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Environmental analysis of *Ribeiro* wine from a timeline perspective: Harvest year matters when reporting environmental impacts

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ABSTRACT

A series of Galician (NW Spain) wines, such as *Rías Baixas* and *Ribeiro* have acquired international renown in the past few years. In this particular study, viticulture, vinification and bottling and packaging in a winery of the *Ribeiro* appellation were studied from a life cycle assessment perspective, with the main objective of identifying the largest environmental impacts for four different years of production (2007–2010). The selected functional unit was a 750 mL bottle of *Ribeiro* white wine, packaged for distribution. Inventory data was gathered mainly through direct communication using questionnaires. Results showed considerable annual variability in environmental performance, stressing the importance of including timeline analysis in the wine sector. Therefore, environmental scaling was proposed for the assessed wine based on the individual environmental impacts for each harvest year. Furthermore, the main hot spots identified were compost and pesticide production and emissions, in the agricultural phase and bottle production and electricity consumption, in the subsequent stages of wine production, in most of the selected impact categories. Suggested improvement opportunities included shifts in the compost transportation policy, recovery of natural resources for vineyard infrastructure, the introduction of new packaging formats in the bottling process and the use of pesticides with lower toxicity potential.

1. Introduction

Wine production has historically been an important economic and social sector in Europe. In fact, three European countries (France, Italy and Spain) are still the main world producers. Not surprisingly, despite a steady decrease since the 1980s due to the proliferation of the vinification industry in Asia and Oceania, Europe still accounted for 67.8% of the world's production in 2009 (OIV, 2010). Spain is currently the country with the highest surface area dedicated to wine production, approximately 2% of its territory. This translates into roughly 10,000 km^2 of surface area that produced around 35 million hectolitres (hl) in 2009 (INE, 2011). Hence, Spanish wine production, as in most Mediterranean countries, is a key subsector within the agricultural sector. Most vine-growing regions in Spain are situated either along the Mediterranean coast or on the Castilian plateau. Nevertheless, Galicia, a wet Atlantic region in NW Spain, which only accounts for 2% of the total land used for grape cultivation in Spain, has acquired international renown in recent years thanks to the quality of some of its wines (Decanter, 2011), such as *Rías Baixas*, *Riberia Sacra* or *Ribeiro* (Fig. 1).

Current quality standards for wine production are based on a series of indicators that comprise a wide range of dimensions, some of which are difficult to measure or report, making their definition complex (Charters and Pettigrew, 2007). Nonetheless, there have been attempts to construct and assess the different components of wine quality (Botonaki and Tsakiridou, 2004; Jover et al., 2004). Jover et al. (2004), for instance, divided red wine quality into 15 different dimensions, which affect both the expected and experienced quality of the wine, grouping them in two separate blocks: seven intrinsic factors, relating to the physical characteristics of the wine, such as age, colour, aroma or harvest; and eight extrinsic factors, linked to other characteristics, such as reputation, appellation, region or advertising and propaganda.

Interestingly, to date, wine quality publications have not considered environmental aspects. However, the fact that consumers are increasingly aware of environmental issues, such as global warming, has led a growing number of stakeholders in the wine sector to analyze and communicate their environmental performance to gain market access and competitiveness (Garnett, 2008; Iribarren et al., 2010). Hence, environmental sustainability has developed into a priority in the wine supply chain (Forbes et al., 2009; Gabzdylova et al., 2009). In this context, the use of life cycle assessment (LCA), a standardized methodology used for estimating the environmental burdens linked to the life cycle of products or

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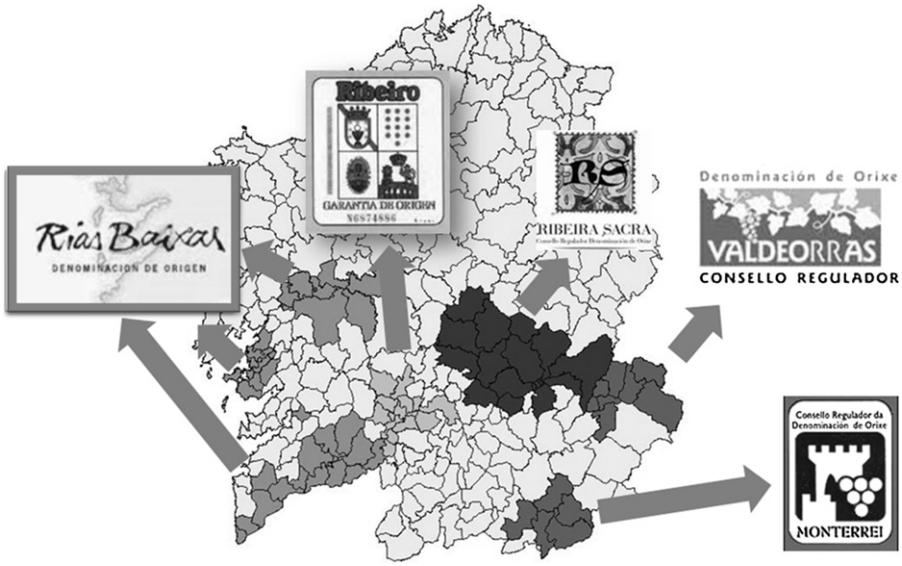

Fig. 1. Location of the main appellations in Galicia (NW Spain).

processes (ISO, 2006a,b), has proved to be an effective mechanism to report environmental performance in the food and beverage sector in general (Andersson, 2000; Cerutti et al., 2011; Cordella et al., 2008), as well as more specifically in the viticulture and vinification sector (Petti et al., 2010).

Consequently, the past decade has experienced a strong proliferation of wine-related LCA studies. Most case studies available in the bibliography relate to specific appellations in nations with a strong viticulture tradition, such as Italy (Notarnicola et al., 2003; Pizzigallo et al., 2008), Spain (Aranda et al., 2005; Gazulla et al., 2010), France (Renaud et al., 2010), and other highly developed nations with incipient wine production sectors, such as Canada (Point, 2008), Australia (SAWIA, 2004) or Chile (Cárdenas-Rodríguez, 2008).

This bibliographic proliferation has definitely helped to picture the environmental profile of the wine sector, identifying the main hot spots throughout the process and suggesting the specific impact categories that are of special relevance. On the contrary, this phenomenon has also revealed the major limitations of applying LCA methodology to this agricultural sector. These limitations have been found to be mainly due to the lack of: i) specific data relating to characterization factors for pesticides and fertilizers used in the viticulture stage; ii) inventory availability when assessing certain stages of viticulture, such as vine planting (Benedetto, 2010; Bosco et al., 2011) or delimiting the temporal boundaries of the study (Ramos et al., 2011); iii) an integrated and broad selection of impact categories, including those that are potentially more suitable for wine LCA analysis (Petti et al., 2010) and iv) a unified criterion on how to include recovery and recycling processes (Jim and Kelly, 2009; Petti et al., 2010).

Hence, the main objective of this article is to perform the environmental assessment of a winery of one of Galicia's most renowned appellations (*Ribeiro*) to (i) evaluate the main hot spots and improvement opportunities within the system; (ii) approach some of the above-mentioned limitations that previous wine LCA studies have identified, such as toxicity impact factors for pesticide emissions through the use of USEtox or temporal inventory availability to analyze harvest environmental performance variations; and (iii) propose an environmental scaling based on LCA results to identify differences in the environmental profile per harvest year.

2. Materials and methods

2.1. Goal and scope definition

As mentioned above, the aim of this LCA study is to assess the environmental burdens related to wine production in the *Ribeiro* appellation. Therefore, inventory data were collected for four different years of production (2007–2010), to identify potential variance in the environmental performance between years.

The functional unit (FU) in an LCA study measures the function of the analyzed production system, providing a reference to which the inputs/outputs are linked to (ISO, 2006b). The selected FU was a 750 mL bottle of *Ribeiro* white wine,[1] which is in accordance with prior wine industry LCA studies that consider a standard amount of wine; usually the content of a regular bottle (Petti et al., 2010). Given that this study also comprises the agricultural stage of wine production, it is important to mention that the selected FU corresponds to 1.1 kg of harvested grape.

2.2. System boundaries

The production system studied embraced the different activities considered in the agricultural phase of wine production, including fertilization, field operations or soil management, (Fig. 2). Vineyard infrastructure and machinery for field operations were also included within the system boundaries. Therefore, the product was traced from the production of supply materials, such as diesel, pesticides or fertilizers, up to the delivery of the grapes at the gate of the winery in late summer after harvesting. Moreover, grape processing in the winery, including all the phases of its production, together with bottling and packaging were also included. Hence, the product was followed up to packaging ready for distribution to wholesalers, constituting a "cradle to gate" analysis (Guinée et al., 2001).

[1] The wine produced by the studied winery is a mixture of a total of seven grape varieties. Approximately 80% of the mixture corresponds to *Treixadura*, while the remaining 20% is a mixture of *Albariño*, *Albillo*, *Galician Torrontés*, *Godello*, *Lado* and *Loureira*.