# DESIGN OF A SMART PACKAGING FOR SHERRY WINES THROUGH HOLONIC ENGINEERING

Ignacio Sena-Trujillo, María-Jesús Ávila-Gutiérrez and Juan-Ramón Lama-Ruiz.
Universidad de Sevilla (Spain)

DOI: https://dx.doi.org/10.6036/10486

## 1.- INTRODUCTION

The wine industry at Jerez de la Frontera area has an extensive production of wines, liqueurs and natural sweet wines. A total of 57,534,209 kg of crushed grapes are used for this purpose, according to the most recent grape harvest report published [1]. The consumption of these wines is mainly in European countries, although they are also distributed to the American and Asian continents thanks to improvements in their distribution channels. In addition, new dissemination mechanisms are being adopted, a good example being the creation of events such as the International Sherry Week [2], which is held in 39 different countries. The aforementioned data contrasts with the scarce evolution of wine packaging.

Currently, "Sherry" is being commercialized in a packaging that is almost identical to the one used at the beginning of the Modern Age. In recent years, studies have been carried out on the packaging, focused on reducing and eliminating some of the problems detected by the Sherry Wines Regulatory Council. A special value is given to the guarantee of origin and the absence of confusing information on the label. On the other hand, internal and external factors are identified, which alter the quality of the wine and the drinking experience, such as: the optimum temperature at which the wine should be served, the existence of wine lees and the cork taste given off by the colonies of molds found on the stopper [3].

This study shows a methodological contribution for the design of smart products from holonic engineering [4] in order to materialize an active and intelligent packaging, which adopts sustainability as design principles and can be adapted without impediments to current markets.

## 2.- RESEARCH OF DESIGN METHODOLOGIES APPLIED TO THE PACKAGING INDUSTRY

The initial phase of the research focuses on the search for information in scientific articles, publications and manuals. The data extracted are analysed to see which are the tools considered to be the most appropriate to the challenge imposed and in this way the Holonic Framework of the study is configured.

Among the methodologies found in the literature, the following are analysed: AHP, QFD, FAST, TRIZ, framework for the selection of techniques for requirement extraction, morphological chart and value analysis. These methodologies share a common use in the conceptual product design phase and are briefly described below.

**AHP (Analytic Hierarchy Process).** Hierarchical analysis is a useful evaluation method in decision making that allows structuring a multi-criteria problem in a visual way, given the construction of a hierarchical model containing three levels: objective, criteria and alternatives [5]. It is used in the conceptual and product detail phases. Among the main advantages of this tool are the condition of homogeneity between variables, given the application of the same common scale in all the elements of the model, and the possibility of verifying the consistency of the decision.

**QFD (Quality Function Deployment, QFD).** Quality function deployment is a method that measures and guarantees the quality of the product and the design process. QFD has the advantage of being very flexible, allowing the design team to use one or more of the methodology matrices, depending on the type of project to be developed [6,7]. This methodology is applicable to the conceptual design, production and market phases.

**FAST (Functional Analysis System Technique).** The functional analysis technique is a method that organises and represents the different functional relationships of a system. In general lines, the FAST diagram begins with a list of functions, which are characterised and subsequently classified. These functions are given a hierarchical order or sequence, which positions them in the diagram as input, intermediate or output functions [8]. The contribution contributes to the functional analysis phase of the Value Methodology.

**TRIZ (Theory of Inventive Problem Solving).** The theory of inventive problem solving is a methodology for innovative problem solving. In the process of designing and developing an innovative product, principles are identified and applied as a method to support creative thinking. This methodology is widely used in various fields of research and is very useful in the simplification of products and processes, in the resolution of contradictions and conflicts [9,10].

**Framework for the selection of extraction techniques.** It is a useful tool to make the designer aware of the degree of suitability of each of the possible techniques applicable to a study. The extraction technique is usually selected by the designer for reasons unrelated to its effectiveness, i.e. because it is the technique they are usually familiar to them without thinking that it might be suitable for the design case under study. Moreover, this decision has a powerful influence on the quality of the requirements and of the final product designed. For this reason, a methodological guide is defined with three basic steps that allow us to identify the most effective techniques in a given situation [11,12].

**Morphological Chart.** It is considered a method of generating alternatives based on the search for solutions to product functions. The combination of these results in a number of possible viable options to solve a problem [13, 14]. The morphological chart starts from the list of product functions; these are identified in the first two columns and the remaining columns are completed with the alternatives and/or possible design solutions.

**Value analysis.** This analysis focuses on the idea: "the value that a customer attributes to a product is determined by the contribution of the product's functions to the satisfaction of his real needs" [15,16]. Value analysis takes into consideration the cost involved in satisfying those needs and establishes the final decision based on the alternative with the highest functional contribution at the lowest cost. Value engineering [17,18] structures the possible manufacturing costs of a product or product line of interest in the design and redesign for a target process cost. Its applicability is found in almost all phases of the process of design and development of industrial products (PDDIP).

Based on the analysis of the different methodologies, a classification can be made according to their use in the PDDIP stage and the type of product view where they could be applied. This classification is shown in Table 1:

*Table 1. Summary of design methodologies, application phases and use perspective.*

| | PHASES OF PDDIP* | | | | | | | VIEWPOINT | |
|---|---|---|---|---|---|---|---|---|---|
| METHODOLOGY | (1) | (2) | (3) | (4) | (5) | (6) | (7) | Macro | Micro |
| AHP | X | X | X | - | - | - | - | YES | YES |
| QFD | - | X | - | - | X | X | - | YES | YES |
| FAST | X | X | - | - | - | - | - | NO | YES |
| TRIZ | - | X | X | - | - | - | - | NO | YES |
| REQUIREMENTS EXTRACTION | X | X | - | - | - | - | - | YES | NO |
| MORPHOLOGICAL CHART | - | X | X | - | - | - | - | NO | YES |
| VALUE ANALYSIS | - | X | X | X | X | X | - | NO | YES |

*(1) Product idea conception, (2) Conceptual design, (3) Detail design, (4) Verification and testing, (5) Production, (6) Market and (7) Final disposal.

## 2.1.- PROPOSED METHODOLOGY

Due to the wide range of existing tools in conceptual product development and the non-existence of a method focused on packaging redesign, it was decided to use a novel approach developed in the Holonic engineering publication [4] and shown in Figure 1.


ISSN: 0012-7361 eISSN: 1989-1490 / DYNA Vol.97 n.5 DOI: https://doi.org/10.6036/10486

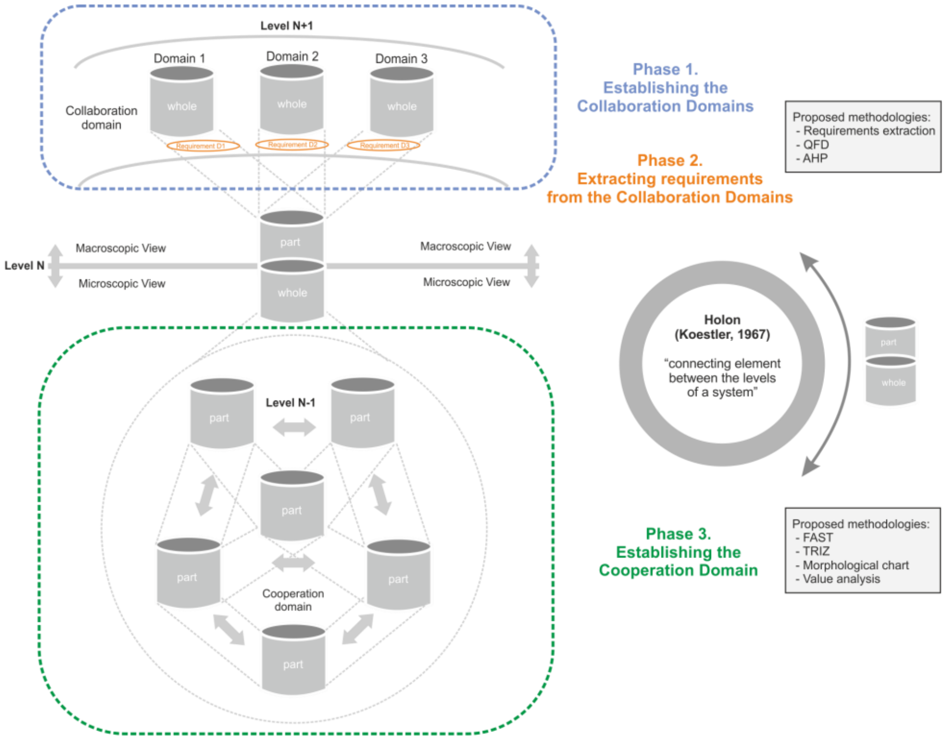


*Figure 1. Formal model of the Holonic paradigm and key phases of methodological application.*

The Holonic framework is structured in three levels of concreteness as shown in Figure 1.

At **level N** or product domain, the product object of the study is formulated: the design and development of a smart packaging for Sherry wine . This domain will be constantly fed back and updated by the information contained in its microscopic and macroscopic vision.

At the **level N+1** or Collaboration Domain, the smart packaging is studied as part of a set of domains from which a set of functional requirements (FR) are extracted. For the development of this level, the techniques of requirements extraction are applied together with the proposed Framework for the selection of these, AHP and QFD.

In the **level N-1** or Cooperation Domain, the product works as a whole. In other words, the intelligent packaging is made up of all its components whose design is shaped by taking into account the information from the macroscopic level. At this level, the tools FAST, TRIZ and morphological charts are applied, obtaining as a result a set of alternatives for the smart packaging that will be evaluated by means of value analysis.

## 3.- METHODOLOGICAL APPLICATION TO SMART PACKAGING

Design and development of an smart packaging for Sherry wines is approached following the three phases shown in Figure 1. In the following, the work carried out is described in more detail, and the methodologies and tools applied in this study are cited.

### 3.1.- PHASE 1. ESTABLISHMENT OF COLLABORATION DOMAINS

This phase is defined on the basis of the domains considered to be relevant to the object of the research. The definition of the domains of level N+1 are the result of the study of the current technology, prospective study and the study of the life cycle of the wine packaging being marketed. As a result of this first phase, five domains of action of the smart packaging for Sherry wines are obtained, as follows: Domain 1: customers; Domain 2: points of sale; Domain 3: wineries; Domain 4: logistics; Domain 5: regulations.


ISSN: 0012-7361 eISSN: 1989-1490 / DYNA Vol.97 n.5 DOI: https://doi.org/10.6036/10486

## 3.2.- PHASE 2. EXTRACTION OF REQUIREMENTS FROM THE COLLABORATION DOMAIN

The objective of this phase is to obtain a list of FRs from the previously established domains. For this purpose, requirements extraction techniques are applied following Moreno and Dieste's Framework Proposal [12]. This study is detailed in *Annex I.*

After applying the requirements extraction techniques, a list of needs linked to each of the defined domains is obtained. In addition, a deployment is carried out that allows detailing the way in which each need (N) is materialised. As a result, the corresponding function, FR, design parameters and components are obtained for each requirement, as shown in *Annex II.* These are required as inputs in the QFD matrices.

At this point, the study focuses on considering that a good design promotes the satisfaction of most of the needs presented. However, it is unfeasible to maintain the same degree of prominence in all of them. For this reason, AHP and QFD tools are applied. AHP allows us to calculate a weight vector for each group of needs belonging to a domain. This vector gives the real importance of each N in the design. It is essential to check the consistency of each of these vectors (CR ≤ 0.1). The steps to follow are shown in Figure 2.

Translated with www.DeepL.com/Translator (free version)

Weight vector calculation (W1)

| Domain 1 | N1 | N2 | N3 | N4 | N5 |
|---|---|---|---|---|---|
| Weights | 0,1081 | 0,2798 | 0,3687 | 0,1351 | 0,1081 |

(W1) is the input od QFD-I

The list of needs, function, components and process is obtained:

Needs (N). Components (C).
Functions (F). Process (P).

QFD-I Matrix. Domain 1.

| | W1 | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|---|
| N1 | 0,1081 | 9 | | | | 3 |
| N2 | 0,2798 | 3 | 9 | | 9 | 9 |
| N3 | 0,3687 | | 3 | 9 | 1 | 1 |
| N4 | 0,1351 | 1 | 9 | | 9 | 3 |
| N5 | 0,1081 | 3 | | | | 9 |
| | ABSOLUTE SCORE | 2,2717 | 4,8402 | 3,3183 | 4,1028 | 4,5894 |
| | RELATIVE SCORE | 0,1187 | 0,2531 | 0,1735 | 0,2145 | 0,2400 |
| | RANKING | 5 | 1 | 4 | 3 | 2 |

QFD-II Matrix. Domain 1.

| | W2 | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|
| F1 | 0,1187 | 9 | | | | 9 |
| F2 | 0,2531 | 3 | 9 | | | |
| F3 | 0,1735 | | | 9 | | |
| F4 | 0,2145 | 1 | 3 | | 9 | |
| F5 | 0,2400 | | 3 | 3 | 1 | 9 |
| | ABSOLUTE SCORE | 1,2828 | 3,6414 | 2,2815 | 2,1705 | 3,2283 |
| | RELATIVE SCORE | 0,1017 | 0,2888 | 0,1810 | 0,1722 | 0,2561 |
| | RANKING | 5 | 1 | 3 | 4 | 2 |

QFD-III Matrix. Domain 1.

| | W3 | P1 | P2 | P3 | P4 | P5 |
|---|---|---|---|---|---|---|
| C1 | 0,1017 | 9 | | | | 3 |
| C2 | 0,2888 | | 9 | | | |
| C3 | 0,1810 | 1 | | 9 | | 1 |
| C4 | 0,1722 | | | | 9 | |
| C5 | 0,2561 | 1 | | 1 | | 9 |
| | ABSOLUTE SCORE | 1,35524 | 2,5992 | 1,8851 | 1,5498 | 2,7919 |
| | RELATIVE SCORE | 0,1328 | 0,2553 | 0,1852 | 0,1522 | 0,2742 |
| | RANKING | 5 | 2 | 3 | 4 | 1 |

*Figure 2. QFD application in domain 1.*

This process must be replicated with the inputs corresponding to the five established domains. Once the calculations have been completed, the information is available for further study, this time from a microscopic point of view.

## 3.3.- PHASE 3. ESTABLISHMENT OF THE COOPERATION DOMAIN

At this phase, support tools are applied and the concept of a smart product is introduced in the packaging configuration: "a product that meets at least one of the following characteristics: situable, customisable, adaptive, proactive, legally accepted, traceable and network capable" [15].

First, the list of functions is obtained, using the FAST diagram [8]. After the application of FAST, 6 mandatory functions are considered out of the 30 functions that constitute the initial list. These are F2, F4, F6, F24, F25 and F27. The functional domain is developed in *Annex III.*

The remaining 24 functions will be analysed to determine their importance from the "product as a whole" perspective of the microscopic vision. For this purpose, we have the list of functions and the weights of each one in its corresponding domain. Both will be used as


ISSN: 0012-7361 eISSN: 1989-1490 / DYNA Vol.97 n.5 DOI: https://doi.org/10.6036/10486

inputs when defining the columns of the interdomain QFD. While the collaboration domains together with their weights will be the inputs that define the rows of the aforementioned matrix. The AHP tool is used to calculate the weights.

After this, interdomain AHP is applied, which encompasses the five domains of the study as shown in Figure 3. Generating an isolated AHP view for each of the domains is not appropriate for the microscopic view and would therefore be erroneous. In the first and second step, the domains are confronted in a matrix of paired comparisons and the vector SUM is obtained. This vector allows the absolute values of each cell of the matrix to be obtained. In the third and fourth steps, the possible weights that each of the domains will take and their sum is calculated. Finally, a contrast test (CR ≤ 0.1) is carried out to determine whether these results fall within the consistency values. This condition is essential for them to be used as the definitive weights of the interdomain QFD (inputs in the rows), which will form the new matrix together with the weights of the different functions (inputs in the columns) calculated in the QFD-1 matrix, step 4. Once the interdomain QFD matrix is completed, a hierarchy of the 24 functions entered is obtained.

The next step involves defining the total number of functions that are retained in this phase of the study. In this case, it is decided to continue with a count of 15 functions; of which 6 mandatory functions have been defined. The remaining 9 are designated as doubtful functions and will be those with the highest scores in the hierarchy. These are functions F1, F3, F5, F7, F9, F10, F19, F22 and F23. It is emphasised that the functions with low scores are omitted as it is considered that it is not necessary to focus this study on their fulfilment as shown in Figure 3.

**Step 1. AHP. Paired comparison matrix**

| Domain 1. User, client / consumer | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Paired comparison matrix | | | | | | | | | | |
| | 9 | 7 | 5 | 3 | 1 | 1/3 | 1/5 | 1/7 | 1/9 | |
| N1 | | | | | | X | | | | N2 |
| N1 | | | | | | X | | | | N3 |
| N1 | | | | | X | | | | | N4 |
| N1 | | | | | X | | | | | N5 |
| N2 | | | | | X | | | | | N3 |
| N2 | | | | | X | | | | | N4 |
| N2 | | | | X | | | | | | N5 |
| N3 | | | X | | | | | | | N4 |
| N3 | | | | X | | | | | | N5 |
| N4 | | | | | X | | | | | N5 |

**Step 2. AHP. Matrix A**

| Domain 1. User, client/consumer | | | | | |
|---|---|---|---|---|---|
| Matrix A | | | | | |
| | N1 | N2 | N3 | N4 | N5 |
| N1 | 1 | 1/3 | 1/3 | 1 | 1 |
| N2 | 3 | 3 | 1 | 1 | 3 |
| N3 | 3 | 3 | 1 | 5 | 3 |
| N4 | 1 | 1 | 1/5 | 1 | 1 |
| N5 | 1 | 1/3 | 1/3 | 1 | 1 |
| Total | 9 | 11/3 | 43/15 | 9 | 9 |

**Step 3. AHP. Matrix A1**

| Domain 1. User, client/consumer | | | | | | | |
|---|---|---|---|---|---|---|---|
| | N1 | N2 | N3 | N4 | N5 | Total | Weight |
| N1 | 1 | 1/3 | 1/3 | 1 | 1 | 0,5405 | 0,1081 |
| N2 | 3 | 3 | 1 | 1 | 3 | 1,3993 | 0,2798 |
| N3 | 3 | 3 | 1 | 5 | 3 | 1,8437 | 0,3687 |
| N4 | 1 | 1 | 1/5 | 1 | 1 | 0,6758 | 0,1351 |
| N5 | 1 | 1/3 | 1/3 | 1 | 1 | 0,5405 | 0,1081 |
| | | | | | | Σ | 0,0998≈1 |

**Step 4. AHP.**

$$W'=A*W=\begin{bmatrix}1 & 1/3 & 1/3 & 1 & 1\\ 3 & 3 & 1 & 1 & 3\\ 3 & 3 & 1 & 5 & 3\\ 1 & 1 & 1/5 & 1 & 1\\ 1 & 1/3 & 1/3 & 1 & 1\end{bmatrix}*\begin{bmatrix}0,1081\\ 0,2798\\ 0,3687\\ 0,1351\\ 0,1081\end{bmatrix}=\begin{bmatrix}0,5661\\ 1,4301\\ 1,9702\\ 0,7033\\ 0,5666\end{bmatrix}$$

$$\lambda max=\frac{1}{5}*\left[\frac{0,5661}{0,1081}+\frac{1,4301}{0,2798}+\frac{1,9702}{0,3687}+\frac{0,7033}{0,1351}+\frac{0,5666}{0,1081}\right]=5,2310$$

$$CI=\frac{\lambda max-n}{n-1}=\frac{5,2310-5}{5-1}=0,0581$$

$$CR=\frac{CI}{random\ index}=\frac{0,0581}{1,12}=0,0521\leqslant 0,1\ \text{Es consistente}$$

| **Domain 1** | **N1** | **N2** | **N3** | **N4** | **N5** |
|---|---|---|---|---|---|
| Pesos a utilizar | 0,1081 | 0,2798 | 0,3687 | 0,1351 | 0,1081 |

**Step 5. Interdomain QFD**

| | Pesos | F1 | F3 | F5 | F7 | F8 | F9 | F10 | F11 | F12 | F13 | F14 | F15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **D1** | 0,3534 | 0,1187 | 0,1735 | 0,2400 | | | | | | | | | |
| **D2** | 0,2096 | | | | 0,1598 | 0,1207 | 0,1951 | 0,2945 | 0,1129 | | | | |
| **D3** | 0,0685 | | | | | | | | | 0,2785 | 0,0655 | 0,1386 | 0,1354 |
| **D4** | 0,2828 | | | | | | | | | | | | |
| **D5** | 0,0854 | | | | | | | | | | | | |
| | | 0,0419 | 0,0613 | 0,0849 | 0,0334 | 0,0252 | 0,0408 | 0,0617 | 0,0236 | 0,0190 | 0,0046 | 0,0094 | 0,0092 |
| | | 0,0611 | 0,0895 | 0,1238 | 0,0487 | 0,0367 | 0,0595 | 0,0900 | 0,0314 | 0,0277 | 0,0067 | 0,0137 | 0,0134 |
| | | 5 | 3 | 1 | 8 | 14 | 6 | 2 | 13 | 16 | 23 | 19 | 20 |

| | Pesos | F16 | F17 | F18 | F19 | F20 | F21 | F22 | F23 | F26 | F28 | F29 | F30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **D1** | 0,3534 | | | | | | | | | | | | |
| **D2** | 0,2096 | | | | | | | | | | | | |
| **D3** | 0,0685 | 0,0601 | 0,1866 | 0,1319 | | | | | | | | | |
| **D4** | 0,2828 | | | | 0,1781 | 0,0960 | 0,0954 | 0,1074 | 0,1406 | | | | |
| **D5** | 0,0854 | | | | | | | | | 0,3118 | 0,1609 | 0,2536 | 0,0945 |
| | | 0,0041 | 0,0127 | 0,0090 | 0,0503 | 0,0271 | 0,0269 | 0,0303 | 0,0397 | 0,0266 | 0,0137 | 0,0216 | 0,0080 |
| | | 0,0059 | 0,0185 | 0,0131 | 0,0734 | 0,0395 | 0,0392 | 0,0442 | 0,0579 | 0,0389 | 0,0200 | 0,0315 | 0,0116 |
| | | 24 | 18 | 21 | 4 | 10 | 11 | 9 | 7 | 12 | 17 | 15 | 22 |

*Figure 3. AHP and QFD interdomain.*

In order to obtain innovative and valuable solutions for the product, TRIZ is applied to the functions that respond to technical or technological aspects of the product, as this tool guarantees good results in this type of functions. The TRIZ results are presented together with the rest of the solutions using the Morphological Charts technique, which is detailed in *Annex IV*.

## 4.- FINAL SOLUTION

The final design alternative is chosen using the Value Added Methodology. This action is firstly based on the classical Value Analysis and then extrapolated to the holonic paradigm, thus formulating a holonic Value Analysis from which a %CDC is obtained for each


ISSN: 0012-7361 eISSN: 1989-1490 / DYNA Vol.97 n.5 DOI: https://doi.org/10.6036/10486

domain. From these values and the weights generated in interdomain AHP, value indices are calculated. Finally, the results obtained for each alternative are represented graphically by means of a scatter diagram. These steps are summarised in Figure 4.

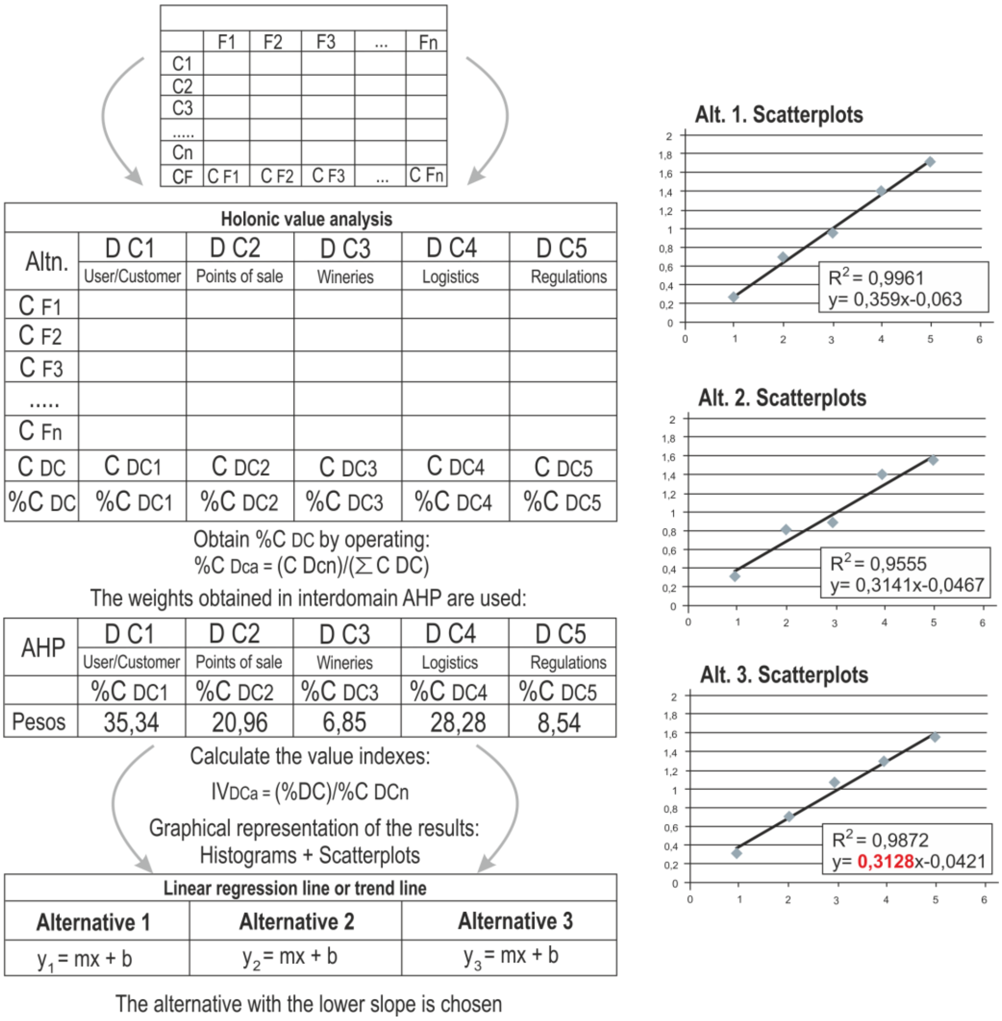


*Figure 4. Alternative 3 selection.*

The choice of alternative 3 as the final solution is mainly supported by two aspects: R2 = 0.9872 and m = 0.3128. First, the alternative selected will be the one whose coefficient of determination (R2) is closest to 1.00. This indicates that the reliability of the results is higher and that the quality of the fit is statistically better for that alternative. The second decision factor involves choosing the alternative whose line has the smallest slope (m). That is, the option that realises the needs presented, in the collaboration domains, in a more equitable way.

Alternative 3 is presented as a smart packaging proposal for the variety of wines produced in Jerez de la Frontera. Its main features are:

- The opening and closing system has an innovative design that prevents repeated contact between the wine and the cork. This eliminates the flavour notes typical of the colonies of this material in the wine. The upper part consists of a temperature sensor plate. The lower part of this system is used for decanting the sediment. Moreover, its handling is safer as it does not require the use of a corkscrew.
- The base of the bottle is equipped with RFID technology, thanks to which it is possible to check for unauthorised handling and whether the product complies with the regulatory requirements of the designation of origin.
- The body of the bottle is more resistant and reusable.


ISSN: 0012-7361 eISSN: 1989-1490 / DYNA Vol.97 n.5 DOI: https://doi.org/10.6036/10486

- The proposal unifies the type of packaging for the variety of wines produced in Jerez de la Frontera area. These are differentiated by the characteristic colour of the type of wine, enhancing the image of the product and making it easily recognisable from other wines.

This reaffirms the potential for improvement of the study result as shown in Figure 5.

*Figure 5. Final design solution for sherry wine variety and opening-closing system.*

## 5.- CONCLUSIONS

As a result of the initial research, it is concluded that the methodologies analysed have their recommended use in some phase of the PDDIP, but none of them, in isolation, allows the product to be designed as a whole. Therefore, a design methodology is needed that covers the product in a complete way in all its views and at the same time makes use of the potential of these tools. In this sense, the holonic paradigm is a methodological framework suitable for this purpose and makes the designed packaging meet the requirements of the domains at both macro and microscopic levels. Furthermore, it should be noted that the use of this proposed methodology can be extrapolated to any product, so that this work can constitute a user manual for product designers who require it.

According to the requirements established in the domains of the collaboration domain, it can be highlighted that the design proposal guarantees a correct consumer experience, thus securing the attraction of a greater number of potential customers. Furthermore, this packaging is advantageous given the reduction in the number of bottles returned for reasons linked to the cork taste and/or the existence of lees in the wine.

Regarding the logistics of the wine contained in this smart packaging, it is more operative due to the incorporation of RFID technology, which allows instant reading and updating of the documentation attached to the product.

The smart packaging is a good successor to the traditional packaging currently used in the wine industry as it provides an answer to the problems described, encouraging commitment to the environment as the cost of the packaging can be recovered by returning it, at an authorised point of sale, after consumption.

On the other hand, it should be noted that compliance and obtaining certifications is another attraction, as the initial requirements in the collaboration domain were established in this way. These environmental standards focus on reducing the company's environmental impact, thus generating social and environmental benefits.

## REFERENCES

[1] Informe de la vendimia https://www.sherry.wine/node/8098 [13 de Septiembre de 2021]

[2] International Sherry Week https://www.sherry.wine/es/sherryweek [07 de Abril de 2021]

[3] González, C.S. (2012). Desarrollo y optimización de nuevas metodologías analíticas de microestracción en fase líquida para la determinación de compuestos responsables del sabor a corcho y del carácter Brett en matrices enológicas. (Doctoral dissertation, Universidad de La Rioja).

[4] Ávila-Gutiérrez, M., Lama-Ruiz, J., Aguayo-Gonzalez, F.. (2020). Design of a sustainable streetlamp under holonic paradigm. Dyna,


ISSN: 0012-7361 eISSN: 1989-1490 / DYNA Vol.97 n.5 DOI: https://doi.org/10.6036/10486

95(5). 468-472. DOI: https://doi.org/10.6036/9326.

[5] Saaty, T. L. (1980). The Analytic Hierarchy Process (AHP). The Journal of the Operational Research Society, 41(11), 1073-1076.

[6] Akao, Y. (1997, October). QFD: Past, present, and future. In International Symposium on QFD (Vol. 97, No. 2, pp. 1-12).

[7] Cristiano, J. J., Liker, J. K., & CC III, W. (2001). Key factors in the successful application of quality function deployment (QFD). IEEE transactions on engineering management, 48(1), 81-95.

[8] Borza, J. (2011). FAST diagrams: The foundation for creating effective function models. General Dynamics Land Systems.

[9] Ilevbare, I. M., Probert, D., & Phaal, R. (2013). A review of TRIZ, and its benefits and challenges in practice. Technovation, 33(2-3), 30-37.

[10] Savransky, S. D. (2000). Engineering of creativity: Introduction to TRIZ methodology of inventive problem solving. CRC press.

[11] Moreno, D. H. C., & DIESTE, O. (2009). Marco para la selección de técnicas de educción de requisitos. Madrid, España. Mayo.

[12] Carrizo, D., Dieste, O., & Juristo, N. (2014). Systematizing requirements elicitation technique selection. Information and Software Technology, 56(6), 644-669.

[13] Cely, C., Andrés, C., & Bonilla Mora, H. (1850). Análisis Morfológico: una propuesta metodológica para el Diseño. Actas de Diseño. Facultad de Diseño y Comunicación. Universidad de Palermo. ISSN, 1850, 2032.

[14] Celani, G. (2009). Enseñando diseño generativo: una experiencia didáctica [Teaching Generative Design: a Learning Experience].

[15] Gutiérrez, C., Garbajosa, J., Diaz, J., & Yagüe, A. (2013, April). Providing a Consensus Definition for the Term "Smart Product". In 2013 20th IEEE International Conference and Workshops on Engineering of Computer Based Systems (ECBS) (pp. 203-211). IEEE.

[16] Arbós, L. C. (2012). El producto. Análisis de valor: Organización de la producción y dirección de operaciones. Ediciones Díaz de Santos.

[17] Navarro, D. (2006). Seguimiento de proyectos con el Análisis del Valor Ganado. Universidad Nacional de Colombia.

[18] Sacristán, F. R. (2007). Análisis del valor añadido para mejorar la productividad. Técnica Industrial, 267, 43.



ISSN: 0012-7361 eISSN: 1989-1490 / DYNA Vol.97 n.5 DOI: https://doi.org/10.6036/10486