

# A Preliminary Investigation into Alternative Wine Packaging for Greenhouse Gas Emissions Reduction in Hungary

Ágnes Csiba-Herczeg<sup>a,\*</sup>, Réka Koteczki<sup>b</sup>, Boglárka Eisinger Balassa<sup>b</sup>

<sup>a</sup> University of Tokaj, 7. Eötvös út, Sárospatak 3950, Hungary

<sup>b</sup> Széchenyi István University, 1. Egyetem tér, Győr 9026, Hungary

[agnes@herczegagnes.com](mailto:agnes@herczegagnes.com)

Based on sustainability aspects, the wine industry is under increasing global pressure regarding the packaging of wine. This means that, in the case of everyday wines, instead of glass wine bottles, they should find an alternative option that has a less burdensome impact on the environment and is more accessible. To investigate this, a scenario analysis was carried out using data from a Hungarian winery to examine two possible scenarios. The winery provided the sales share of each packaging type for 2022. In the scenarios, the rates of packaging types were varied in terms of the degree of acceptance of alternative packaging in each country. After determining the packaging ratios, GHG (greenhouse gas emission) was calculated for one million bottles, which would make the first scenario a more sustainable approach, as emissions would be 16 % lower than the emission of 2022 sales volume. Overall, the greater uptake of alternative packaging results in lower emissions in terms of production.

## 1. Introduction

Wine packaging is one of the most important issues in the wine sector for three main reasons: supply chain issues, rising costs due to inflation and rising energy prices, and, third and most important – reducing GHG emissions for environmental sustainability. According to Ferrara and De Feo (2020), the worst packaging type from a sustainability perspective is the single-use glass bottle. The use of alternative packaging can also contribute to cost reduction and economical and environmentally more sustainable transport solutions. In this paper, two alternative packaging types will be examined, as they have lower GHG emissions than single-use wine bottles. Examining the environmental impact of packaging is important because packaging accounts for a large part of the overall Life Cycle Analysis. The wine supply chain contributes 0.3 % to greenhouse gas emissions, which is a high figure for a single product category (Rugani et al., 2013). Hungary will reach a major milestone in beverage packaging recycling with a law to make the return of disposable beverage packaging mandatory from 2024. This law will also have a major impact on the wine market. The deposit return scheme (DRS) has already been introduced in several countries, and the experience so far shows that it has been a successful operation for the collection of waste and has successfully contributed to reducing pollution (Rhein and Sträter, 2021). The use of alternative packaging for wine will become increasingly common (Ponstein et al., 2019a), as it is considered a more sustainable alternative from an environmental point of view than single-use glass packaging (Ponstein et al., 2019b). All sectors of the economy should strive to reduce greenhouse gas (GHG) emissions (Hashim et al., 2022).

The aim of this study is to investigate how increased use of alternative packaging would affect Global Warming Potential (GWP) emissions. Data for the calculation were provided by a large Hungarian winery. Based on Loose's (2023) research, two scenario alternatives for winery sales will be outlined based on the level of acceptance of alternative packaging (bag-in-box, PET) in different countries. GHG emissions associated with each packaging type were determined based on research by Ponstein et al. (2023).

## 2. Theoretical Background

### 2.1 Alternative wine packaging types

The most common type of wine packaging is the glass bottle, which provides excellent gas and vapor barrier protection for wine, allowing it to be stored for a long time. Even though glass bottles can be recycled and refilled, alternative packaging has emerged, which may be more environmentally friendly than glass bottles (Thompson-Witrick et al., 2021). PET (Polyethylene Terephthalate) bottles are a good alternative due to their lightweight and low cost, but they are not very favorable from an oxidation point of view, so they can only be used for storing wine that is consumed within 1 y. Bag-in-boxes (BIB) are generally available on the market in 3 and 5 L sizes. In Norway, Sweden, and Australia, roughly 50 % of wine packaging is bag-in-box (Thompson-Witrick et al., 2021). Other alternative packaging options are aluminum cans and TetraPak, which have the advantage of being lightweight. Aluminum cans are also easy to transport and perform well in oxidation, and are easy to consume from the packaging. Wines sold in TetraPak packaging are usually 500 mL, which are efficient to transport and easy to produce. Ferrara and De Feo (2020) conducted Life Cycle Analysis which showed that bag-in-box packaging is the most sustainable alternative, followed by aseptic cartons.

### 2.2 Adoption of alternative packaging by countries

Different countries, including producers, retailers, and consumers, are willing to accept alternative packaging for wine to varying degrees. There are differences between consumer acceptance and the measures taken by the trade and producers. According to Loose (2023), consumers would be more accepting of alternative packaging than retailers and producers consider. There are also significant differences between countries. Innovators and early adopters include countries such as Norway, the United Kingdom, Finland, Denmark, Sweden, and Canada. These countries show a strong inclination towards alternative wine packaging. For bag-in-box, countries plan to increase over the next 2 y ranging from 44 % to 100 %. For PET bottles, they show a slightly lower propensity, but Norway shows a 100 % propensity for PET bottles too. The Middle group includes France, Spain, the USA, Belgium, and Portugal. They intend to list alternative packaging at a roughly medium level. The average listing rate for bag-in-box is 43 % and for PET bottles 17 % in the case of the middle group countries. Laggards include the Netherlands, Italy, Germany, Austria, and Switzerland. These countries show the least inclination towards alternative packaging. The deposit return scheme is part of everyday life for Norway's 5.42 million inhabitants. Nearly 1.7 billion cans and PET bottles have been sold in Norway, of which more than 1.5 billion have been collected (Infinitum report, 2021).

### 2.3 Consumer attitudes towards alternative wine packaging

Packaging has a very strong influence on consumers' purchasing decisions in the case of wine, potentially even more influential than price or brand label (Mueller and Lockshin, 2008). A study by Orłowski et al. (2022) also supports this finding, as their results suggest that packaging has an indirect effect on purchase intention. Consumers are more inclined to associate higher quality with glass packaging, one of the main reasons being that heavier products are perceived as higher quality. If a product has low appeal, it has the potential to affect taste perception (Orłowski et al., 2022). Ferrara et al. (2020) conducted research among 1,000 wine consumers to investigate how skeptical they are towards alternative wine packaging. The results show that 91 % of consumers do not want to consume wine in alternative packaging, preferring only to store it in a glass bottle. The main reason for this is that they believe that these types of packaging are not suitable for storing wine (Ferrara et al., 2020).

## 3. Methodology

The aim of the study is to investigate the impact of changing the proportion of alternative packaging on emissions through a case study. In the study, we used the Hungarian winery's 2022 sales data to set up two further scenarios to examine the extent to which GWP would change in terms of production if the proportion of packaging types were to change. These calculations illustrate two possible scenarios, with the aim of presenting one possibility of how the wine market could reduce CO<sub>2e</sub> emissions through measures. The sales data for 2022 include both domestic and export sales. The winery was not allowed to provide the actual sales figures, only the sales rates for each type of packaging.

In the present study, GHG emissions associated with each type of packaging were not calculated but were based on the values given by Ponstein et al. (2023). The sales volume of the Hungarian wineries considered in the case study was multiplied by the kgCo<sub>2e</sub> determined by Ponstein et al. (2023) to estimate what the environmental impact of each scenario would be. Sales volumes were provided on a volume per million bottles basis.

- Average Glass Bottle, EU: 0,472 kgCO<sub>2</sub>e
- Bag-in-box 3L: 0.052 kgCO<sub>2</sub>e
- PET 0.75L: 0.182 kgCO<sub>2</sub>e (Ponstein, 2023).

$$GHG_{gb} = (GHG_{ab} \div W_{ab}) \times W_{gb} \quad (1)$$

Where:

- $GHG_{gb}$  = GHG emission of Glass Bottle (kgCO<sub>2</sub>e)
- $GHG_{ab}$  = GHG emission of Average Glass Bottle (kgCO<sub>2</sub>e)
- $W_{ab}$  = Weight of the Average Glass Bottle, EU (480 g)
- $W_{bo}$  = Weight of the Glass Bottle (404.30 g)

The winery sells five different types of glass packaging, which vary in weight (400 g; 430 g; 440 g; 580 g; 700 g).  $GHG_{ab}$  covers the emission of these types of packaging. In the calculations, the estimated sales volume to obtain the emissions of each scenario is multiplied by the emissions of bag-in-box and PET.

In both cases, the proportion of bag-in-box and PET packaging types is based on the research of Loose (2023), which examines the extent to which the country's retailers are willing to buy these packaging types in the next 2 y. The research examined the willingness to buy each type of packaging individually, which explains why in some markets, there is a 100 % willingness to buy both BIB and PET bottles. In the first scenario, sales are optimized for the willingness to buy the BIB, and in the second scenario, they are optimized for the PET bottle, with the criterion that only the glass bottle is switched to the PET bottle, with no change to the existing BIB sales volume. In the two scenarios, the likely adoption rates of BIB and PET bottles have been integrated, which are as follows in the countries studied:

- Norway: BIB 100 %; PET 100 %
- Finland: BIB: 69 %; PET 77 %
- Sweden: BIB: 69 %; PET 63 %
- Canada: BIB: 44 %; PET 11 %
- Germany: BIB: 37 %; PET 5 %
- Hungary: BIB: 2 %; PET 5 %

Data for Hungary were not available in the research, so data from Austria were used for the calculations, as there are strong economic similarities between the two countries.

#### 4. Case study results

The Hungarian winery has a large volume of sales in Hungary and exports to countries such as Germany, Norway, Sweden, Canada, and Finland. The winery also exports to other countries, but we do not include these in this case study. The other countries account for 21.50 % of 2022 sales. The winery currently sells wine and sparkling wine in different types of bottles (5 types) and BIB packaging. However, in our calculations, we only distinguish between two types of packaging – glass and BIB, as the weight of the glass produced is the only significant factor in terms of emissions. Based on Loose's (2023) research, we split two cases in which the sales ratios of each type of packaging were varied. As the research does not indicate the share of each packaging type that each country would like to list, two scenarios were proposed, one for BIB sales and one for PET bottle sales. In the second scenario, we did not change the proportion of BIB, but only the proportion of glass bottles to PET bottle sales.

Table 1 illustrates the proportion of each packaging type based on 2022 sales and the two scenarios. The winery sells the largest volume (60.35 %) of wine in Hungary, where a high percentage (97.60 %) is sold in glass packaging. In Norway, where packaging recovery is efficient and where conservation is very important, the winery exports only bag-in-box packaging. The first scenario is set up according to the adoption of bag-in-box packaging in each country. The scenario shows that the share of bag-in-box is much lower in the lagging countries. In Scenario 2, the adoption rate of PET bottles was incorporated.

The GWP (kgCO<sub>2</sub>e) for each scenario is illustrated in Table 2. Based on the calculations, Scenario 1 and Scenario 2 would also result in fewer emissions than sales in 2022, as in those cases, the proportion of alternative packaging is higher, and they result in fewer emissions from a production perspective.

Table 3 shows the rate of kgCO<sub>2</sub>e emissions compared to the 2022 sales rate. Overall, almost for each country, the first scenario is the more favorable, the one with the higher sales volume of bag-in-boxes, partly due to the fact that they are generally more accepted as a packaging type and partly due to the fact that bag-in-boxes have lower CO<sub>2</sub>e emissions than PET bottles.

Table 1: Share of wine packaging types by country (%)

Country	Sales ratio (%)	Packaging type	2022 sales (%)	Scenario 1 (%)	Scenario 2 (%)
Hungary	60.35	Bag-in-box	2.40	21.00	2.40
		Glass Bottle	97.60	79.00	92.72
		PET Bottle	0.00	0.00	4.88
Norway	2.18	Bag-in-box	100.00	100.00	0.00
		Glass Bottle	0.00	0.00	0.00
		PET Bottle	0.00	0.00	100.00
Sweden	9.10	Bag-in-box	85.90	69.00	85.90
		Glass Bottle	14.10	31.00	5.22
		PET Bottle	0.00	0.00	8.88
Finland	0.30	Bag-in-box	21.74	69.00	21.74
		Glass Bottle	78.26	31.00	18.00
		PET Bottle	0.00	0.00	60.26
Canada	2.39	Bag-in-box	0.00	44.00	0.00
		Glass Bottle	100.00	56.00	89.00
		PET Bottle	0.00	0.00	11.00
Germany	4.18	Bag-in-box	11.08	37.00	11.08
		Glass Bottle	88.92	63.00	84.48
		PET Bottle	0.00	0.00	4.45
Other countries	21.50				
Total sales	100.00				

The largest emission reductions could be achieved in Finland, where emissions would be roughly halved. To Sweden, the winery exported a small amount of glass bottles in 2022, but Looses' (2023) results suggest that the country as a whole is not as accepting of alternative packaging as the amount exported from the winery. This explains the almost 70 % higher output in Scenario 1 than in sales. To Norway, the winery exports only bag-in-box packaging, which makes Scenario 1 identical. Norway's emissions are more than three times higher in the second scenario because the amount of pollutants emitted in the production of PET bottles is also more than three times higher. The table clearly shows that the GWP of the PET bottle is higher than that of the bag-in-box.

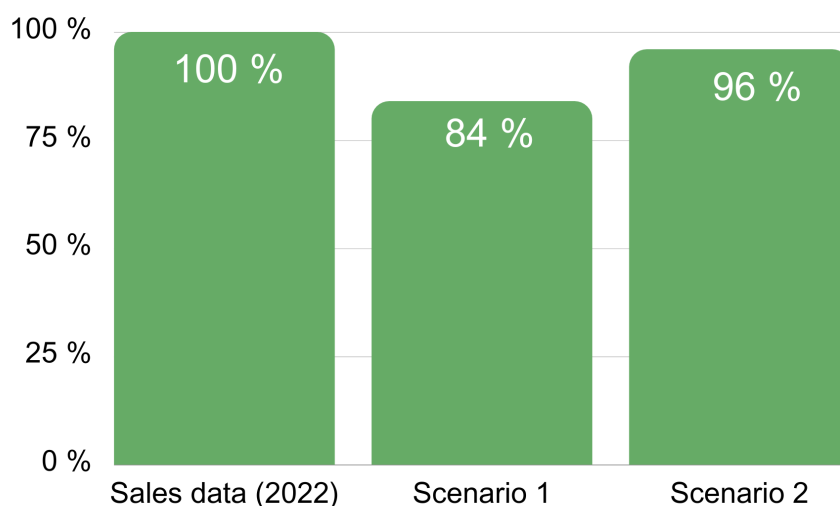


Figure 1: Degree of reduction in pollutant emissions under the scenarios compared to 2022 sales

Table 2: Emissions per million bottles (kgCO<sub>2e</sub>) for a Hungarian winery

Country	Packaging type	2022 sales (kgCO <sub>2e</sub> )	Scenario 1 (kgCO <sub>2e</sub> )	Scenario 2 (kgCO <sub>2e</sub> )
Hungary	Bag-in-box	753.212	6,590.056	753,212
	Glass Bottle	311,226.192	251,907.658	295,656.000
	PET Bottle	-	-	5,359.90
	SUM	311,979.404	258,497.714	301,769.120
Norway	Bag-in-box	1,134.545	1,134.545	-
	Glass Bottle	-	-	-
	PET Bottle	-	-	3,970.876
	SUM	1,134.545	1,134.545	3,970.876
Sweden	Bag-in-box	4,065.455	3,265.726	4,065.455
	Glass Bottle	7,248.061	15,931.879	2,681.695
	PET Bottle	-	-	1,471.776
	SUM	11,313.515	19,197.605	8,218.935
Finland	Bag-in-box	31.515	100.033	31.512
	Glass Bottle	1,244.364	492.925	286.226
	PET Bottle	-	-	305.785
	SUM	1,275.879	592.958	623.523
Canada	Bag-in-box	-	547.038	-
	Glass Bottle	16,117.727	9,025.699	14,344.415
	PET Bottle	-	-	478.658
	SUM	16,117.727	9,572.737	14,823.073
Germany	Bag-in-box	241.091	805.156	241.072
	Glass Bottle	15,269.677	10,818.294	14,506.083
	PET Bottle	-	-	338.629
	SUM	15,510.768	11,623.450	15,085.784
Total GWP		357,331.838	300,619.009	344,491.311

Table 3: Changes in GWP ratio by country compared to 2022 sales data

Country	Sales 2022 (%)	Scenario 1 (%)	Scenario 2 (%)
Hungary	100	82.86	96.73
Norway	100	100	349.99
Sweden	100	169.69	72.65
Finland	100	46.47	48.87
Canada	100	59.39	91.97
Germany	100	74.94	97.26

If the production output of bottles sold in 2022 is assumed to be 100 %, emissions will decrease by 16 % in the first scenario and by 4 % in the second scenario. In the second scenario, emissions decrease less because the CO<sub>2e</sub> of PET bottles is higher than that of BIB, and countries are less accepting of this type of packaging.

## 5. Conclusions

In the present study, two possible scenarios have been outlined to examine how GHG emissions would vary as a proportion of different packaging types in the case of a Hungarian winery. In the first scenario, sales volumes were based on the adoption of BIB alternative packaging, and in the second scenario, on the adoption of PET bottles. Overall, in both scenarios, GHG emissions for the Hungarian wine industry are lower than sales in 2022. Per million bottles, emissions are almost 57,000 kgCO<sub>2e</sub> less in the first scenario and almost 13,000 kgCO<sub>2e</sub> less in the second scenario compared to 2022 sales data. In this case, the data may show a slight bias, as only one winery's emissions were considered, and only production emissions were taken into account. Presumably, if we look at the total emissions of a country, the most favorable figures for wine packaging would be for countries that are sustainability heralds and have a high level of adoption of alternative packaging, such as Norway. Overall, the state, wineries, retailers, and consumers should all promote and increase the use of alternative

packaging to reduce GHG emissions. In this respect, it would be important to educate consumers about the environmental impact of different types of packaging and the impact of different types of packaging on the quality and flavor of wine. In addition to alternative packaging, reuse, and recycling should not be neglected. Incorporating these alternatives into operations can promote sustainability in the wine market.

The limitation of the study is that the emissions are only calculated for 1 million bottles and not for the total sales volume, with the emissions for the wine industry being much higher. However, the main objective of this study was to present the figures and to examine whether it is worthwhile to sell more alternative packaging from a sustainability point of view the options and other types of alternative packaging in order to get a more comprehensive picture of all possible alternatives for packaging in the wine industry. However, in addition to sustainability considerations, it is also worth looking at consumer attitudes toward alternative packaging, reuse, and recycling. The problem needs to be approached from several angles to get a more comprehensive picture of the issue.

### Acknowledgments

The research was supported by the European Union within the framework of the National Laboratory for Artificial Intelligence. (RRF-2.3.1-21-2022-00004).

### References

- Ferrara C., De Feo G., 2020, Comparative life cycle assessment of alternative systems for wine packaging in Italy. *Journal of Cleaner Production*, 259, 120888.
- Ferrara C., Zigarelli V., De Feo G., 2020, Attitudes of a sample of consumers towards more sustainable wine packaging alternatives. *Journal of Cleaner Production*, 271, 122581.
- Hashim H., Zubir M.A., Kamyab H., Zahran M.F.I., 2022, Decarbonisation of the Industrial Sector Through Greenhouse Gas Mitigation, Offset, and Emission Trading Schemes. *Chemical Engineering Transactions*, 97, 511-516.
- Infinitem, 2021, Annual Report <infinitem.no/media/scdgvtx3/en\_infinitem\_a-rsrapport\_2021\_100422\_01.pdf>, accessed 25.04.2023.
- Loose S., 2023, Alternative Packaging in Practice: Insights from international wine trade and producers [Conference presentation] Meininger's International Wine Conference, Königsallee 59, Düsseldorf, Germany, 40215, March 18, 2023.
- Mueller S., Lockshin L., 2008, How important is wine packaging for consumers? On the reliability of measuring attribute importance with direct verbal versus indirect visual methods, PhD Thesis, Academy of Wine Business Research, Siena, Italy.
- Orlowski M., Lefebvre S., Back R.M., 2022, Thinking outside the bottle: Effects of alternative wine packaging. *Journal of Retailing and Consumer Services*, 69, 103117.
- Ponstein H. 2023, Sustainability redefined: understanding and mitigating impacts from wine production, [Conference presentation] Meininger's International Wine Conference, Königsallee 59, 40215 Düsseldorf, Germany, 40215, March 18, 2023.
- Ponstein H.J., Ghinoi S., Steiner B., 2019a, How to increase sustainability in the Finnish wine supply chain? Insights from a country of origin based greenhouse gas emissions analysis. *Journal of Cleaner Production*, 226, 768-780.
- Ponstein H.J., Meyer-Aurich A., Prochnow A., 2019b, Greenhouse gas emissions and mitigation options for German wine production. *Journal of Cleaner Production*, 212, 800-809.
- Rhein S., Sträter K.F., 2021, Intended and unintended effects of statutory deposit return schemes for single-use plastic bottles: Lessons learned from the German experience. *GAIA-Ecological Perspectives for Science and Society*, 30(4), 250-256.
- Rugani B., Vázquez-Rowe I., Benedetto G., Benetto E., 2013, A comprehensive review of carbon footprint analysis as an extended environmental indicator in the wine sector. *Journal of Cleaner Production*, 54, 61-77.
- Thompson-Witrick K.A., Pitts E.R., Nemenyi J.L., Budner D., 2021, The impact packaging type has on the flavor of wine. *Beverages*, 7(2), 36.