was 11%.

In addition, biodynamic agriculture is more labor intensive than conventional farming methods, because it requires more attention to detail.[36] Many winemakers claim that biodynamics increased their workload by ~30% compared to conventional viticulture, mainly due to planning, organizing and preparing precisely calibrated natural treatments for their vineyards.[26,37]

It is important to highlight that the biodynamic farming system is associated with a lower yield per acre (of 20–30%) if compared to conventional technique.[26,34]

In conclusion, producing a bottle of biodynamic wine costs at least 50% more, but the sale price of the bottle is not much more expensive.[37]

The biodynamic certification is a multiple-step process including application and inspection; it must be renewed every year, and it represents a yearly additional cost for a biodynamic winery. It is based on a surface unit (ie, acre or hectare) and includes soil tests for traces of chemicals, checking the vineyards' health status and recording the application of compost and preparations. The certification cost includes also the royalty for the trademark, a membership fee and the cost of the inspectors. For these reasons (cost and length of the procedure), some biodynamic farms and wineries follow biodynamic rules but without certification.[38] Often small farms prefer to certify grapes or wine only as organic, because in many cases for biodynamic there is no premium price on the market with respect to other green wines (low awareness of the consumers about the different typologies on eco-friendly labeled products).[11]

Distribution strategies

The role played by the different channels in the distribution of "bio"-agricultural products differs across countries. Considering Europe, in northern countries, Switzerland and the UK, modern retailers distribute most of the products (with shares ranging from 75% in the UK and Switzerland to 90% in Sweden), whereas in Mediterranean countries, traditional distribution channels have maintained an important role.[11]

Considering nonconventional wine, an important channel is represented by direct sale. Many Italian wineries prefer this kind of distribution, particularly during the start-up phase, to keep selling costs low. Furthermore, it is a suitable channel when there are low production volumes.[8,11] In addition, the research conducted by McCullough et al[38] in California found that a majority of biodynamic producers (55%) sold wines in their own tasting rooms.

According to Castellini et al,[8] in Italy, the most used sale channels (33% wineries of the sample) are represented by wholesalers and traders. Other channels are represented by wineshops/bars and Hotellerie-Restaurant-Cafè (Ho.re.ca.; Ca. could mean cafè or catering).[8,28,38] Finally, small winegrowers prefer to sell their products through traditional retailers, while large-scale wineries prefer foreign or domestic supermarket chains or direct selling to final consumers.[39]

Consumer preferences and perception toward biodynamic wine

Although much has been written about sustainable wine consumption in the past few decades, obtaining reliable information on consumer attitudes and preferences for biodynamic wine can be an arduous task, as they have not been yet truly investigated.[31,40–47]

While some studies analyzed consumers' preferences toward environmentally friendly wine products, considering carbon neutral, organic and further eco-friendly claims, only a few of them describe in detail consumers' preferences toward biodynamic wine.[2,7,48–54] Furthermore, although results from a number of studies reveal that most consumers are willing to pay a higher price for sustainable wines and a few estimated that environmentally friendly ones receive a very limited premium compared to conventional wines, to our best knowledge none describe the willingness to pay for biodynamic wines.[5,26,55–59]

Concern over definition and communication

Consumers are often unable to make informed purchase decisions when choosing among sustainable and conventional food, because the benefits associated with sustainable products are poorly communicated to them and because they have limited knowledge of sustainable agricultural production practices.[31,52,60] In addition, it could be difficult for producers to communicate complicated farming practices to consumers.[61] These problems seem to be particularly hard to solve for

biodynamic products in general and increase when dealing with biodynamic wines.[62]

First of all, an aspect that could create confusion among consumers seems to be the definition. Several authors pointed out that the definition of organic wine is not consistent globally, and related terms such as biodynamic and sustainable can be very confusing to the consumer.[51,63,64] In addition, they explained that the exact criteria for what is needed to use different terms are usually not explained on the label and it is questionable whether most consumers would appreciate the small differences that distinguish one level from another.[51] Moreover, Szolnoki et al,[65] by analyzing 55 interviews, showed that there is no common definition for sustainability in the wine industry and that organic/biodynamic is very often mixed up with sustainable farming.

Skepticism of labels and familiarity

In the wine industry, there are a number of different eco-labels related to organic and biodynamic certification that are only partially recognized and understood by consumers.[36,66,67] Delmas and Grant[36] stated that a lack of knowledge about the various eco-labels (organic, made from organically grown grapes, and biodynamic) might diminish their signaling power. Moreover, currently, consumer awareness of sustainable winegrowing and winemaking is low and products and processes are confused with vague terms such as "green". For example, Borra et al[68] pointed out that on the one hand the sustainability of wines has a great appeal to Italian consumers, and on the other hand they do not seem to know the implications of the application of this concept to winegrowing and winemaking techniques. Ginon et al[69] investigated how Burgundy wine consumers perceive a series of logos indicating environmental sustainability in wine production. They also considered the biodynamic wine production logo, which was associated with the category "organic wine". Their findings suggested that consumers were not aware of the difference between environmentally sustainable practices; in fact, the biodynamic wine logo was not linked to the idea of reduced use of chemical products, additives or pesticides for the participants of this study. McCullough et al[38] explored consumer knowledge and behavior of the millennial generation in California toward eco-labeled wines. They showed that millennials were a generally uninformed generation of consumers regarding eco-label wines and particularly about the practices associated with biodynamic products. Their results indicated that young consumers who were unfamiliar with biodynamic wines had a negative perception about their quality. A survey conducted at the University of California in 2006 provides insights into wine consumers' familiarity with organic and biodynamic wines.[35] A small percentage of 400 respondents (17%) were familiar with "wine from biodynamically grown grapes" and only 8% had tasted biodynamic wines. Among the respondents who were familiar with organic wine, the vast majority (76%) had not heard of a biodynamic product. In addition, a survey carried out in Italy among 214 consumers has shown that 73% were not familiar with biodynamic wines, and that 17% were irregular consumers of them.[70] In addition, by interviewing 203 people, Borra et al[68] found that 11% bought wines according to biodynamic parameters.

Furthermore, consumers' perceptions of organic and biodynamic wines were assessed through an online survey by Delmas.[71] Results showed that not only exposure to information mattered to improve the perception of biodynamic wines, but the content of that information also mattered. Consumers with knowledge of organic wines tended to have a more positive attitude toward biodynamic wine, while the reverse was not true.

Kelley et al[72] found in examining the factors on wine bottle back labels, representative of those found in the US market, the changes to wine bottle characteristics and the standard wine composition that appealed to consumers and could affect their purchasing decision, that only a minority of respondents were more likely to increase purchases if the wine was marketed as being "made with biodynamic grapes", "biodynamic wine" or "Demeter-certified wine", while changes that may invoke a positive response were decreased calorie content, wine made from "sustainably farmed" or "naturally farmed" grapes and producing United States Department of Agriculture (USDA)-certified organic wine.

Sirieix and Remaud[1] conducted an online survey, of 151 people living in Adelaide (Australia), about the perceptions of a number of eco-friendly claims (ie, organic, preservative free and biodynamic) compared to conventional wines. Their findings showed that biodynamic wines were associated with daily consumption, and then they were considered, to a lower extent, good to give as a gift, innovative, need education to appreciate and more expensive. To counterbalance the perception that only these wines have a genuine taste, they suggested trying to incorporate terms such as trendy and distinctive taste in the communication strategy of specific wines, such as the biodynamic ones.

Perception of quality and sensory evaluation

A number of studies explored the perception of quality and perceived differences between organic and biodynamic wines. For example, Parpinello et al[73] found that panelists highlighted

differences in color intensity between organic and biodynamic wines, although no preference was found by consumers. With a sensory evaluation work, Ross et al[74] indicated perceptible sensory differences between the 2003 and 2004 biodynamically and organically grown wines produced from Merlot grapes. McCullough et al[38] stated that an overwhelming majority of consumers in their sample who had tasted organic and biodynamic wines indicated a very positive experience with both wines. Delmas and Grant[26] reported results from the survey conducted at the University of California (Santa Barbara) and stated that they varied greatly according to the familiarity of the respondents with wines. Among the respondents, a few who had tasted biodynamic wine had a positive to very positive perception of the quality of the wine. But the majority of respondents expressed confusion, unjustified skepticism or an incorrect perception of biodynamic wine. Moreover, the majority of respondents who were not familiar with biodynamic wine associated the term with "genetically modified organisms" or bioengineered products.

As a result of this lack of awareness of consumers, Gabzdylova et al[6] stated that customers' demand is not one of the most important drivers behind the adoption of sustainable practices by wineries.

Health aspects of biodynamic wine

The association between wine and human health derives mainly from the presence of tannins and phenolics in the beverage; in fact, these substances appear to play a role as antioxidants and cancer preventive agents. Few articles have surveyed this issue, and in particular the number of those studying biodynamic viticulture and wine (and their influence on health) is even more reduced.[36] Reeve et al[75] stated that the biodynamic method affects the vineyards increasing the grape sugar and phenol content in comparison to the organic system.[36] Therefore, biodynamic wines may also have higher concentration of tannins and polyphenolics, and consequently it could be possible to hypothesize a positive effect on human health.

Environmental concerns in the biodynamic wine sector

The wine industry can affect the environment not only through the activity of grape cultivation but also during the processing stage. In the field phase, soil erosion, pollution from fertilizers and pesticides and water use (and waste) represent the main negative impacts, whereas water use and waste (ie, from fermentation tank cleaning, barrels and the bottling line) and energy consumption are the principal environmental concerns of the processing activity in the cellar.[35]

In a comparative study among conventional, organic, biodynamic and sustainable wineries, Szolnoki[76] found that from a management point of view biodynamic units emphasize the importance of the environment, whereas conventional wineries are more focused on the value chain optimization.

Some years ago, Biodynamic Agriculture Australia Ltd. (in the project "Farmers are the solution"; Biodynamics, 2016) supported the idea that the use of the biodynamic method generally addresses to a better environmental sustainability of the activity: less water used for agriculture, an increase in humus production with an improved soil texture.[11] In addition, biodynamic activity also improves the relationship between the natural factors and the farmer and positively affects the life cycle. According to Reeve et al,[75] the biodynamic preparations can improve the vegetative–reproductive balance of plants, increasing sugar and total polyphenol and anthocyanin concentrations of grapes.

The evaluation of the biodynamic environmental effects is often studied by comparing them with conventional and/or organic techniques. Both biodynamic and organic systems pay attention to sustainability in vineyards and in the winery, respecting nature, and they both try to reduce as much as possible the use of chemical elements, but there are also important differences. First of all, no industrial elements but only specific natural preparations can be used in biodynamics (the preparations admitted are made with natural ingredients, directly by the farmer himself or together with a biodynamic advisor. Special natural preparations are available for growers because synthetic substances are not admitted; they must be distributed in keeping with the rhythms of the nature. Moreover planting, harvesting and all the operations are regulated by a special calendar (based on lunar and planets cycles). The preparations must be sprayed on the field [dynamized water] or spread on the land), while the organic method permits specific active ingredients according to the situation; the timing of their applications is also different. Specifically, they are the horn silica preparation, horn manure preparation and compost preparations. This is required at least once a year at an appropriate time, and plant growth stage, before the first "in conversion to Demeter" certification can be issued. Demeter-certified farms are also strongly encouraged to use a composite preparation on those areas receiving no prepared compost in a particular year (Demeter-International) can be used in biodynamics, while the organic method permits specific active ingredients according to the situation; the timing of their applications is also different. Vastola and Tanyeri-Abur[11] believe in many cases organic winegrowers naturally evolve towards biodynamic agriculture following their organic belief.

The use of compost and biodynamic preparations can nourish the soil, activating its food web, which generates humus, and it could improve plant resilience against water stress because the water holding capacity of soils is increased. These effects must be studied in depth, and they depend largely on the crops.[3,77]

A lower environmental impact of biodynamic viticulture compared to the conventional system is also linked to the preference for manual labor over mechanical labor, the reduced use of lubricants and diesel with respect to the conventional.[3]

In the study by Colman and Päster,[78] biodynamic wine has been compared to conventional and sustainable wines in terms of environmental impact of their transport to Chicago (US). Results are interesting: total carbon emission of biodynamic wine from France (specifically from Couleé de Serrant, the winery of Nicolas Joly, a French winegrower leader of biodynamic winegrowing) is equal to 2.12 kg and it is the lowest value when compared with a US top brand conventional product and with a sustainable wine made in California; however, they appear to be influenced by the typology of means of transport more than by the agriculture system.[78]

Conclusion

Biodynamic viticulture took origin in the past and today it could represent a sort of primitive agriculture. Hence, it is difficult to foresee the future of biodynamic winemaking and know what direction it will take. Probably, biodynamic agriculture will not reach widespread level of development but it will continue for a long time acting as a pressure force on the agrifood system.[16]

Some final remarks are as follows:

- Institutional programs and political measures can play an important role in enhancing the adoption of green practices as biodynamic certification among winegrowers. More research and studies about this technique may stimulate and support the governmental actions. A stronger request for a public regulation of biodynamic vitiviniculture is necessary to give an official recognition and position to this sector.
- Biodynamic winegrowers' movement should be better organized making it able to highlight proposals, communication and knowledge dissemination about the product. On the wine market, biodynamic official brands (certified by independent bodies and transparent criteria) are weakened by competition with other biodynamic brands only guaranteed by the producer themselves producer.[10,36]
- It is worth pointing out the necessity for biodynamic winemakers to better communicate their standards and characteristics in comparison to the other bio-sounding labels and claims. Many authors underline the impact on individuals' perceptions of well-designed labeling practices and a clear certification logo.[1,11] A collective communication about their distinctiveness could represent a good approach to consumers.[1] Moreover, Szolnoki[76] says that it is essential to achieve a clear differentiation between sustainable and biodynamic (or organic) wines to facilitate the communication to the consumers and increase their knowledge about the product.
- Consumers' pressure has created a market for wines inspired by environmental issues, such as biodynamic wines.[2] In addition, sustainability has developed into a priority in the wine supply chain, which is very likely to become a major competitive advantage in the international arena, and biodynamic production could be seen as a strategy to diversify production.[2,8,31,79] Nevertheless, the reasons behind consumers' attitudes, intention to purchase, and willingness to pay for sustainable and in particular biodynamic wines remain largely unexplored. Attempts to determine consumer perceptions of biodynamic wine have returned results that indicate lack of knowledge regarding mainly the biodynamic farming concept and the label. Moreover there are no data about willingness to pay for biodynamic wines.
- Research on customer awareness of biodynamic wines is valuable information for addressing some of these issues and for the purposes of forecasting future trends.
- As far as the environmental impact of biodynamic viticulture is concerned, Villanueva-Rey et al[3] conclude that biodynamic viticulture seems to be an attractive alternative in terms of environmental sustainability and organoleptic characteristics of the wine, although the consequences on production (low yields in comparison with an increasing demand) are not clear, and the debate on the positive effects of biodynamic farming on crops is currently open.

Disclosure

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