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A multicriteria system useful for evaluating the eco-performances of food packaging connected to the functional, communicative and design criteria

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Abstract: The paper is aimed at illustrating a multidisciplinary research, which is funded by the Piedmont Region and involves several research units belonging to different institutions. Within this project, the Research Unit of Industrial Design of DAD (Department of Architecture and Design, Politecnico di Torino) is carried out with the aim of outlining a multicriteria methodology for assessing the level of sustainability of food packaging, useful not only for assessing the functional, communicative, environmental and design criteria, but also for identifying the weakness of the food packaging that should be improve with a new design.

Keywords: food packaging, environmental life cycle performances, evaluation system and method, packaging end-of-life treatments

1. Introduction

The paper deals with a multidisciplinary research Poliedro (Pollenzo Index Environmental and Economics). This research is aimed at developing a sustainability index able to evaluate at the same level, the environmental, social and economic variables that influence the performances of the agri-food product throughout its entire life cycle. In other words, Pollenzo Index would be a single score that summarize and evaluate the agri-food performances on a scale of five ranges, that could be

adopted by the local producers for assessing the sustainability of their product and manufacturing processes and, at the same time, that could be useful for the consumer during the choice of more sustainable agri-food products.
Within this project, a specific work-package (which is carried out by Research Unit of Industrial Design DIPRADI, Department of Architecture and Industrial Design, Politecnico di Torino) is focused on the food packaging, with the purpose to outline a multi-criteria methodology for assessing the sustainability level of the food packaging which must be integrated into the wider Pollenzo index.
Usually packaging sustainability is evaluated by taking into account mainly environmental criteria, with very well-known indicators, such as Carbon Footprint, Embodied Energy, percentage of recycled materials and by forgetting others important aspects, such as functional, communicative and design (Shape, Colours, Material) requirements that have to be satisfied by a food packaging. Consequently the research has been focused on the relationships between the environmental and functional and communicative requirements [17].
Environmental requirements related to resources and energy consumption and to waste generation and air emissions. Functional requirements linked to the need of correctly using the packaging, and communicative requirements concerning the need to recognise and identify the food content [13].

2. Food Packaging State of the Art

According to this goal, the research has been started from an analysis of the state of the art of the food packaging.
Currently the main criticisms concerning the food packaging are due to its short life cycle, since the food consumption lead shortly to the packaging end of life with an increase of the waste amount into the landfill. In the EU countries packaging waste represent about the 30% in mass of the total Municipal Solid Waste (MSW) produced yearly [1]
In order to tackle this problem, preventive strategies for increasing the recyclability potential of the constituent materials and eco-design guidelines for improving the environmental life cycle performances of the packaging have emerged [2].
These strategies were addressed in the EU Directives 94/62/EC - 2004/12/EE, which has led to the creation of national consortia for the management of packaging wastes, but have not yet yielded the expected results. At European level, while on one hand, the percentages of recycling of packaging materials are increasing, underlining the efficiency of consortia dedicated to this purpose, on the other hand, the continuous increase per capita production of packaging waste highlights how these prevention practices are not yet consolidated [3].
Moreover LCA studies about food packaging are available, but generally the outcomes of these studies don’t take into account the existing relationships between the environmental and the functional and communicative requirements that in any case must be satisfied throughout the packaging life cycle. As a result the existing LCA are strictly focused on the evaluation of the food packaging environmental performances that can be quantified, without including an assessment of the other requirements that should be estimated by using qualitative criteria. In addition, since, during the food production phase the packaging itself becomes as an ingredient of the food product, rarely these LCA studies consider the existing relationships between the food production and packaging chains.

On these assumptions by adopting a life cycle approach, the research has been started by comparing the life cycle of the food product and the packaging (Fig. 1).

From this comparison, it can be noted that while the phases of production, packaging, transport, purchase and consumption of the product can be directly controlled by the agri-food producer, the pre-production and end-of-life phases are the responsibility of others players, who are involved in the life cycle.

Consequently the requirements identification on which is based the assessment of the packaging eco-compatibility firstly was focused on identifying the requirements that must be met during the stages of the life cycle directly controlled by the agri-food producer and, secondary, was extended to include the requirements that must be also satisfied in the other phases not directly controlled by the food producer.

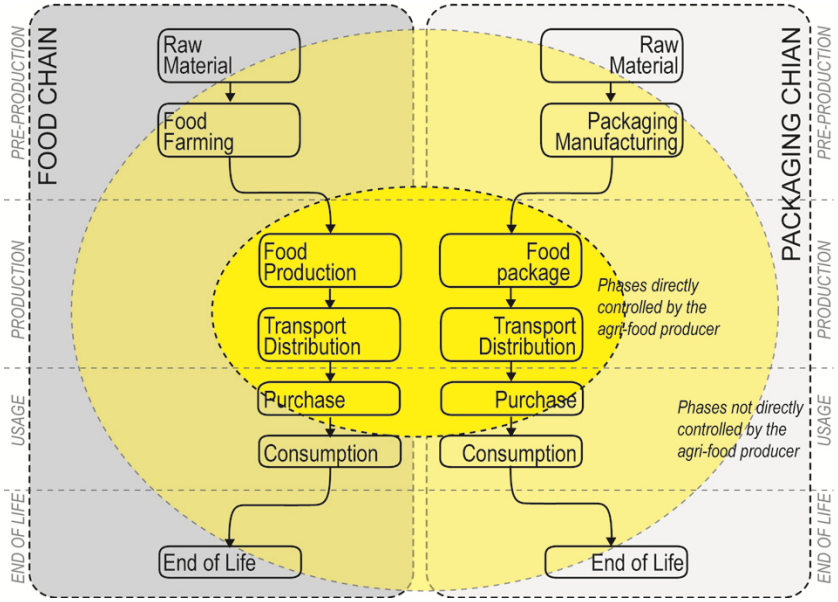

Figure 1. Comparison between Packaging and Food life cycles

In this way, it has been possible to point out the several qualitative and quantitative requirements that have been included into the multi-criteria assessment.

3. Methodological Approach for defining multi-criteria evaluation system of the food packaging

In order to define the multi-criteria evaluation of packaging performances, the methodological approach adopted into the research has been divided into the following phases:

- selection and analysis of the food product in order to delineate a reference scenario,
- identification of the packaging requirements that are converted as evaluation criteria included into the packaging assessment;
- definition of the qualitative and quantitative evaluation criteria adopted into the packaging multi-criteria assessment;
- conversion of the several criteria assessment in a single index, which is representative of the performances packaging in a scale of 5 range: very bad, bad, average, good and excellence with its representation by a spider graph.

4. Selection of the Food Packaging Case Studies and Packaging Analysis

On these background studies, the research starts with the analysis of three case studies: chocolate, alcoholic beverages and meat, which are representative of the principal agri-food chains in the Piedmont region.

For each case study, a sample of several food packaging has been selected and a deep analysis of the packaging and the requirements associated with the contained food has been carried out.

The sample was not aimed at being representative of the current market situation, but at highlighting the different types of possible packaging within the same category. Moreover the selection of the product included into the sample was made in order to compare products that come from medium-sized production plant of the Piedmont region with other products easily available on the market.

Specifically the analysed packaging that have been included in the three case studies were 61 in total: 25 chocolate products, 24 alcoholic beverage and 14 meat products (Table 1).

Since the collected packaging vary a lot in function of the contained food, in order to perform a consistent comparison, within each sample it has been necessary to split them into subcategories. As a result three chocolate sub-categories (chocolates, creams and chocolate bars), two alcoholic beverages sub-groups (wine and beer) and three meat subcategories (cured meat, cooked and fresh meat) have been pointed out.

Case studies	Sub category	Number of packaging	Sample per case study
Chocolate	Creams	6	25
	Bars	11	
	Chocolates	8	
Alcoholics beverage	Wine	12	24
	Beer	12	
Meat	Cured meat	5	12
	Fresh meat	5	
	Cooked meat	2	

Table 1. Packaging sample description

Following this, each product included in the sample was then investigated on the basis of a common form of analysis structured on a series of functional, environmental and communicative requirements (Fig. 2).

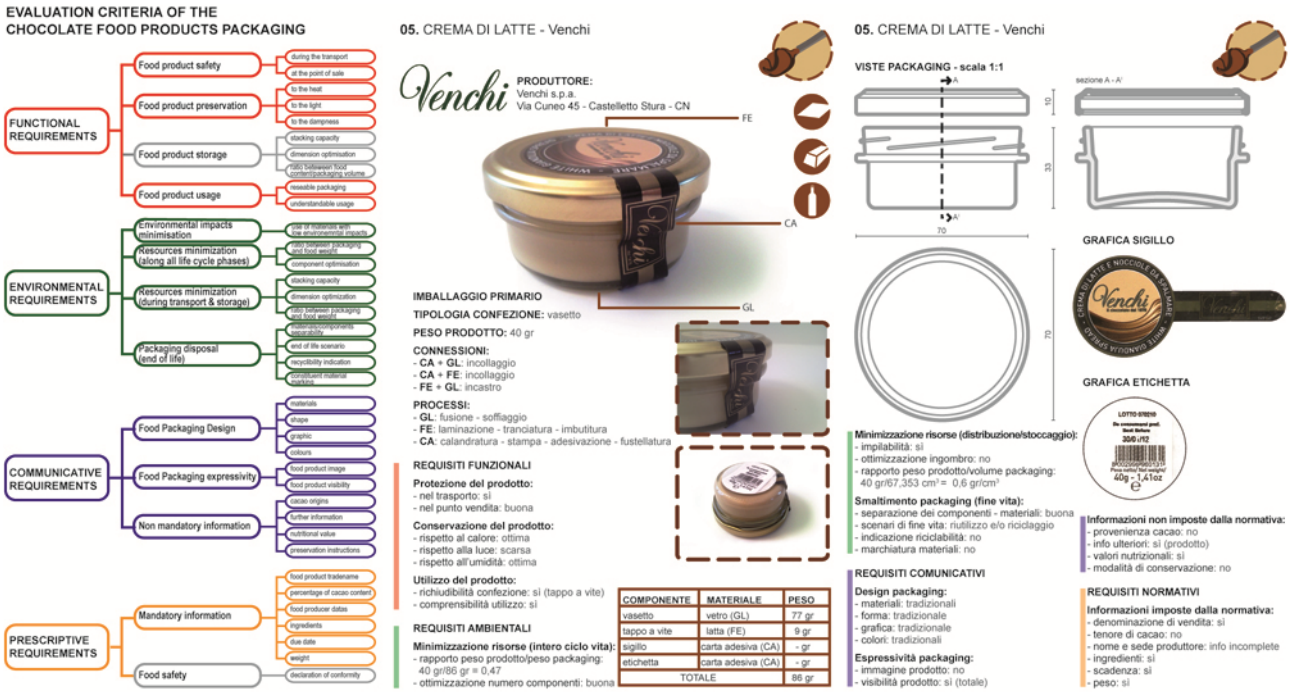

Figure 2. Analysis of chocolate food packaging

After a first analysis of the food packaging included into the three case studies, is possible to underline that the three case studies are very different for the material mix (Fig. 3).

By taking into account that in this first analysis the secondary and tertiary packaging were not considered due to the difficulties to collect direct data about them and only in the case of the alcoholic beverage packaging the secondary packaging (cardboard boxes and LDPE film) were assumed, it is possible to argue that: alcoholic beverage shown the highest quantity of glass, meat packaging are mainly made of plastics and chocolate packaging are made of all kind of material in equal quantity, with the exception of steel and wood

For this reason the chocolate case studies will be used for illustrating the methodological approach adopted for the elaboration of the evaluation multi-criteria system.

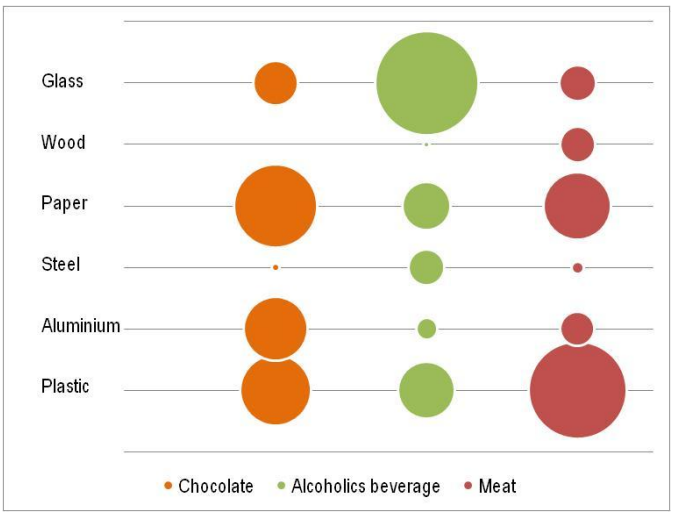

Figure 3. Packaging sample, material mix

In this way, by classifying the packaging in function of the presentation form of the contained food and the constituent materials, it has been possible to delineate a reference scenario of each investigated case studies that will be useful for delineate a multi-criteria evaluation of these packaging.

For example, in the case of chocolate scenario, packaging subcategories related to the food presentation form have been recognised, such as chocolate bar, cream and chocolate.

From the analysis of packaging included in each sub-category, it was possible to deduce some preliminary considerations about the complexity of packaging included into this scenario (Fig. 4).

Packaging complexity, which should be related both to the components number and the mass and the material composition of the analysed chocolate packaging.

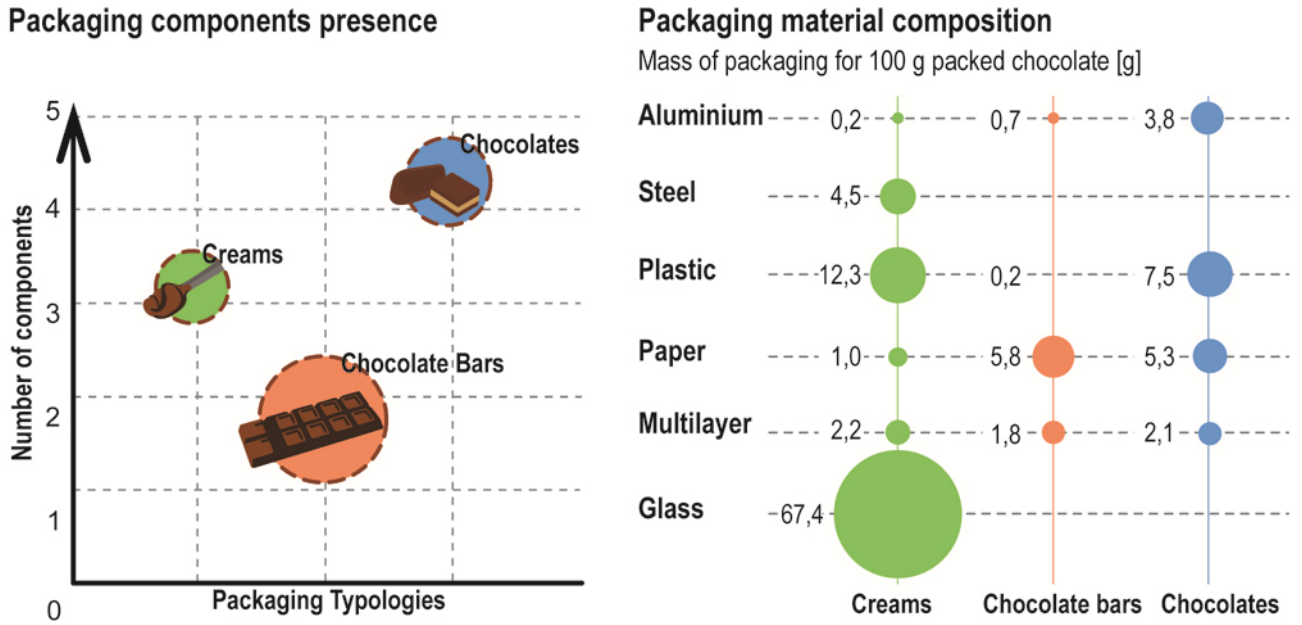

Figure 4. Chocolate Packaging complexity in function of the component number and the material composition

First of all, in relation to the number of packaging components which constitute the analysed chocolate product packaging (Fig. 4), it is possible to argue that the packaging with the largest quantity of components is by far chocolates with about 4 components for each package, followed by creams with about 3 components, and finally the bars, the category with the largest number of samples analysed, registering an average of 1-2 components.

On the other side, in relation to the material composition of the analysed packaging and the related masses of involved material (Fig. 4), by analysing the averaged masses of the samples per 100 grams of packaged product, it is possible to see that the creams, compared with a wide diversity of materials used, are reported to have a high usage of glass, as this category consists mainly of glass jars. While the chocolates contribute important values of mass that are used mainly in plastic materials and paper, all are at a lower intensity of material with a high contribution of paper material

From these first assessments, it is possible to note how the three identified categories differ from each other not only based on content but also according to the different material composition of the various packaging.

5. Requirements - criteria identification

Once the selection and analysis of the packaging has been made and a reference scenario has been outlined, the research has focused on the requirement identification that could be used as evaluation criteria.

From the several requirements that were considered for the analysis of the food packaging of the three case studies a selection of requirements that can be considered as transversal and then can be adopted for evaluating other kind food packaging has been carried out.

These requirements should be classified in two groups:

- quantitative requirements, that are linked to some performances of the packaging that should be measured in a quantitative manner, such as the Carbon Footprint and the Embodied Energy that are generally used in an analysis of LCA (Life Cycle Assessment), or the recyclability percentage, the kilometres of transport involved along the life cycle.
- qualitative requirements, which are connected to some functions of the packaging. Their evaluation is made on the basis of the degree of fulfilment of the investigated function and their evaluation is based on dichotomous value scales (yes/no).

For the identification of requirements on the one hand, in the case of quantitative criteria, reference was made to SLCA (Streamlined Life Cycle Assessment) type analysis, a methodology widespread used for the analyses of packaging [5] and, on the other hand for the qualitative criteria, the needs/requirements/performances approach extended to the whole life-cycle was adopted; a design approach, conceived in the Industrial Design Degree Course (1^Faculty of Architecture, Politecnico di Torino) where man, or rather the end-user, is at the centre of the project. [12]

As a result, the requirements that has been picked out for developing the evaluation criteria of packaging life cycle performances on which is based the multi-criteria evaluation, are the following (Table 2) :

1) **Environmental Criteria:** this group involves requirements that should be evaluated in quantitative way, such as the Carbon Footprint and Embodied Energy, the recyclability percentage.
   As a result, apart the component/materials separability (in order to allow the collection of different materials to assign to the several waste treatments), the chain of custody (the adoption of an environmental responsible management of the manufacturing/production chain, that should be certified such as FSC or PFC certification) and the reusability (criterion that is based on the fact that the packaging can be reused for other purposes and should therefore be designed for that purpose) that can be evaluated in a qualitative way, these environmental requirements can be mainly assessed in a quantitative ways.
2) **Functional criteria:** in this group are collected requirements that in the majority should be evaluated by a qualitative assessment (Yes/No), such as: the stacking capacity (the ability of the packaging to be stacked due to the formal characteristics and mechanical resistance of the packaging and / or of the product itself), the resealability (the possibility to open and close the packaging several time), the guarantee of the product integrity at the point sale and during the transport, the presence of an understandable and easy opening and handling.
   Beside to these qualitative criteria, in this group are included also some quantitative requirements such as: the components number, the lightness of packaging (given by the ratio between the packaging and the food weight).

3) **Communication criteria:** in this group are included criteria that assess the communicative capacity of the packaging in relation to the contents or to the proper handling and management of the packaging. This group of requirements are evaluable in a qualitative way (Yes/No), such as the evaluation of information presence about: the preservation method (the presence of information for the costumer about the correct handling of the product also, through the proper use of the packaging itself), the nutritional value (that help the users to focus attention on the correct nutrition), the origin of food (into the acquisition of raw material, the food farming phase or the food production), the packaging disposal instructions (useful for guiding the customer to correctly manage the packaging disposal).

In addition to the criteria related the environment, the function and the communication, another way to analyse the packaging is to focus the attention also on the main aspects of the packaging design.

By analysing the material, shape, colours of the packaging, it is possible to argue if the packaging design is common or not common in comparison with the other packaging of the same analysed product category.

In this way, by adopting this evaluation approach it s possible to offer not only an objective assessment of the sustainability performances of the packaging, but also to provide suggestions for improving the design of the packaging in coherence with its brief (follow the tradition, to be innovative in comparison with the product categories, etc.).

Area	Indicator	unit
Environmental	GWP	gCO2eq
	GER	MJ
	Potential recyclability	% (mass of material to recycling)
	Separability	%
	Chain of custody	Y/N
	Presence of identification code	Y/N
	Reusability	Y/N
Functional	Stacking capacity	Y/N
	Resealability	Y/N
	Complexity	n (number of components)
	Lightness	% (food and packaging mass ratio)
Communicational	Preservation method	Y/N
	Nutritional value	Y/N
	Packaging disposal instructions	Y/N
	Origin of food	Y/N

Table 2. List of analyzed criteria

It is important to underline that these requirements (Table 2) have been selected for defining an assessment method because they can be considered as universal for each analyzed packaging case study, but the functional and communicative requirements should be increased with more specific requirements in accordance with the contained food needs that packaging have to fulfil.

6. Definition of the packaging multi-criteria assessment based on quantitative and qualitative evaluation criteria

Based on this scenario analysis, the research carried on with the delineation of an multi-criteria assessment system, subdivided into two main sections in accordance with the requirements classification.
In other words, the adopted evaluation approach is based on two different levels of analysis.
The first level, quantitative through the adoption of a SLCA (Streamlined LCA) approach or by using quantitative measure of some representative performances of packaging life cycle phases.
The second, qualitative, by following a qualitative functional approach that is based on the degree of fulfilment of the various qualitative requirements that the packaging must satisfy.
Therefore, the food packaging performances along with the entire life cycle have been taken into account into this evaluation system.

6.1 Quantitative criteria and SLCA (Streamlined LCA) indicators

The SLCA type analysis has been carried out by using two main quantitative indicators of environmental impact, namely:

- GWP (Global Warming Potential): is an indicator that evaluates the emission of all gases that contribute to the greenhouse effect (such as carbon dioxide, methane, nitrogen oxides, chlorofluorocarbons) attributable to the various ground processing activities involved in getting the material ready for use. This indicator, also known as the Carbon Footprint is expressed in kilograms of CO2 equivalent and is calculated by adding together the different contributions of greenhouse gas emissions, after an appropriate conversion through their specific conversion factors defined by the IPPC in 2007 [6]. The most important detail used here is to calculate the only fossil component according to the PAS 2050 [7] guidelines.
- Embodied Energy or GER (Gross Energy Requirement) is an indicator, expressed in MJ or kWh, of the total energy consumed throughout the life cycle of a functional unit of the product / service. In accordance with the methodology of energy analysis, the mass balance is generally calculated by adding up the different levels of energy that are involved, i.e. direct energy (one directly consumed in the production process, such as electric energy), indirect energy (the energy quota needed to make direct energy available, or energy consumption connected to the different processes of transformation inputs), feedstock energy (energy absorbed in the material input used as such and not as fuels, but which at the end of useful life still allow energy recovery through combustion, prior to being discarded as waste) and energy consumed in transport, to make the analysed material/semi-finished product available. In short, with this indicator the amount of energy consumed in food production processes are counted, to produce fuels used in the processes and transport phases. [18]

The use of such indicators, currently used in streamlining analyses, is mainly due to the capacity of describing the potential impacts they have on the two environmental sectors which, at the time, are considered of major interest both from an environmental point of view as a whole (because they are attributable to global warming and the consumption of energy resources) and for their easy communicability to a non-experts audience.

For the calculation of these SLCA indicators, a specific reference database was prepared by collecting data from databases such as the Cambridge EcoSelector (Granta Design Limited) and the studies carried out by professional associations of the European producers of the principal materials used in packaging (including Plastics Europe for polymeric materials, the EAA, European Aluminium Association - for aluminium, FEFCO - for paper, etc.). The analytical approach adopted for the environmental assessment of materials in the packaging production has been based on an allocation of impacts depending on the quantities of material or semi-finished product used [8] while further information with regard to the manufacturer's specifications for each individual analysed package have been founded on internal hypothesis based on shaping technologies [14].

Furthermore, the use of SLCA indicators for packaging materials are referred only to the *Cradle* to *Gate* phase, because they are easily describable by using data from literature, while for the definition of the end-of-life phase (*Cradle to Grave*), there are too many approaches to perform LCAs [15].

This choice has been also made to not further complicate the LCA elaboration with the calculation of end-of-life impacts. In the case of the end-of-life, it has been considered only the potential for recycling as a value in itself and by definition of the potential recycling rate from the official data of the Italian Consortium for Packaging Waste Management [9] relating to the particular Italian context of packaging waste disposal (Table 3).

Material	End of life scenario (CONAI data)			End of life scenario (without recycling)		
	Recycling	Incineration	Landfill	Recycling	Incineration	Landfill
Steel	71%	0%	29%	-	0%	100%
Aluminium	72%	6%	22%	-	20%	80%
Paper	79%	8%	13%	-	39%	61%
Wood	60%	3%	37%	-	7%	93%
Plastics	34%	36%	30%	-	55%	45%
Glass	68%	0%	32%	-	0%	100%

Table 3. End of life scenario definition

In relation to the end-of-life, since it not being possible to address to the process of recycling all the individual material components of packaging, the degree of recyclability of each analysed packaging has been evaluated on the basis of the actual recyclability of each component, in turn determined by the specific characteristics of the packaging. For example, in the case of multilayers packaging, because of the inseparability of the different materials, or because of possible contamination with the product, they were classified as non-recyclable.

Based on this observation, an average end-of-life scenario was prepared for the non-recyclable mono-material components, obtained by allocating the recycling potential to the two remaining scenarios. For the specific case of multilayers, the average scenario of the Italian average Municipal Solid Waste was used [10] which provides that approximately 12.1% of the MSW produced is sent for incineration with the remainder used for other scenarios, and for the specific nature of multilayer that may be approximated with a single landfill.

In summary, together with the SLCA indicators, a further quantitative indicator relating to the recycling potential elaborated in a specific Italian context and the quantitative evaluation given by the

ratio between the weight or mass of packaging used and the amount of product contained was also undertaken, to highlight the volume of material used.

6.2 Qualitative evaluations

On the other hand, the qualitative assessments are derived from the adoption of the demand/requirements/performances approach [12] extended to life cycle, which allowed the identification of the functional, environmental and communicative requirements that must be satisfied by packaging. These requirements once used as reading criteria in the cataloguing of the various products covered by the analysed sample were then converted into evaluation criteria.
Easily recognisable and assessable criteria through direct observation of the package, the assessment of which was based on dichotomous value scales (yes/no), based on the fulfilment or non-fulfilment of the investigated requirement.

Finally in relation to the obligatory functionality criteria, dictated by the regulations in force concerning packaging, these were not taken into account in the evaluation system because it is assumed that the various packaging analysed in the sample respected them, thus providing no additional useful information in the delineation of the evaluation system.
For each of the criteria considered a score based on the satisfaction or otherwise of the specific requirement in question was allocated.

7. Conversion of the multi-criteria assessment in a single index

From calculations carried out, the different categories show values, averaged on the sample, very different from each other.
For example, the packaging for chocolates registers higher Carbon Footprint values compared to the other two categories, a value in contrast with the quantities of used material (Fig. 5), which shows the creams category as the one with the greatest mass of material use, with an equal amount of content. This observation refutes the common idea that lighter packaging necessarily leads to environmental benefits.
However, the interest of the study is not to highlight the differences between the categories but to show how, within the same category, it is possible to find different result ranges that describe the current scenario of chocolate product packaging in order to develop an evaluation model, to be used for the assessment of packaging relating to the three defined categories.

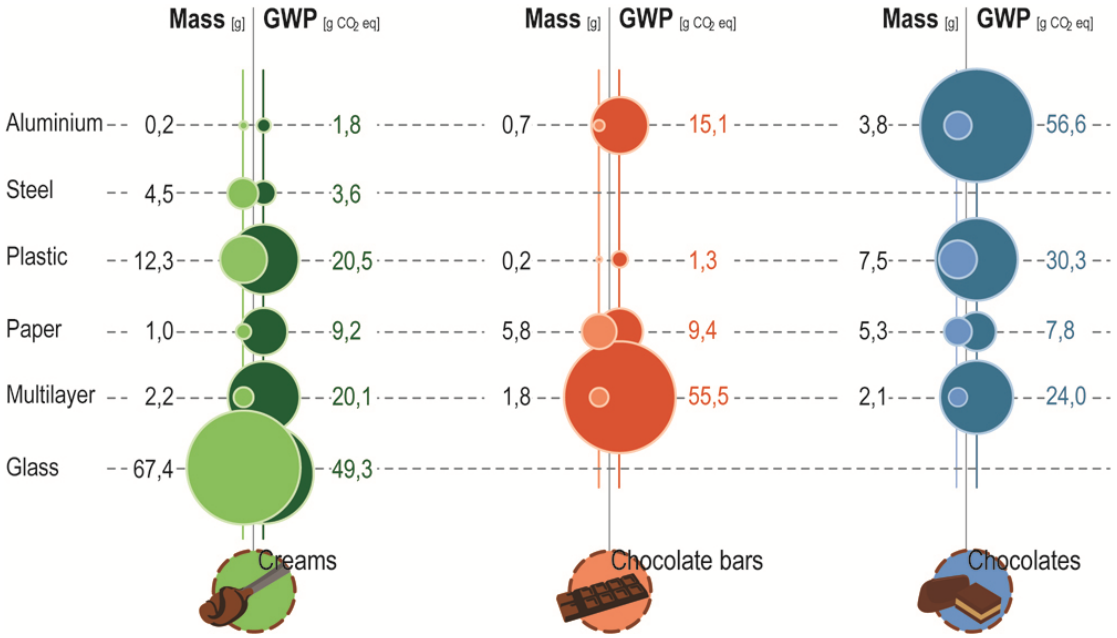

Figure 5. Footprint vs Mass for 100 g of chocolate [data in gCO_2eq]

From calculations carried out both by quantitative and qualitative evaluation (Fig. 6-7), average values for each indicator within each category were extrapolated.

Starting with the average value, the upper and lower average values of the sample were identified. Using the maximum and minimum points recorded as further reference, the division of the variable of the results in 5 representative ranges was obtained, that are:

- average values: values included between the upper and lower average of the samples analysed. This value equals to 3 – Average;
- values above average: values included between the upper average and the maximum value analysed. This value is equivalent to 4 – Good;
- values below lower average: values included between the lower average and the minimum value analysed. This value equals to 2 – Bad;
- values lower than the minimum analysed. This value equals to 1 - Very Bad;
- values higher than the maximum analysed. This value is equivalent to 5 - Excellent.

The assessment from 1 to 5 can be reversed on the basis of the indicator under analysis, following the principles of “more is better”, i.e. the quantitative attributes of percentage of potential recycling or by adopting the principle “less is better”, i.e. the quantitative attribute of carbon footprint.

The identification of the thresholds is different for the two types of adopted evaluation criteria.

For the quantitative indicators the average is elaborated as a mathematical average, without using weighting factor.

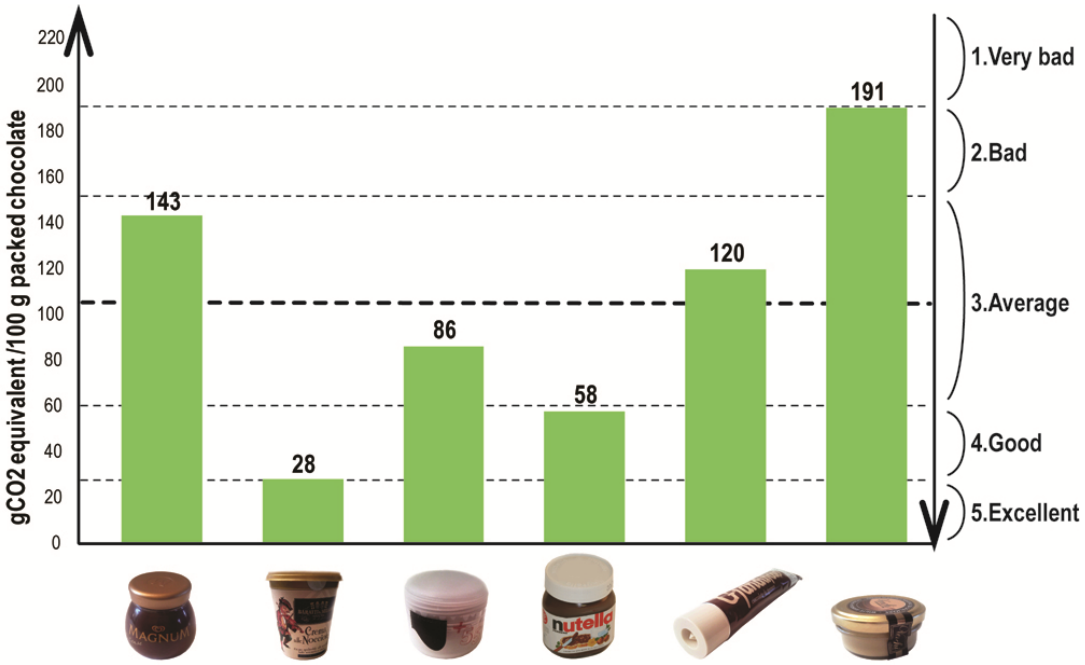

Figure 5. From quantitative analysis to qualitative judgment

For qualitative indicators, the ranges are calculated by using a different approach because qualitative indicators are weighed with a dichotomous values (Yes/No), as a result it is not possible to elaborate upper and lower averages.

In this case, the assessment of the qualitative indicators is referred to the definition of the attractive quality of Kano theory [16], which differentiates the quality attribute in five categories, on basis of perceived quality by the consumer.

Specifically inside the Kano theory the five perceived quality attributes are the following:

- Attractive quality: the attractive attributes can be described as surprise and delight attributes; they provide satisfaction when achieved fully, but do not cause dissatisfaction when they aren't fulfilled;
- One dimensional quality: these attributes are equivalent to the satisfaction when they are fulfilled and dissatisfaction when they aren't not fulfilled;
- Must-be quality: these attributes are taken for granted when they are fulfilled, but, when they are not satisfied, they lead to dissatisfaction;
- Indifferent quality: this kind of attributes refers to aspects that are neither good or bad, and, consequently, they do not result in both customer satisfaction or dissatisfaction;
- Reverse quality: the reverse attributes refer to a high degree of achievement resulting in dissatisfaction (and vice versa, a low degree of achievement resulting in satisfaction) and to the fact that not all customers are alike.

In the same way of other previous studies that investigated these attributes in the packaging area [4], the Kano quality attributes are also adopted in this research, but they are adapted to the research goal.

As a result in order to convert the qualitative evaluations, that are included into this evaluation system, into a range of 5 groups, only two of the five Kano attributes categories are adopted in this research: must-be quality and attractive quality.

Furthermore, even if the perception of quality attributes normally is elaborated by a customer investigation in order to understand how the customers perceive the quality attribute, in this research

the purpose is to clarify how in the current market situation the qualitative indicators, that are adopted in the food packaging evaluation, are fulfilled or not.

Therefore for each product category a percentage of fulfilment of each qualitative indicator has been calculated. This percentage has been used as reference value to define if a qualitative indicator is a must-be quality attribute or an attractive quality attribute depending on the sample behaviour.

In other words, if the majority of the packaging of the sample fulfil the requirement it means that the requirement can be defined as must-be quality attribute, and on the contrary, if no packaging of the sample fulfil the requirement it means that it is an attractive attribute. Between these two attributes three degrees of judgement are set. An example of the assessment procedure is described hereinafter.

All the chocolate bars packaging fulfil the functional criteria of stacking capacity, it means that if the assessed packaging fulfil the stacking capacity, the value assigned (from 1 to 5) is equal to 3 (average), because the criteria is a must-be quality attribute.

Otherwise if no packaging in the sample fulfil a requirement, as in the case of the re-usability for the chocolate bar, and the packaging that we want to assess fulfil the criteria, as a result, the assigned value will be 5, that is excellent, because the criteria has been defined as attractive quality attribute.

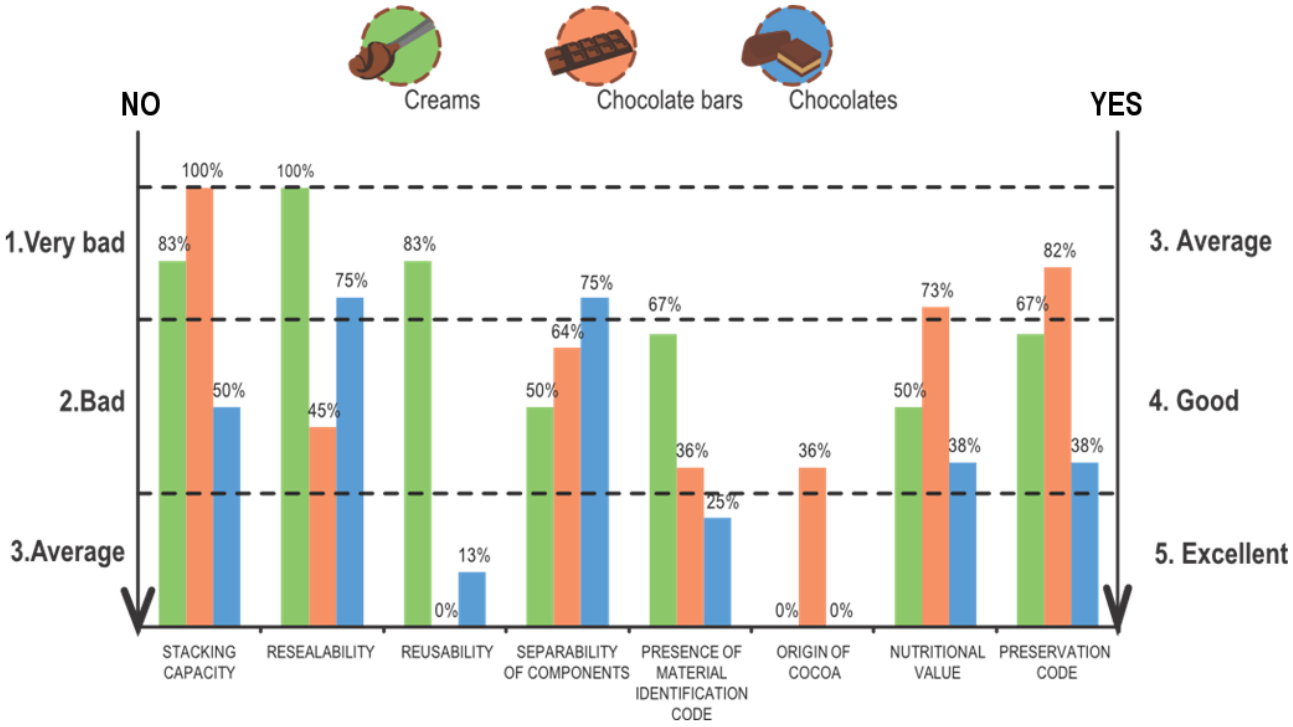

Figure 6. From dichotomous criteria to the qualitative judgment

Thanks to the elaboration of the ranges in this way, it is possible, by carrying out an analysis of a chocolate packaging with the same procedures described in the paper, to transform the evaluation of the quantitative indices into value judgments so as to relate them to the qualitative indicators previously analysed (Fig. 7).

Wanting to transform the judgement on all indicators into a single yardstick, as indicated by the goals of the Poliedro project, the last step in the definition of the evaluation system is the creation of weighting systems for the various indices. This final part of the work is still considered to be in the

development stage. Furthermore, all the criteria adopted up to now into this packaging evaluation system, are easily described and shown in a "spider" graph (Fig. 8).
By using this representation of the results and thanks to the fact that all the measurement are translated in a judgement from 1 to 5, the evaluation carried out should be also useful during the design stage for evaluating the several solutions of new design packaging.

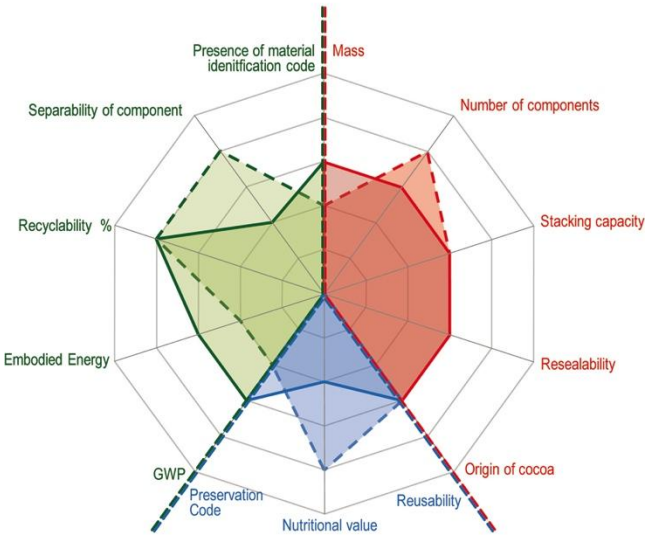

Figure 7. Representation of the results as a "spider" graph

4. Conclusions

The paper illustrates the results achieved up to date into the definition of a multi-criteria evaluation of the food packaging.

A multi-criteria evaluation system that can be an useful tool for several aims:

- as a multi-criteria system evaluation that converted in a scale of 5 range could be included in the Poliedro Index;
- as a tools useful for the agri-food producer, because by outlining a reference scenario of product groups, any type of packaging can be included into this scenario and can be evaluated in order to determine its position with respect to the current market situation.
- as an instrument for supporting designers into the designing of new packaging, because by the reading of the currently weakness of the existing packaging together with the suggestions about its design, characterized by the material, colour and shape parameters, the designer should define the correct eco-design strategies for a new more sustainable packaging.

An evaluation system that in the next steps of research will be developed as an automatic procedure in order to elaborate the indicator values of a packaging that shall be submitted in the Poliedro system evaluation. The procedure will have the aim of translating all the elaborated indicators in a synthetic score by which is possible to set the thresholds to define the conformity of packaging in the Poliedro criteria.

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Conflict of Interest

The authors declare no conflict of interest.

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