The surplus production in the wine sector: environmental costs analyzed by LCA, the case of an Italian winery

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Abstract

In order to reduce the risk of surplus wine production and its consequently environmental damages, this research tests the integration between the grape and others rural productions in the creation of a fruit juices to enlarge grape use and promote new market opportunity for wine sector. The idea is to move from the present linear model of this sector, in which grapes are grown only for wine production, to a more complex one, in which grapes are grown for other uses too, in order to obtain a better exploitation of raw materials, contrasting waste production, like nature does in the ecosystem, where there is no concept of waste. To evaluate the hypothesized improvement of the environmental performance achieved by the complex model compared with the linear one, an LCA analysis was conducted on both.

1. Introduction

The Declaration of the World Summit on Food Security, held at the FAO "Natural Resources Management and Environment Department" in 2009 in Rome, stresses the urgent need for the implementation, in agriculture, of "sustainable practices, improved resource use, protection of the environment, conservation of the natural resource base and enhanced use of ecosystem services" (FAO, 2009). In order to assess these impacts, several research were developed into practical tools such as, among others, the ecological footprint, the water footprint and the carbon footprint (Kastner et al., 2011). Also wine sector deals with the environment. As reported by Christ and Burritt (2013), in their review on environmental burdens of the wine production sector, this industry influences the physical environment and, due to its economic and cultural importance in many regions of the world, it is vital to invest in scientific research to minimize its negative environmental impacts. Furthermore, many producers see in this topic an opportunity to increase their sales, especially in a context which is largely influenced by the reduction in wine sales due to the world economic crisis (Villanueva-Rey et al., 2014).

For all these reasons, the whole wine sector should incorporate eco-efficiency and eco-innovation to become more environmentally sustainable while ensuring its competitiveness and economic profitability. This can be fostered by adopting new production models in which there is a better and a more complete use of resources produced in order to avoid unsold commodities or waste production. In fact, it should be noted that the wine industry, generally, is undergoing a chronic surplus of production estimated at approximately 30 MhL which depreciates prices (Ramos et al., 2012) and this global wine-grape surplus is entering its eighth year (Aylward, 2012).

The wine sector is going through deep changes also for the appearance, since the late 1980s, on the global market, of new producing countries such as South Africa, New Zealand, Australia, Chile and California, etc. At the same time, the traditional wine-producing regions (Europe) have struggled to adapt to changing market conditions (Outreville, 2013).

Furthermore, the International Organisation of Vine and Wine (OIV, 2013), highlights the overall trend in the world wine sector: European vineyards continues to decrease, but more slowly as in USA and in the southern hemisphere. The wine production is in slight overall increase in 2013 compared to previous years and also the wine consumption is in a slight recovery.

However, from the OIV analysis it is interesting to note that there is a gap between the production and the consumption of wine of about 37 MhL: the world wine production has increased significantly in 2013 and consumption is stabilising (OIV, 2013). In Europe in 2009, the production exceeds the consumption: 182,216 MhL vs 156,029 Mhl (OIV 2013). Therefore, this tendency of the wine market, especially from a European point of view, generates an increase in wine surplus, a problem to be managed. Since the 70s, the EU addressed this surplus giving economic incentives to the wine producers for its distillation.

Despite the efforts of the EU to reduce surplus and to improve its management, the problem remains: the last EU wine policies reform has ratified the end of the distillery destination for the wine surplus. The portion of wine that does not find its place in the market and, therefore, remains in storage in the cellar, can be considered a waste, just like many other agricultural products. When this occurs, it becomes necessary manage this waste or, by choosing a more sustainable way, plan new strategies to reduce the risk of unsold wine, consequently, the analysis of their environmental impacts.

In accordance with this latter case, this study has combined some agricultural products belonging to the same area (southern part of Piedmont) in the formulation of an innovative product made primarily with grapes. The underlying idea is to move from a linear model in which grapes are grown only for wine production to a more complex model in which grapes are grown also for other uses, in this case as a ingredient in a fruit juice. The hypothesis is that with this new model a more efficient and sustainable use of grape can be achieved and the risk of unsold wine is lower. In order to verify the hypothesis a Life Cycle Assessment (LCA) analysis was applied to compare the environmental impact potentials of the both the linear and the complex models.

2. Material and methods

2.1. Description of the case study

Data were collected in the main cellar of a wine industry (MGM – Mondo del vino) which is located in Priocca (Province of Cuneo, in the south-western part of Piedmont). The core business of this company is the production of typical Italian wines, premium quality, both red and white. The grapes used for the wine production comes from selected winegrowers located in the most important Italian wine regions (e.g. Piedmont, Emilia-Romagna, Veneto, Sicily, Puglia).

The yearly production is about 224741 hL (average of the 2 vintages considered, 2012 and 2013), all bottled (the main part in glass and the other part in Bag-in Box); the main market is the international one (95 %): only the 5 % is sold in Italy. The industrial production process is carried out with the most recent technological equipment and it is important to highlight that the half energy demand is satisfied with renewable fonts (a photovoltaic plant produces around 400 KW). The main processing steps of this cellar are showed in Figure 1.

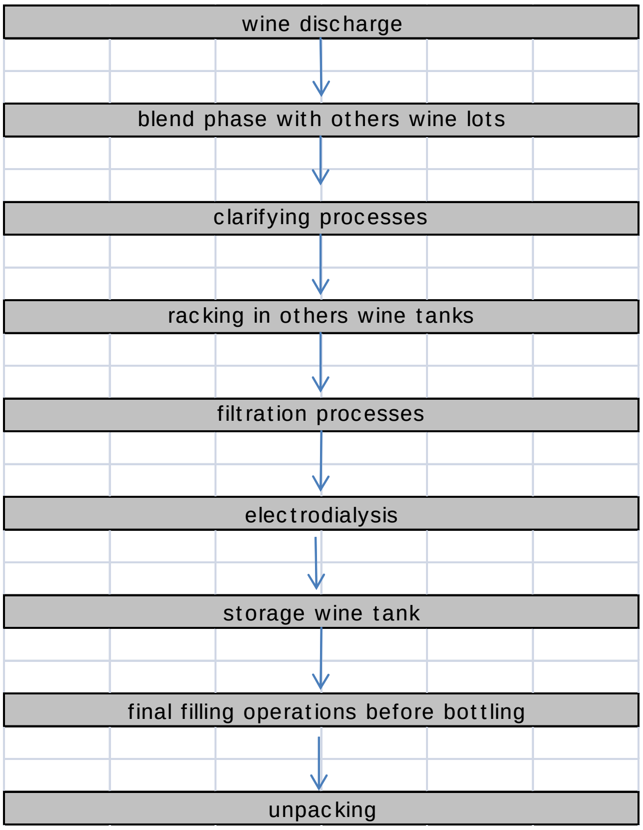

Figura 1: Winery process system

2.2. The environmental impacts assessment

The study was performed in accordance with the guidelines and requirements of the ISO 14040 standard series and with the cradle-to-gate approach as the basis for the LCI. Since among the goals of this study there's the improvement of grape exploitation, specifically of the Barbera, the data here collected refer only to local red wines. therefore all resource use and potential impacts were allocated using a mass-based approach. For the purpose of the study, it's been decided to set the system boundaries from the wine arrival to the wine storage phase, before bottling (Figura 2). The functional unit chosen was 1 L of red wine. The two models were then considered and evaluated:

Model A: focusing on the environmental performance of the actual wine production system. This scenario includes grape production, all winemaking process phases to produce and store 1 bottle of wine, the disposal of unsold wine. It excludes the user phase and the end of life.

Model B: focusing on the environmental performance of the wine production system with the option of transferring part of the must to the juice production system. In the light of industrial optimization, in the analysis of this scenario, a theoretical exercise was made. The hypothesys it's been that the unsold wine amount could correspond, upstream of the production system, to the quantity of must to be allocated to the production of fruit juices. In order to use precise figures, the average quantity of unsold red wine for 2012 and 2013 in the case study was considered (5405 hL). This scenario includes grape production, all winemaking process phases to produce and store 1 bottle of wine, excluding the user phase and the end of life.

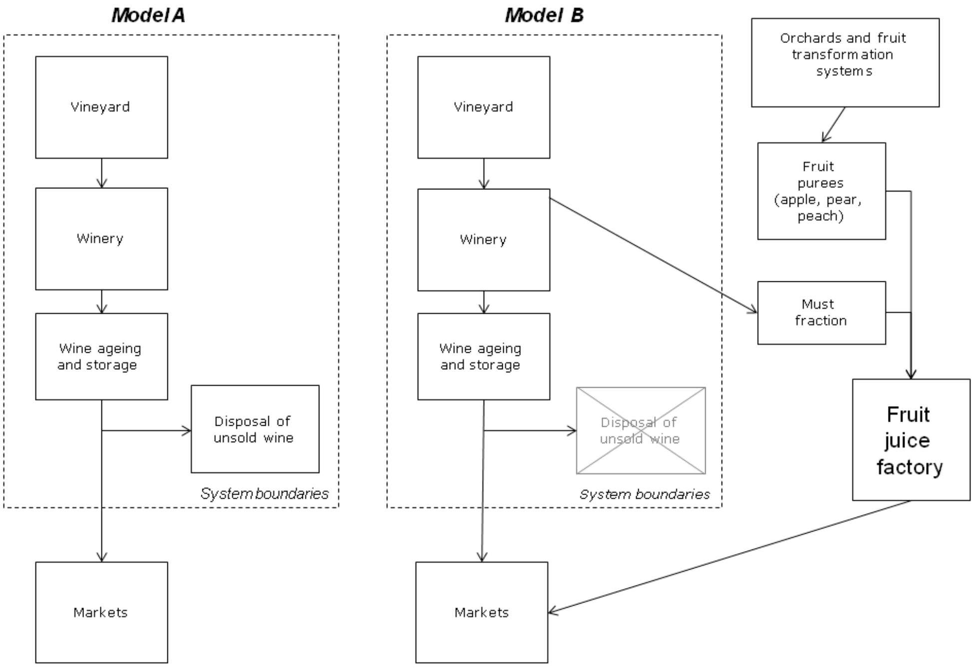

Figura 2: Schematic representation of the systems streamlines. Processes outside the dotted box are not considered in the assessment

Because each scenario is constituted by specific subsystem, a modular LCA approach was used (Jungbluth et al., 2000, Rebitzer, 2005; Buxmann et al., 2009; Cerutti et al., 2014a). This method includes the same steps as an LCA according to the guidance given in ISO 14044, but instead of performing a single assessment of a broad system, key processes are extrapolated and managed as stand-alone sub-systems. Furthermore, a proper life cycle impact (LCI) assessment (i.e. with classification and characterization) is performed at the sub-system level according to the reference flow that links the sub-system with the rest of the production system. According to ISO 14044, the modular approach is allowed providing that the resulting data are not different from those obtained in a standard LCA application (Rebitzer, 2005).

In our study, we divided the investigated system in three modules: the field module, the winery module and the disposal module (just for model B). The field module (vineyard) was modelled taking into account recommendations for LCA applications in orchards (Milà i Canals and Polo, 2003; Milà i Canals et. al., 2006; Cerutti et al., 2011, Cerutti et al., 2014b). In particular, in addition to one-year field operations, all the environmental impacts related to the entire lifetime of the vineyard were taken into account, including: (I) establishment stage, (II) nursery stage, (III) production stage A, which is characterised by low yield production due to young plants; (IV) production stage B, which is characterised by high production during the mature stages of the vineyard; (V) production stage C, which is characterised by low production due to ageing plants; and (VI) disposal of the vineyard installations.

Based on the emissions estimated in the LCI analysis, the environmental impacts were calculated here in the impact categories of the EDIP 1997 method and considering impact categories that quantify environmental impacts on ecosystems rather than on resource consumption or human toxicity, with particular attention to global warming, eutrophication and acidification potential.

3. Results and discussion

The impacts of the two models are shown in Table 1 according to the modules used. As expected, the model A is the most impacting: it corresponds to the conventional model that can generate surpluses or rates of unsold wine. The interesting result is the increasing of environmental performance achieved through the experimental system. In particular almost 4% of impact reduction is achieved for both Global warming potential and Nutrient enrichment potential, almost 2% is achieved in Acidification potential and non-significant reduction in the other impact categories.

	Field module	Winery module	Unsold wine	*Model A Total*	*Model B Total*
Acidification potential *[kg SO_2-Equiv.]*	3.62E-03	6.14E-04	8.46E-05	4.32E-03	4.23E-03
Global warming potential (100 years)*[kg CO_2-Equiv.]*	7.74E-01	8.73E-02	3.50E-02	8.96E-01	8.61E-01
Nutrient enrichment potential *[kg NO_3-Equiv.]*	6.24E-03	3.15E-04	2.69E-04	6.82E-03	6.55E-03
Ozone depletion potential *[kg R11-Equiv.]*	8.32E-10	8.33E-10	6.57E-14	1.66E-09	1.66E-09
Photochemical oxidant potential (high NOx) *[kg Ethene-Equiv.]*	2.97E-04	3.82E-05	3.96E-07	3.35E-04	3.35E-04
Photochemical oxidant potential (low NOx) *[kg Ethene-Equiv.]*	2.58E-04	3.97E-05	5.15E-07	2.99E-04	2.98E-04

Table 1: Characterisation results using functional unit: 1 L wine stored at the farm gate

One of the most common impact categories for commercial purposes is the Global warming potential as it is often divulgated as Carbon Footprint; detail of this impact category for the case study are presented in Figure 3. The total CO_2 emissions in the A model correspond to 0.896 kg CO_2-Equiv. / 1 L of wine, whereas those of the B model are 0.861 kg CO_2-Equiv. / 1 L of wine. Even if this difference could appear small referred only to 1 L of product, this becomes around 18.9 tons referred to the average of unsold wine (5405 hL) under study.

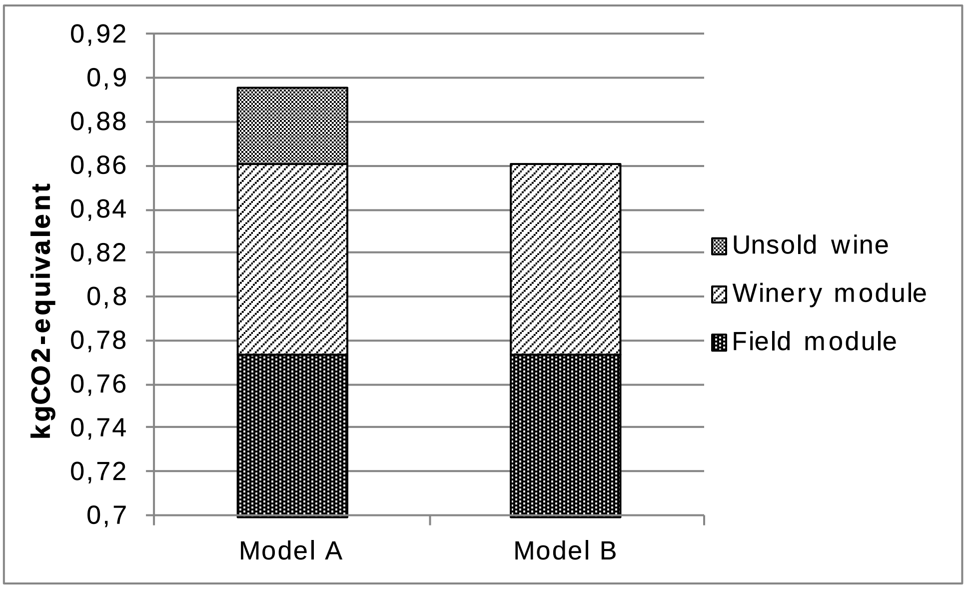

Figure 3: Detail of the Global Waming potential impact category (Carbon footprint) calculated for the functional unit: 1 L wine stored at the company gate

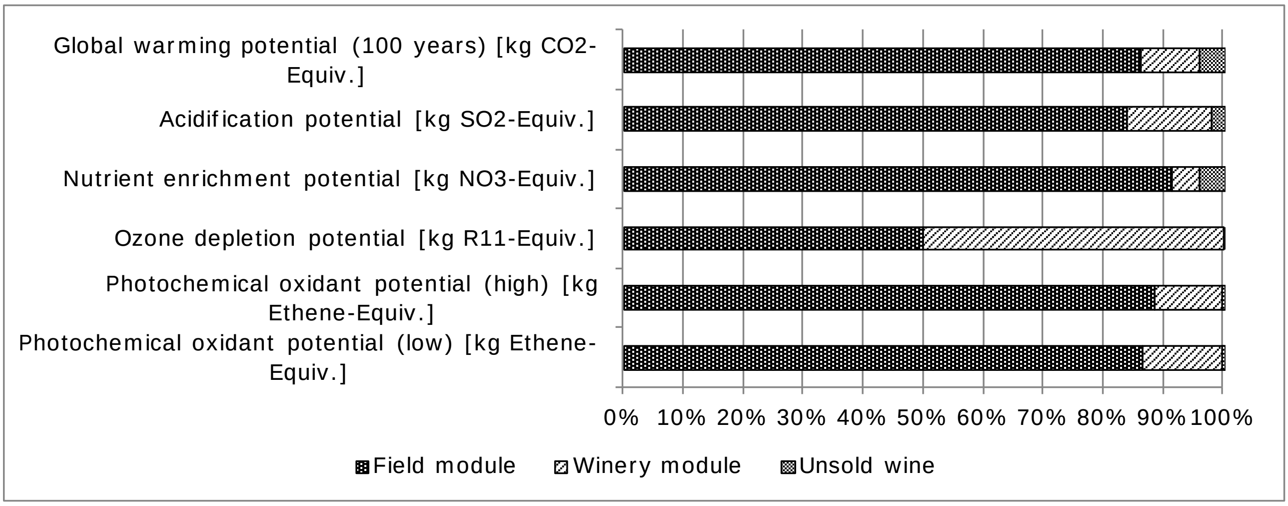

Figure 4: Comparison of characterisation results of the three modules

The field module is the most impacting (Figure 4), ranging from 91% in Nutrient enrichment potential to 50% in Ozone depletion potential.

In order to assess the contribution of the different impact categories compared with the impacts that an average person would otherwise be responsible for, the results were normalised according to the EDIP 1997 method with reference to the total impacts of activities in Europe. The normalised results are expressed in units of person equivalents (PE), which corresponds to the impact one person has in a given category. For both models, the dominant impact categories were similar to those commonly identified as important in agricultural LCAs, namely global warming potential (most important), nutrient enrichment potential and acidification potential (Figure 5).

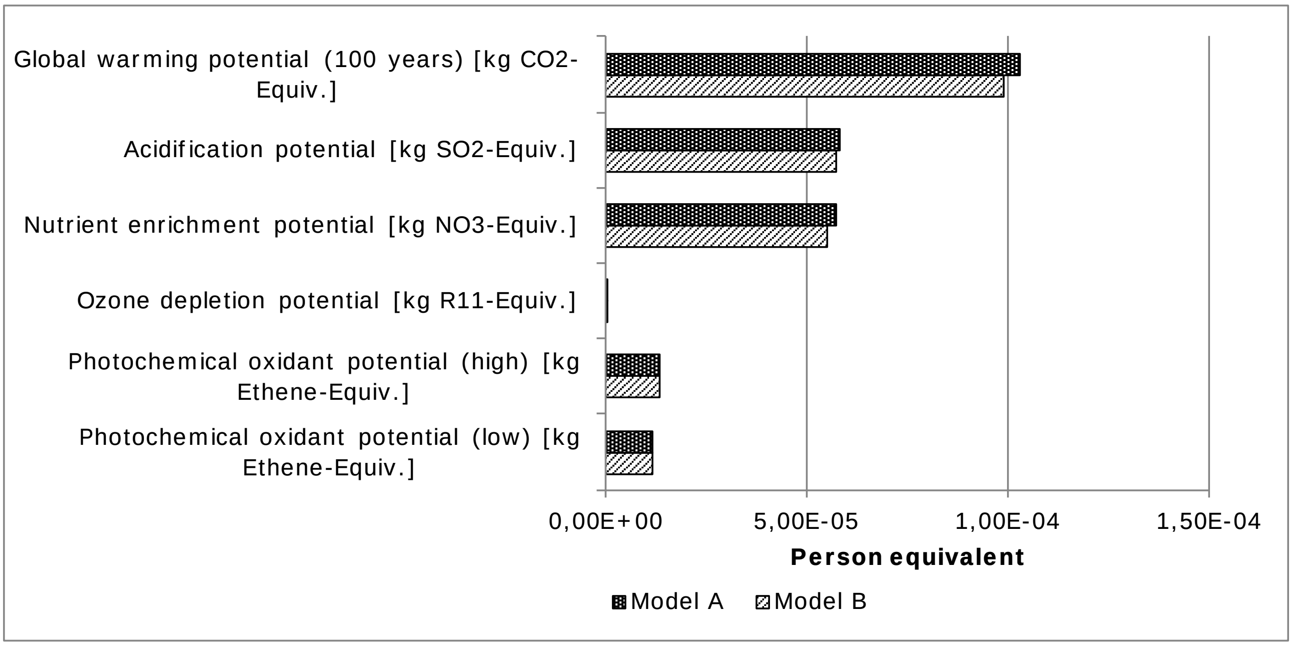

Figure 5: Normalised impact potentials using the functional unit: 1 L wine stored at the company gate

4. Conclusion

Though this work is focus at compare the environmental performance of the two models, here discussed, the LCA analysis provides, anyway, interesting general outcomes.
In fact, while a study focused on a LCA analysis for a Sardinian wine, showed that to produce 0.75 cl of wine, 1.64 kg CO_2-Equiv. are emitted (Benedetto et al., 2013), in the case here in study, for the same quantity, the emissions are lower: 0,67 Kg. This difference may be due also to the photovoltaic plant adopted by the company under investigation. In comparison with other published studies, the current research showed similar hot spots: as revealed in Figure 3, the field module of this research is the most impacting phase: the same results were found by the work of Villanueva-Rey (et al., 2014), in which three different management agricultural techniques were compared. Also in that study, in fact, the vineyard operations proved to be the main sources of environmental impacts in all the three management systems (biodynamic, conventional and an intermediate biodynamic-conventional wine-growing plantation) (Villanueva-Rey et al., 2014). The avoided quantity of CO_2 emissions, here described and hypothesized, are already been achieved: the model here proposed has already attracted the attention of a company for the implementation, in an industrial phase, of the here described fruit juice. This product is already sold on the market from almost two years.
In conclusion, this study demonstrates that the complex model allow a real differentiation and enlargement in the market opportunity of the grape based products, contributing to reduce the waste amount (unsold wine) and to improve, consequently, the environmental performances.

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