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Study of Environmental Alternatives of Improvement for the Preparation of Vermouth Formulations

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Abstract

The study is based on the application of the principles from the UNE-EN ISO 14040:2006 and UNE-EN ISO 14044:2006 standard. From an environmental perspective, the research will be carried out implementing the methodology from CML IA baseline V3.04/EU25 and ReCiPE V1.13. These impact assessment methodologies model the damage caused by greenhouse gas emissions in production processes, as well as allow comparing the results obtained from the impact categories knows as numerical values or through ecopoints.

This research has allowed to generate a calculator of environmental impacts to assess the environmental impact of each vermouth formulation designed according to each of the components provided and the operations performed. As a final conclusion, it is possible to determine that the environmental impacts may vary according to the elements added, although the greatest environmental impact is due to the production procedure of the base wine used in the vermouth.

Keywords: LCA; environmental impact; vermouth production

1. Introduction

Within the industry, LCAs have traditionally been implemented in the development of less polluting products. They have also been used to improve the company's environmental policy. Its application to agriculture requires the systematic application of existing methods as well as new methods, Audsley et al. (Audsley et al. 1997) investigated how to apply LCA to the agricultural field by setting the standard to determine the difficulty of applying it on this field. Similarly, 11 international conferences about the application of the LCA in the food industry have been organized, the 12th International Conference on Life Cycle Assessment of Food will take place in Berlin (2020). In these conferences, the most important topics are the following:

- Tackling complexity of food systems (modelling, cyber-physical systems, LCSA)
- Opening the data on food for LCA (databases, tools and software developments)
- New models for food LCA.
- Evaluation models and how to deal with normativity
- Sustainability assessment/evaluation approaches in food
- Value scales (e.g. SDGs) in food LCA & LCSA

The development of the Life Cycle Analysis in Spain has its origins in the beginning of the nineties. In 2002, the Spanish LCA Network was created. Among its main objectives, there is the promotion of cooperation between the different organizations that are interested in the application of this tool; currently it is integrated by about 26 entities.

Moreover, in the Spanish territory, several research groups have implemented the application of LCA in different agrarian sectors. The most important projects related to the horticultural sector in which research works have been carried out, some can be mentioned, such as one made by (IRTA University Rovira Virgili through the AGA group), citriculture (Polytechnic University of Valencia), and apple trees (Autonomous University of Barcelona). In the University of La Rioja, the group participating in the project has extensive experience in LCA (energy, fungus, or latest publications on barrels and wine aging).

The environmental impact study of wine production through the LCA methodology has a references in different publications, where the production process is described and environmental impacts are analyzed (Notarnicola et al. 2015, Flores 2018, Merli et al. 2018, Recchia et al. 2018, Borsato et al. 2019, Villanueva-Rey et al. 2019). Being the first addresing to this environmental problem as well as being its synthesis one of the most noteworthy. Subsequently, many studies have emerged: Bosco et al(Bosco et al. 2011) analyze the emissions of greenhouse gases from wines in Tuscany, Jiménez et al. (Jiménez et al. 2014) execute a methodological approach towards sustainability by integrating the environmental impact into production system models analyzing the life cycle in La Rioja wine sector. If all these studies are analyzed in depth, it can be determined that they are SIMPLIFIED approximations of the problem to be studied.

The importance and complexity of the data that comprise the study is basic, prioritizing the primary data (which is collected by the researcher for the first time) regarding the secondary data, which is the data collected or produced by other entities. If the publication “Life cycle analysis of wine from La Rioja” is analyzed (Fullana et al. 2005), or the Project “LIFE03 ENV/E/0085 SINERGIA.” Quality and respect for the environment. “THE LIFE CYCLE ANALYSIS OF WINE FROM LA RIOJA” will be the data obtained as secondary character. Therefore, the inventories presented in the study do not allow a sensitivity analysis. In addition, if the attention is focused on these studies, it can be seen that there is no LCA on barrels, since the first study was by Flor et al. (Flor et al. 2017) “Environmental impact of oak barrels production in Qualified Designation of Origin from La Rioja" or about barrel aging "Environmental impact of wine aging process in oak barrels in wineries from La Rioja (Spain)" by Flor et al. (Flor et al. 2018) in the prestigious journal “American Journal of Enology and Viticulture.”

In fact, a relevant reflection about the previous analysis is the criticality of obtaining primary data when it comes to modeling the productive process. Without primary data, obtained from the study of each of the tasks in the process, it is IMPOSSIBLE to generate alternatives for continuous environmental improvement. Generalist studies, such as the one mentioned above, are appropriate as an outreach tool but there are not useful for environmental optimization purposes. Therefore, the previous information allows this study to guarantee an opportunity to generate knowledge, as well as to banish the SIMPLISTIC concept of "carbon footprint" from the winegrowing culture through the LCA. Specially, this project goes beyond the provisions of Regulation (EC) No. 1221/2009 or Decision (EU) 2017/1508 seeking to establish a higher analytical range.

In addition to the development of the project in the vermouth field, a greater singularity is achieved without leaving behind a fundamental annual market, which is between 25 and 30 million liters of vermouth (only in Spain), with a highly demanding consumer profile that is sensitive to ecological and environmental saving values.

Finally, it is important to mention that there have been no studies and/or publications on LCA or environmental impacts in the production of Vermouth, and even less on the preparation stage of vermouth formulations.

2. Methodology

2.1. Objectives and scope

The main objective is to obtain a complete environmental vision from different activities involved in the process of creating formulations for vermouth. The study considers each stage of the life cycle, starting from the entry of materials and ending in the storage of the final product to identify critical activities within the process. It is an analysis of door to the door; analyzing the productive processes and identifying materials, energy resources and process flows of each of them, until the creation of the final functional unit. In order to be a useful tool, an impact calculator has been generated that enable the selection of different ingredients and work processes; obtaining multiple winemaking alternatives as a result.

2.2. Functional unit

The functional unit used in the research is a liter of vermouth formulation for its dissolution in base wine.

2.3. System boundaries

For the present study, some system boundaries have been established. These limits from the LCA model comprise the overall production of the product, as well as the creation of a liter of formulation defined as a functional unit (see Figure 1).

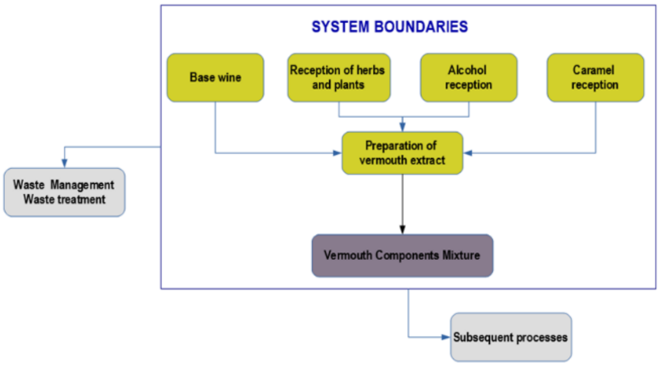

Figure 1. System boundaries

The following activities have been included within the system boundaries:

- Entry of materials and transportation from the original company to the plant of study.
- Electricity consumption from the stations of the plant as well as measurement and monitoring equipment throughout the winemaking process.
- The transportation of the materials used by the different processes and stations of the plant.

The following activities have not been considered within the system boundaries:

- The installation and dismantling of the plant or any station within the plant, as well as the improvement, reconstruction, or relocation of any plant station.
- Collection, treatment, and transportation of waste produced during the process.
- Final product distribution and transportation

2.4. Calculations

The environmental impacts calculator uses two methodologies from the LCA: CML-IA baseline V3.04/EU25 and ReCiPe V1.13. For the first methodology, the Global warming impact category (GWP100a) with its kg CO_2 eq unit is used whereas for the second methodology, the category of Total impacts is used, which unit is Ecopoints.

The calculator comprises the phases of entries portrayed in Figure 1, which are the following:

- Reception and classification of components

- Herbs and plants: In this section 54 species of herbs and plants have been included.
- Alcohol: the impact characteristics of the added alcohol are included.
- Sugar: It will be supplied in the form of caramel.
- Base wine: It is the type of wine where the formulation is performed. It must be as neutral as possible in terms of organoleptic properties

- Dosage of components to obtain the vermouth extract. In this phase, it is necessary to select:

- The amount and dose of herbs and plants to be used in the extract.
- The amount of sugar that is intended to be added. The quantities normally used may vary between 10 to 15%.
- The amount of distilled liquor to be added to the extract.
- The base wine to be used as extract.

- Preparation of the vermouth extract: The calculator considers two possibilities:

- Option 1: Make the wine boil with the ingredients, filter, and sweeten the mixture.
- Option 2: Make part of the wine boil with the ingredients, filter, and sweeten the mixture. Then adding the remaining wine.
- Option 3: Macerate the ingredients in the wine between ten to thirty days. This method requires adequate temperature control, as well as optimal humidity conditions.

3. Results

Three traditional vermouth formulations are presented. The doses come from the production of 100 liters of vermouth formulation.

3.1. Formulation 1

The following ingredients are used in this formulation.

Table 1. Ingredients and dosage

Ingredient	Grams	Ingredient	Grams
Artemisia arborescens	180	*Benzoin*	30
Teucrium chamaedrys	80	*Cinchona ledgeriana*	50
Hyssopus officinalis	76	*Quassia amara*	50
Salvia hispánica	30	*Canella*	40
Centaurium erythraea	40	*Curcuma longa*	60
Centaurium erythraea	2	*Syzygium aromaticum*	20
Crocus sativus	50	*Coriandrum sativum*	90
Alpinia officinarum	40	*Illicium verum*	20
Acorus calamus	80	*Agarico*	40
Gentiana	40	*Citrus × aurantium*	50

The amount of sugar in the form of caramel of 12%, 5% of alcohol, where the method of production 1 has been chosen.

The results shown by the calculator are illustrated in Table 2 and 3.

Table 2. Global environmental impact (kg CO_2 eq / liter of vermouth formulation) by CML-IA baseline V3.04/EU25

Herbs and plants	Electricity	Sugar
1.7172E-02	5.4833E-02	5.8563E-03
Alcohol	**Red wine**	**Labor**
4.8657E-01	1.2680E+00	2.5021E-03
TOTAL		**1.8349E+00**

Table 3. Total impact (eco-point) by ReCiPe

Herbs and plants	Electricity	Sugar
0.110	0.055	0.006
Alcohol	**Red wine**	**Labor**
0.049	1.599	0.001
TOTAL		**1.840**

3.2. Formulation 2

The following ingredients are used in this formulation.

Table 4. Ingredients and dosage

Ingredient	Grams	Ingredient	Grams
Artemisia arborescens	200	*Crocus sativus*	60
Thymus	100	*Alpinia officinarum*	60
Cnicus benedictus L.	80	*Acorus calamus*	80
Dictamnus albus	70	*Iris sp.*	40
Sambucus nigra L.	100	*Canella*	80
Centaurium erythraea	2	*Syzygium aromaticum*	40
Pimpinella anisum	20	*Arillus*	50
Coriandrum sativum	80	*Citrus × aurantium*	90

The amount of sugar in the form of caramel of 12%, 5% of alcohol, where the method of production 1 has been selected.

The results shown by the calculator are displayed in Table 5, 6, and Figure 2:

Table 5. Global environmental impact (kg CO2 eq / liter of vermouth formulation) by CML-IA baseline V3.04/EU25

Herbs and plants	Electricity	Sugar
6.5213E-02	5.4833E-02	5.8563E-03
Alcohol	**Red wine**	**Labor**
4.8657E-01	1.2680E+00	4.3906E-03
TOTAL		**1.8849E+00**

Table 6. Total impact (eco-point) by ReCiPe

Herbs and plants	Electricity	Sugar
0.092	0.055	0.006
Alcohol	**Red wine**	**Labor**
0.092	0.055	0.006
TOTAL		**1.803**

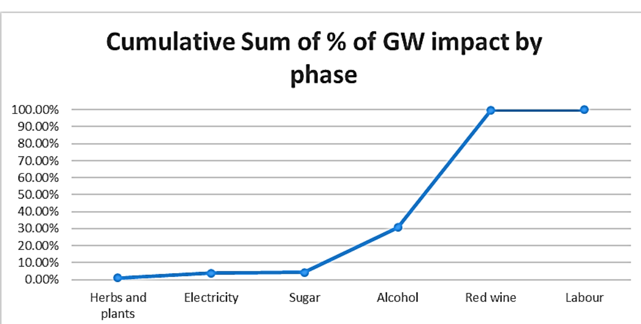

Figure 2. Global Warning impact evolution by phase.

3.3. Formulation 3

The following ingredients are used in this formulation..

Table 7. Ingredients and dosage

Ingredient	Grams	Ingredient	Grams
Artemisia arborescens	130	*Centaurea*	120
Gentiana	60	*eucrium chamaedrys*	120
Angelica	60	*Canella*	100
Cnicus benedictus L.	120	*Myristica*	15
Acorus calamus L.	120	*Artemisia arborescens*	130
Inula helenium	120	*Gentiana*	60

The amount of sugar in the form of caramel of 12%, 5% of alcohol, where the method of production 1 has been selected.

The results shown by the calculator are displayed in Tables 8 and 9:

Table 8. Global environmental impact (kg CO2 eq / liter of vermouth formulation) by CML-IA baseline V3.04/EU25

Herbs and plants	Electricity	Sugar
6.5213E-02	5.4833E-02	5.8563E-03
Alcohol	**Red wine**	**Labor**
4.8657E-01	1.2680E+00	4.3906E-03
TOTAL		**1.8849E+00**

Table 9. Total impact (eco-point) by ReCiPe

Herbs and plants	Electricity	Sugar
0.120	0.055	0.006
Alcohol	**Red wine**	**Labor**
0.049	1.599	0.001
TOTAL		**1.830**

4. Conclusions

As a matter of fact, the main objective of this study was to obtain a complete environmental vision of the different activities involved in the process of making formulations for vermouth. The study has developed an environmental impact calculator, which considers each stage of the life cycle through the LCA methodologies; CML-IA baseline V3.04/EU25 and RECIPE V1.13. In addition, three formulations have been analyzed with the same manufacturing procedure.

Consequently, results show that the determining stages in terms of environmental impacts are the electrical energy consumed, as well as the addition of sugar and wine to each formulation. The results also indicate that the production of a liter of red vermouth generates an average environmental impact of 1.88 kg CO2 eq/liter of vermouth formulation in the Global environmental impact category, and a total of between 1.803 and 1.8eco-points in the Total impact category of ReCiPe.

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