The importance of considering loss rates in life cycle assessment: an example of wine bottle closure systems (ID:389)

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Abstract Among published studies assessing the environmental impacts of wine, some consider the environmental impacts of different closures systems. However, different types of closures—such as natural cork stoppers, synthetic stoppers or screw caps—have different properties and can therefore present varying risk for wine loss. The environmental implications of loss rates have been studied by taking two wine closures—natural cork stopper and screw cap—as examples. The functional unit used to address environmental impacts of bottled wine should imply an equivalent function among all types of closures. It needs to consider the different loss rates associated with different closure systems. This evaluation concludes that the wine loss rate induced by the type of closure is an important parameter to consider and can be more influential than the closure material itself in the environmental performance of the closure system. This paper illustrates the risk of drawing conclusions regarding environmental preferability without considering the full implications of the product studied.

1 Introduction

The environmental impacts of different wine closure systems are assessed by several studies offering comparative conclusions (WWF [1]; Corticeira Amorim SGPS SA 2008 [2]). However, though different types of closures—such as natural cork stoppers, synthetic stoppers or screw caps—have different properties and thus present more or less risk for wine loss, the influence of closure type on the overall environmental impacts of wine has not been studied in a life cycle assessment context. In other words, when closures are studied without considering associated loss rates, the closure systems are, from a life cycle perspective, not functionally equivalent. The influence of closures on environmental impacts of wine is analyzed in the present study through the evaluation of loss rates of bottles of wine using two selected closure systems: corks and screw caps.
The objectives of this study are (i) to gain understanding on the potential environmental impacts of bottled wine loss rates and (ii) to discuss the implications of loss rates in terms of environmental performance depending on the closure system.

2 Wine, closure systems, wine spoilage and associated impacts

2.1 Wine and its impacts

A literature review has been performed on studies which assess the life cycle impacts of wine production (Kounina et al. 2011 [3]). Studies considering one bottle of wine as a functional unit do so without considering whether or not the bottle of wine had the expected quality to be drunk by the consumer. The figures were recalculated for all studies to have the equivalent functional unit of providing the closure of a 750 ml bottle of drinkable wine. This functional unit allows the comparison of studies evaluating the life

cycle impacts of wine production, as well as consideration of wine loss rates due to the use of different types of closures.

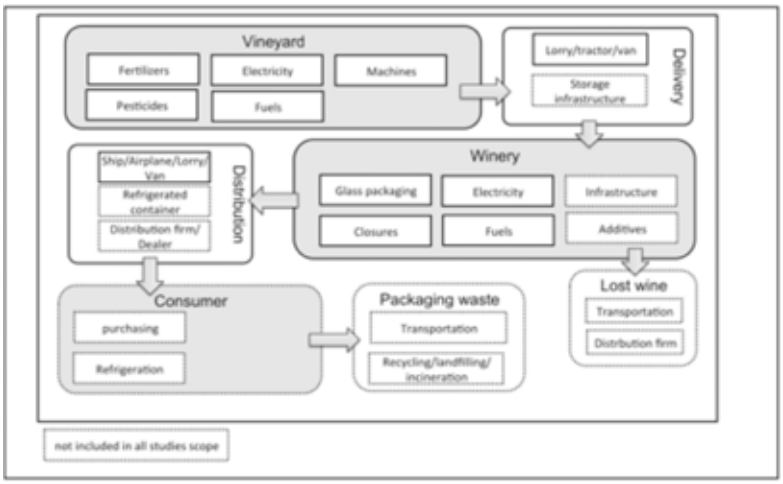


Fig.1: System for a bottle of wine, including the different steps of the life cycle

2.2 Closure systems and their impacts

The most wide-spread closure systems used in the world market are (1) cork stoppers (natural and technique; approximately 60 % of world market), (2) synthetic stoppers (approximately 30% of world market), and (3) screw caps (approximately 10 % of world market). « Crowns stoppers » are used only for the low-end wines or during the manufacture of the effervescent wines. Their market share is negligible. In the present study, two types of closures have been chosen and are compared in view of their impacts as well as their associated losses and spoilage rates and associated impacts: cork stoppers and screw caps.

The impacts of closure systems are directly taken from the Corticeira study and are shown in Table 1.

2.3 Wine loss and spoilage rates associated with the closure systems and their impacts

Thirty interviews have been carried out and are used as primary data in order to determine the loss from bottles of wine with the two types of closures.

The following closure system failures can be distinguished at the consumer level:

1. unfavourable odour due to accidental failures at different life cycle stages (e.g., unsuitable transport or storage in inappropriate places before the bottling process);
2. unfavourable taste due to problems of conservation (e.g., prolonged storage);
3. corked taste.

The estimated loss rates at the consumer for cork stopper and screw cap are, respectively, 2%-5% and 0.2%-0.5%.

2.4 Impact of wine poured into the sewage system and waste water treatment plant

Figure 2 shows the emissions due to wine poured into the sewage system and entering the wastewater treatment plant (in % of carbon originally in the wine). Values representing the fraction of carbon emitted as methane and carbon dioxide are estimated.

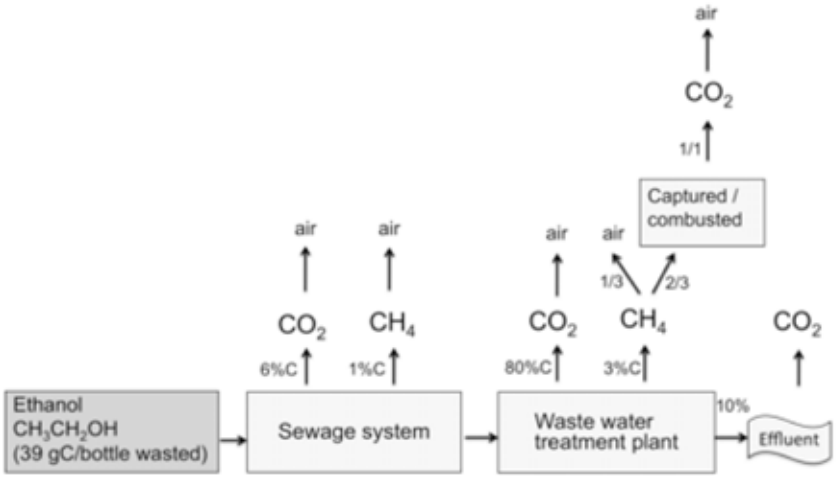


Fig.2: Methane and carbon dioxide emissions (associated with carbon contained in ethanol) due to wine poured into the sewage system and treated in the wastewater treatment plant

Methane emissions from wine poured into the sewage system represent 2.6E-2 kg CO_{2eq}/bottle wasted, which represents 9.1E-4 kg CO_{2eq}/average cork stopper and 9.1E-5 kg CO_{2eq}/average screw cap. In addition to the emissions associated directly with the wine, there are emissions associated with the treatment processes. Values from ecoinvent (Ecoinvent 2010 [4]) are employed in this study, assuming an average of 750 ml of tap water is used in addition to the 750 ml bottle of wine disposed. The global warming score associated with the tap water production and the wastewater treatment plant emissions are estimated to be 6.3E-4 kg CO_{2eq}/bottle wasted. All impacts due to the pouring of one bottle of wine into the sewage system are summarized in Table 1.

2.5 Impact scores found for wine production, closures and wine lost

Table 1 summarizes the results from the literature review on the impact of wine production, the impacts of closures and the impacts due to wine poured into the sewage system.

Tab.1: Impact scores found for wine production, closures and wine poured into the sewage system

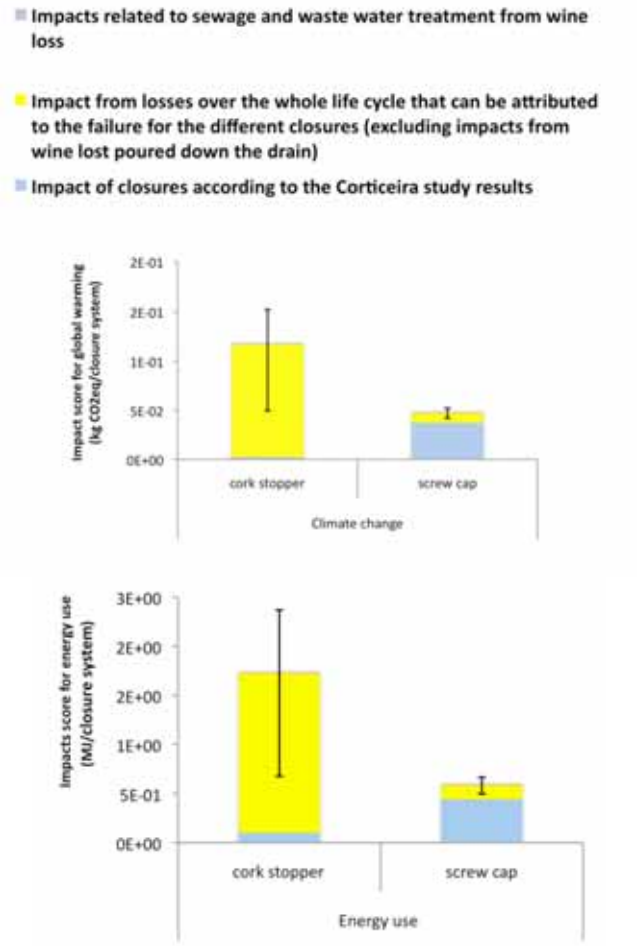
Impact category studied	Wine production		Closure production (Corticeira Amorim SGPS SA 2008 [2])		Wine poured into the sewage system
	Average results and range of results from the literature review for 750 ml of wine (Kounina et al. 2011 [3])		Cork stopper	Screw cap	For 750 ml of wine
Global warming [kg CO_2eq]	3.3	1.0 – 4.0	2.0E-3	3.7E-2	2.7E-2
Energy use [MJ]	47	16 – 58	0.10	0.44	1.1E-3
Atmospheric acidification [g H^+eq]	0.78	0.27 – 1.3	1.3E-3	8.2E-3	2.7E-4
Photo oxidants formation [kg ethylene eq]	1.9E-03	1.1E-3 – 2.3E-3	3E-6	1.4E-5	1.6E-7
Eutrophication [kg PO_4^{3-}eq]	4.5E-03	1.4E-3 – 7.8E-3	6E-7	7E-7	5.2E-6
* figures without use phase considerations					

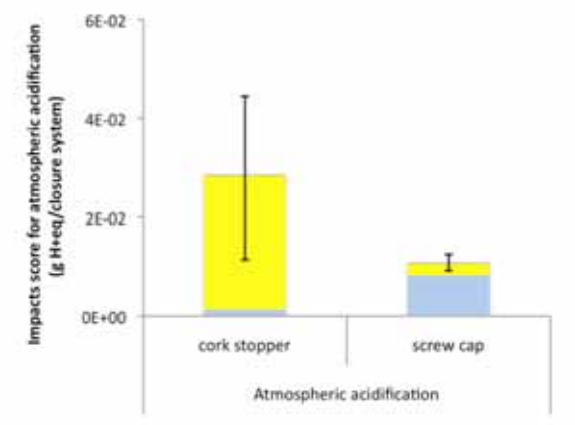
3 Influence of wine loss rate on the overall environmental performance of the different types of closures

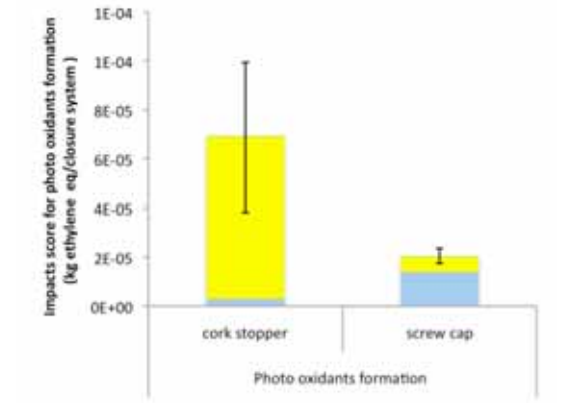
The overall environmental performance of closure in packing and preserving wine prior to its consumption is estimated. These results are discussed in comparison to the Corticeira study.

Figure 3 displays the results of combining the impacts from all losses over the life cycle that can be attributed to the failure of the different closures and to the impact of closures according to the

Corticeira study results. The estimated loss rates and spoilage rates increase the amount of wine needed to fulfill the functional unit. This additional amount adds impacts to the environmental profile. The standard deviation presented considers the range between the 2.5 and 97.5 percentile of a triangular distribution of the impact of a bottle of wine (see range and average in Table 1) combined with a triangular distribution of the estimated losses from 2% to 5% for the cork stopper and 0.2% and 0.5% for screw caps, with the average assumed to be an arithmetic mean between the minimum and the maximum loss rates. The details of the standard deviation calculations are presented in supporting information.




Impacts score for atmospheric acidification (g H+eq./closure system)
6E-02
4E-02
2E-02
0E+00
cork stopper
screw cap
Atmospheric acidification


Impacts score for photo oxidants formation (kg ethylene eq/closure system)
1E-04
1E-04
8E-05
6E-05
4E-05
2E-05
0E+00
cork stopper
screw cap
Photo oxidants formation

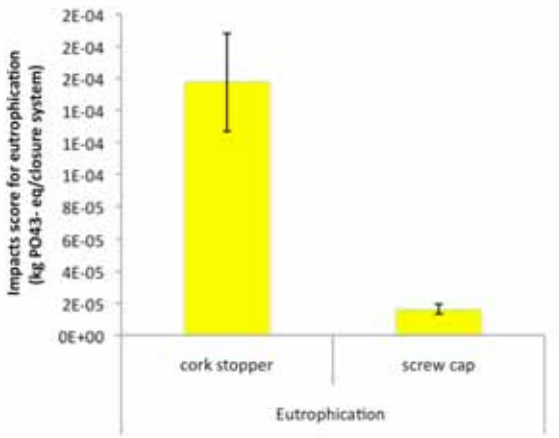

Impacts score for eutrophication (kg PO43- eq/closure system)
2E-04
2E-04
2E-04
1E-04
1E-04
1E-04
8E-05
6E-05
4E-05
2E-05
0E+00
cork stopper
screw cap
Eutrophication

Fig.3: Comparison of the impact from losses over the whole life cycle that can be attributed to the failure of different closure systems and the impact of closure systems according to the Corticeira study results

The lost bottles of wine (i.e., the extra amount of wine needed to fulfill the functional unit) can contribute between one third of the impacts of the closures themselves (e.g., in the case of screw caps for the global warming category) and up to several orders of magnitude more than the closures themselves (e.g., in the case of cork stoppers for all impact categories). When the loss rate is considered, the cork stopper presents a higher average score than the screw caps for all impact categories. Wine loss rate due to closure device is consequently a key parameter to consider when evaluating life cycle impacts of closure systems.

Note that several limitations apply, including the loss rate of wine that is very difficult to estimate. This study is therefore based on estimates that can be revisited with new data. The full list of limitations can be found in Kounina et al. 2011 [3].

4 Conclusions

This study provides a better understanding of the global environmental profile of bottled wine considering the different closures used and taking into account the loss and spoilage rates induced by each closure system.

The main conclusions are as follows:

1. The different closures and associated wine lost represent less than 5% of the total life cycle impact of bottled wine.
2. The wine loss rate induced by the type of closure is a key parameter to consider when assessing the impact of different wine closures.

3. In the case of a cork stopper, the impact of wine loss is larger than the impact of the cork stopper material itself for all examined life cycle impact categories.
4. When the impact of wine loss is considered, the cork stopper presents a higher impact score than the screw cap in all impact categories.

This study exemplifies the danger of drawing conclusions regarding environmental preferability among different products without considering the full implications of these components on overall product functionality.

5 Acknowledgements

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6 References

[1] WWF, Cork Screwed? Environmental and economic impacts of the cork stoppers market, 2006.
[2] Corticeira Amorim SGPS SA, Evaluation of the environmental impacts of Cork Stoppers versus Aluminium and Plastic Closures, 2008.
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[4] Ecoinvent <http://www.ecoinvent.ch> (Accessed 12.2010)

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being “Kounina A, Tatti E, Pfister R, Pike A, Ménard J-F, Loerincik Y, Humbert S. The importance of considering loss rates in life cycle assessment: an example of bottled wine closure systems.) The current version (as of April 2011) is under review. Final results and conclusions may change compared to the results and conclusions presented here.