Integrating ecodesign in food packaging solutions for EPR compliance in Chile: Knowledge transfer from theory to practice

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Integrating ecodesign in food packaging solutions for an extended producer responsibility in Chile: From theory to practice

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Abstract: An extended producer responsibility legislation will operate in Chile, to help solve the problem of product post-consumer waste. Packaging is subject to the law, and waste management systems are being created to deal with post-consumer packaging waste. To enable products' packaging for a successful waste management in such systems, deep changes will need to be made in new packaging solutions as opposed to existing ones. To help in this task, the course Packaging Ecodesign for EPR Compliance was created, for an audience of professionals in packaging companies. This article reports about the design, implementation, and results of this course, focusing on final project results, for an audience of designers and non-designers involved in design processes. The course students succeeded in incorporating its core contents in applied systemic packaging design solutions for real products, which can comply with the extended producer responsibility through the upcoming waste management systems.

Keywords: ecodesign; packaging design; product life cycle; sustainability strategies; extended producer responsibility

1. Introduction

1.1 Extended producer responsibility in Chile

An extended producer responsibility legislation (EPR) has been recently enacted in Chile. Producers of products that are subject to the law, or priority products, will need to comply with specific goals of its waste management and valorization in the near future (Ministry of the environment of Chile MMA, 2016). Initially six priority products are in the law, although it allows for more. These products are post-consumer motor vehicle tires, batteries, lubricant oils, packaging, batteries and cells for domestic use, and electrical and electronic equipment (WEEE).

Starting with the producer, and downstream until waste valorization and management, several actors have roles to play and obligations to comply with according to the EPR. Actors with key functions defined in the law are producers, consumers, waste generators, grassroots recyclers, and waste managers. The EPR is relevant for everybody.

Consumers become waste generators when we determine that a product is no longer useful and we do not want to keep it. As waste generators, we are obliged by law to perform certain activities. Our customs certainly will change. For example, as generators of packaging waste, we will need to clean, prepare and deliver containers for recycling, things we have not been obliged to until today. Things will change more for producers, who will hold responsibility for the product after its use life, when it eventually becomes waste.

1.2 Packaging as an EPR priority product

Packaging is widely used in the contemporary product industry. It has become indispensable to contain, protect, preserve, transport, handle, and sell products, as well as enabling product use in many cases.

At the same time, the environmental problems derived from packaging waste are significant. This is one of the reasons why it is included as a priority product in the EPR law. Regarding impacts, post-consumer packaging in Chile represents the largest quantity of waste to deal with among all six priority products. It also has significant volume, occupying space in collection points, transport vehicles, and landfills. In landfills, non-biodegradable packaging materials will not degrade, therefore not being integrated into biological processes. Biodegradable materials will degrade in anaerobic conditions, emitting methane, with a greater global warming potential than that of carbon dioxide. The upcoming EPR will help dealing with these externalities.

Another reason for packaging inclusion in the EPR is that significant amounts of valuable materials can be found in its waste. These can be used to make new products and create circular economies. If not recycled, some packaging will be valorized as energy carriers, being burned in industrial operations to produce heat for a variety of purposes. Then, as by-products of incineration, gasses and particulate matter are emitted into the air causing negative impacts. Even though this is not the preferred option, it is still allowed for compliance with the EPR.

1.3 Course on packaging ecodesign for EPR compliance

For packaging as an EPR priority product, it is the producer of the packaged goods the one who needs to comply with the law. This is different from the other priority products, in which the producer of the priority product should comply with the EPR. Nevertheless, packaging producers are the ones who can create packaging solutions that enable or facilitate compliance with the EPR.

The continual education course *Packaging Ecodesign for EPR Compliance* was created, as a means to transfer environmental knowledge to the packaging industry that can be used for

EPR compliance. Industry plays a fundamental role in reducing the negative impact of its products and to make progress towards sustainable development. Such goals can be fulfilled through ecodesign used to comply with the EPR, and may also be an opportunity for product innovation in the packaging industry. Companies that implement ecodesign earlier can have a competitive advantage within the packaging industry. Students of such a course could learn how to create packaging solutions with minimal environmental impact, that can be used for compliance with the EPR, and aligned with the country's goals of sustainable development.

2. Background to the research

2.1 Food packaging design

Food packaging's characteristics make it an interesting object of study for design research. In a packaging-system, a number of different containers and packing products are often used. A packaging-system can be defined as the various kinds of packaging and associated processes used in a product, understood with a life cycle perspective. It includes all processes in packaging manufacturing, transport, packing operations, packaged product distribution, sales, use, consumption, preparation, and final waste management including recycling and other forms of valorization (Huerta, Melo & Rubio, 2021).

Several stages of design exist in a packaging product's life cycle. These stages range from being more technical designs to more user oriented, spanning from material production and conversion to detailed design of all graphics and information for the consumer in the final product. It can be said that packaging is a fertile ground for the design disciplines associated with them.

Packaging is especially important for the provision of food. More than merely containing a food product and allowing its handling and transportation, it helps keep the organoleptic properties of food, maintaining its smell, flavor, color, and texture, among other characteristics. It also displays important–and also mandatory–information about food for the consumer, such as dates of production and expiry, nutritional information, ingredients and preparation, as well as marketing and branding information.

In Chile the pandemic influenced packaging use trends, with implications on environmental impact and sustainability. Extended quarantines made home delivery sales grow compared to people going for shopping, increasing by 69.7% compared to 2019 figures (Cabello, 2021). This led to the proliferation of single-use packaging, and increased the number of containers and wrappers used per product in an attempt to protect consumers from possible infections (Galotto, 2020a). Social distance encouraged individual consumption, which was promoted through single-dose packaging, by the means of rigorous health protocols, to minimize the risks involved in food sharing, especially in the hotel, restaurant and cafeteria (HORECA) channel (Gob.cl, 2021).

EPR legislation will oblige valorization of post-consumer packaging, with metrics based on mass (weight) of packaging put in the market and recovered for valorization. Thus, a decrease in the number of materials and components used has been promoted in packaging design together with an optimized structure, following the principle of “less is more” (Galotto, 2020b). This principle is a good rule of thumb for packaging design, but more can be achieved by using ecodesign strategies, for the sake of sustainability and compliance with EPR.

2.2 Ecodesign

Ecodesign can be defined as a practice by which environmental considerations are integrated into product and process design and engineering procedures (Brezet & Van Hemel, 1997). Ecodesign is based on a product’s life cycle stages, and proposes strategies to minimize its environmental impact per stage (White et al., 2013). Within ecodesign strategies, a variety of actions are proposed that can be used to design product systems with minimal environmental impact. Figure 1 shows ecodesign strategies and actions.

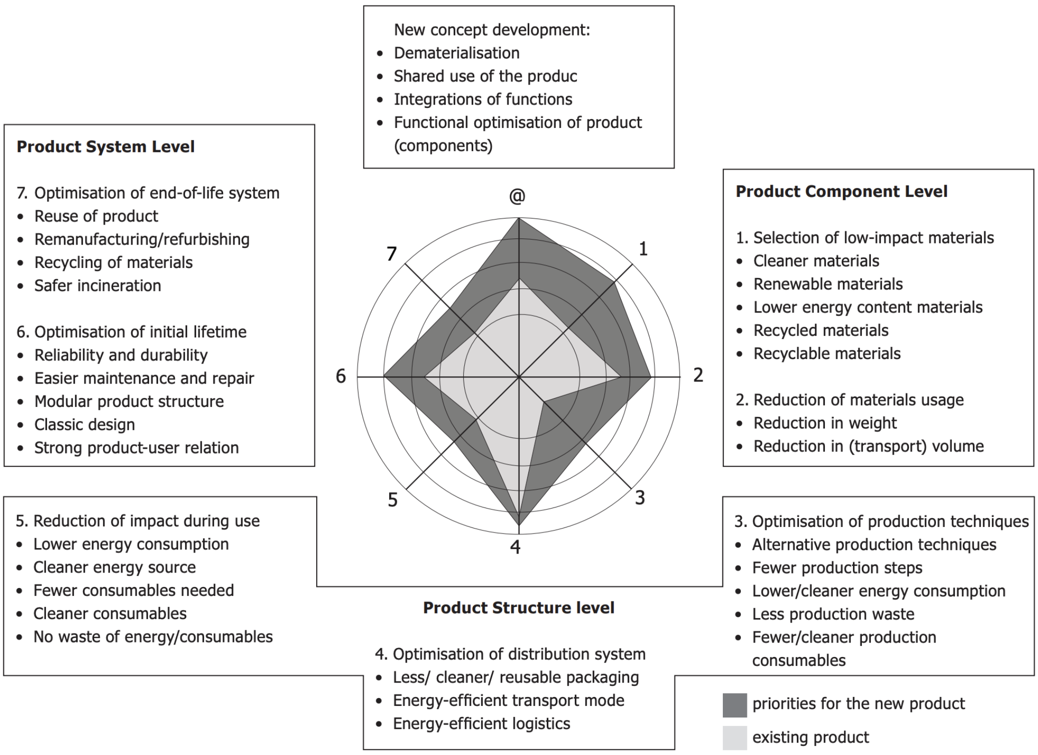

Figure 1. Life Cycle Design Strategy Wheel, also known as the LiDS Wheel, by Brezet and Van Hemel 1997; Van Hemel 1998. First of multiple versions of ecodesign strategy wheels that have been created afterwards by several authors. Retrieved from: https://www.researchgate.net/profile/Joost_Vogtlander/publication/270104932/figure/download/fig4/AS:295163848085509@1447383953881/The-LiDS-Wheel-Brezet-and-Van-Hemel-1997-Van-Hemel-1998.png

Ecodesign applied to the packaging industry can be used to minimize its life cycle environmental impacts. It has been acknowledged that more than eighty percent of a product's environmental impact is defined during the design stage (Yang, 2005; Chouinard & Stanley, 2012). From choosing or making packaging product materials, through manufacturing processes, distribution, sales, use, and until waste management and valorization, using ecodesign can have a strong influence on the environmental performance of packaging since it is implemented at the very beginning during the design stage.

Besides minimizing impacts, ecodesign is mentioned in the EPR legislation in Chile as a preventive approach to minimize priority products' environmental impacts and to facilitate their post-consumer waste management properly. Thus, applying ecodesign on EPR priority products can have a positive impact in reducing environmental externalities and fulfilling the requirements of the EPR.

2.3 The role of design and designers in food packaging

Food packaging design is a complex process. In order to design packaging with a focus on their environmental performance or to create packaging with a sustainability approach, a systems perspective must be adopted.

Packaging design, far from being just designers' domain, is an activity in which several diverse ranges of professionals intervene. Even though designers are very relevant in the design process of food packaging, their interventions are often conditioned by short-term requirements which are imposed on through company strategy (Gaziulusoy, 2010). Other professionals intervene as well, such as product and process engineers, technicians, marketing specialists, and different levels of management and executive decision makers. The integration of practices and competencies to the design processes from professionals of other areas is not new, especially in business and innovation (Brown, 2008). Nevertheless, for the packaging industry in Chile, this integration is rather uncommon.

Dorst (2011), explains that design thinking is interesting to other disciplines because it has a long experience in dealing with open and complex problems. In addition, designers have developed interesting ways to "frame" problems, in order to understand them better and think of alternatives to solve them. In the words of Cross, design thinking is a "style of thinking that combines empathy for the context of a problem, creativity in the generation of insights and solutions, and rationality to analyze and fit solutions to the context" (Raffaghelli, 2014: 276). Therefore an increasing interest in design thinking has been observed among different other disciplines that contribute to problem solving and product design (goods or services). As Herbert Simon (1996) stated, everyone designs to the extent that they transform existing situations into preferred ones. Consequently, not just designers have a significant role in configuring appropriate product systems.

3. Research design

The course *Packaging Ecodesign for EPR Compliance* took place between September and November 2020. The COVID-19 pandemic had an influence on the course, being entirely online and using the Zoom platform. It had twenty-three students working in the packaging industry, from companies affiliated to the National Packaging Center, an industry association from Chile.

The course consisted of ten weekly sessions of four hours each, in which various experts gave lectures and conducted applied exercises. Among these ten sessions, three were dedicated to a workshop aimed at integrating the course's contents into a single project. The results of this project are the object of study of this research.

Food packaging design calls for a truly interdisciplinary approach. Since a variety of professional profiles intervene in packaging's life cycle, it is hypothesized that gathering diverse kinds of knowledge during the design stage, when the product still does not exist, can help configure packaging systems that are functional across all life cycle stages, with minimal environmental impact, and that can comply with the EPR.

3.1 Study objective

The objective of this study was to inquire about the integration of ecodesign strategies in a food packaging life cycle design project for real products, performed by interdisciplinary teams of students, and in compliance with the Chilean EPR legislation.

The project assignment considered the following constraints: to choose an existing food product as a baseline reference case, consider the COVID-19 pandemic as a context, and to define a specific group of consumers as the target market for the product.

3.2 Research questions

- Do the design solutions proposed by the students incorporate ecodesign? If so, which strategies and actions were actually used?
- Can the packaging design outcomes of the project be incorporated into waste management systems in order to comply with the EPR legislation?

4. Methodology

The sessions of the course consisted of lectures given by different experts on each content covered, followed by short exercises in which students worked in groups applying the contents of the lecture and then shared their results in a plenary discussion. Each session was held for four hours. Three sessions within the course were devoted to a Packaging Ecodesign Workshop, where the students worked in teams on a final project. Table 1 shows a timeline with the topics addressed and activities for each session of the course.

Table 1. Sessions of the course Packaging Ecodesign for EPR Compliance.

Sessions	**Contents**	**Activities**
Session 1	EPR Legislation in Chile	Lecture and Exercise
Session 2	Product Life Cycle	Lecture and Exercise
Session 3	Waste Management Systems	Lecture and Exercise
Session 4	Ecodesign	Lecture and Exercise
Session 5	Packaging Ecodesign Workshop # 1	Project Launching
Session 6	Sustainable Production & Consumption	Lecture and Exercise
Session 7	Packaging Ecodesign Workshop # 2	Project development feedback
Session 8	Sustainability Tools	Lecture and Exercise
Session 9	Corporate Sustainability	Lecture and Exercise
Session 10	Packaging Ecodesign Workshop # 3	Project Delivery and Presentation

4.1 Packaging ecodesign workshop and project

The packaging ecodesign workshop took place during sessions 5,7, and 10 of the course. Before the first session of the workshop, the students had already received a significant portion of the contents to be covered (EPR Legislation in Chile, Product Life Cycle, Waste Management Systems, and Ecodesign).

The workshop used a project-based approach in which teams of three to four students were asked to work on a food packaging design project through a given assignment. The project was named “Ecodesign of a food packaging system in times of pandemic”. Each team was asked to select an existing packaged food product, and to redesign its packaging with a systems approach in order to reduce its environmental impact while enabling compliance with the EPR. The COVID-19 situation was included as a constraint for the project, to include sanitary and social distancing restrictions as well as the characteristics of specific target consumers.

The design teams were arranged by the instructors, with the purpose of assuring diverse disciplinary backgrounds, industries, and working positions for the members of each team. This was done by classifying the students based on their profession, packaging industry, working area, and position within the company with the aim of assembling interdisciplinary teams. Table 2 shows the details of the six design teams for the project.

Table 2. Design teams and characteristics of participants.

TEAMS	PARTICIPANTS JOB TITLE	AREA	COMPANY	INDUSTRY	SELECTED PACKAGING SYSTEM TO REDESIGN
1	Key account executive	COMMERCIAL	Paper and cardboard recycling	PAPER AND CARDBOARD	PIZZA PACKAGING
	Commercial director	COMMERCIAL	Packaging factory	PLASTIC	
	Key account manager	COMMERCIAL	Paper and cardboard factory	PAPER AND CARDBOARD	
	Technical manager	DEVELOPMENT	Medical supplies	HEALTH	
2	Tooling technician	PRODUCTION	Packaging factory	PLASTIC	ONE LITER ICE-CREAM
	Account manager	COMMERCIAL	Cardboard packaging factory	PAPER AND CARDBOARD	
	Development manager	DEVELOPMENT	Cardboard packaging factory	PAPER AND CARDBOARD	
	General manager	COMMERCIAL	Packaging factory	PLASTIC	
3	Account manager	COMMERCIAL	Cardboard packaging factory	PAPER AND CARDBOARD	NON-GLUTEN PASTA
	Development engineer	DEVELOPMENT	Cardboard packaging factory	PAPER AND CARDBOARD	
	Sales manager	COMMERCIAL	Packaging factory	PLASTIC	
4	Account manager	COMMERCIAL	Cardboard packaging factory	PAPER AND CARDBOARD	PACK OF BEER AND SALAMI
	Operations manager	PRODUCTION	Packaging factory	PLASTIC	
	Development engineer	DEVELOPMENT	Packaging factory	PAPER AND CARDBOARD	
	Commercial manager	COMMERCIAL	Packaging factory	PLASTIC	
5	Sales manager	COMMERCIAL	Metal packaging factory	METAL	MAYONNAISE DOYPACK
	Account manager	COMMERCIAL	Cardboard packaging factory	PAPER AND CARDBOARD	
	Process engineer	DEVELOPMENT	Packaging factory	PLASTIC	

	Technical and development manager	DEVELOPMENT	Food producer	FOOD	
6	Packaging and brand designer	DEVELOPMENT	Food producer	PLASTIC	CHOCOLATE-COVERED MARSHMALLOWS
	Packaging development engineer	DEVELOPMENT	Food producer	FOOD	
	Business and marketing analyst	COMMERCIAL	Paper and cardboard recycling	PAPER AND CARDBOARD	
	Designer	DEVELOPMENT	Design studio	DESIGN	

During the workshop, participant teams were asked to describe the packaging system of a specific food product of their choice, and identify its different functions throughout its life cycle. Three main stages were defined by the instructors to organize the design process: diagnose and problem framing, explore and define, and deliver. Table 3 shows the project phases, activities, objectives and tools used during the workshop.

The research team decided to consider two main transversal dimensions for the design of the workshop program, previously explored by Cortés et al., (2018) in a training program of design thinking for school teachers in Chile: 'problem framing' and 'productive collaboration'. According to Lloyd (2013), problem framing relates to the capacity to discover, define the scale, and redefine problems. In the case of the ecodesign of food packaging, problem framing relates to the analysis of the packaging system to map the main points of conflict in the process. The dimension of 'productive collaboration' relates to the skill of designers to communicate their ideas and receive feedback from others to engage in productive dialogues. In the case of this workshop, it relates to combining the expertise of professionals from other disciplines to define key actors, define actions and measure technical facts.

Table 3. Phases, activities, objectives, and tools used during the workshop sessions.

Ecodesign process phases	**Team Collaborative Activities**	**Learning Objective**	**Tools / Techniques used**
DIAGNOSE PROBLEM FRAMING	Starting brief	Describe and characterize the packaging system of a specific food product and its possible user.	Brief
	Packaging-system life cycle	Model the life cycle of the current packaging system, to identify at each stage materials and energy resources, processes, resulting waste, and its management.	Life cycle diagram

	Insights generation	Analyze the information collected to identify possible problems/opportunities in the product life cycle, which would become requirements to define the objectives of the new packaging-system.	
EXPLORE AND DEFINE	Ecodesign strategies and actions	Review the Ecodesign Strategy Wheel to explore those that would allow addressing design objectives, proposing actions for the different life cycle stages.	Ecodesign Strategy Wheel (Brezet & Van Hemel, 1997)
	Evaluation of Ecodesign strategies and actions	Define and rank the project requirements to evaluate preliminary proposals, define the final proposal and suggest improvements.	Evaluation matrix
DELIVER	Final proposal	Propose a new packaging system with reduced environmental impact in compliance with EPR.	Brief of new packaging-system
			Life cycle of new packaging-system
			Solution visualization (low-resolution prototype schematics, drawings, or photos)
			Technical datasheet of each component of the system (if applicable)

4.2 Quantitative project assessment process

At the end of the workshop the resulting projects were analyzed by the researchers of this study. A quantitative assessment was performed as follows. A Likert scale with five achievement scores was used: Strongly disagree, the indicator is not appreciated or is absent; Disagree, the indicator appears with obvious defects; Neutral, the indicator is achieved to a degree that only meets the minimum required criteria; Agree, the indicator is almost fully achieved; and Strongly agree, the indicator is achieved in its entirety. Scores were assigned numeric values from one to five, being one Strongly Disagree, and five Strongly Agree. These achievement scores were used with assessment indicators, used independently by each researcher to evaluate the projects. The assessment indicators used are:

- Integrates the contents of the course in a real case.
- Describes and characterizes the packaging system of the chosen food product and its end-user.
- Models the complete life cycle of the current packaging system used by the food product.

- Analyzes the information collected to identify potential problems and, or opportunities observed throughout the product's life cycle.
- Develops a proposal based on Ecodesign strategies.
- Proposes a solution with an emphasis on the user.
- Project reporting is well structured, good quality writing and use of academic format.
- Project contents were communicated well visually and persuasively.

Then, a consensus process was undertaken by the researchers to produce a unified score for each assessment indicator. The scores with the corresponding assessment indicators for all projects were tabulated and compared in order to obtain results for this research.

4.3 Qualitative project comparative assessment

Additionally, the researchers analyzed the final reports and presentations prepared by each team to explain the project cases. This analysis was necessary because although the assignment was the same for all teams, and the final deliverable had common requirements, the specific context, challenges, and constraints addressed in each case were diverse.

In order to observe, understand, and compare the various approaches, applied knowledge, and decision-making of the design teams, a comparative matrix was produced that classifies the information contained in the documents, using the following categories: Case summary, Purpose of the project, Description of the consumer, Design process steps, Insights, Proposed strategies, Ecodesign proposed solution, and Highlights of the proposed solution in relation to sustainability improvement of the packaging system.

For the purpose of this paper, three of the six cases have been selected to describe in depth, focusing on the data which informed about the strategies and actions–out of the contents covered in the course– that the teams actually used in their ecodesign projects, and about the feasibility of the designed outcomes of the projects to be incorporated into waste management systems for EPR legislation compliance.

5. Results

5.1 Quantitative analysis of scores per assessment indicators

The analysis of the achievement scores per assessment indicators yielded the following results. The assessment indicator with the greatest scores was “Develops a proposal based on Ecodesign strategies” for which all the projects scored the maximum of thirty points. This was followed by “Describes and characterizes the packaging system of the chosen food product and its end-user” with twenty nine points, and “Analyzes the information collected to identify potential problems and, or opportunities observed throughout the product's life cycle” together with “Integrates the contents of the course in a real case” with twenty eight points each. The assessment indicator “Project contents were communicated well visually and persuasively” scored twenty six points, “Proposes a solution with an emphasis on the user" scored twenty four points, "Models the complete life cycle of the current packaging system used by the food product" scored 21 points, and finally "Project reporting is well structured, good quality writing and use of academic format" scored eleven points, being the less achieved assessment indicator.

5.2 Qualitative comparative case analysis

A summary of the three selected cases is given to contextualize each of the packaging redesign challenges faced by the teams.

Pizza packaging system

This team chose to redesign the family pizza box as the primary packaging. The secondary container is the thermal backpack which works as a means of transport to bring the final product to the consumer's table. This packaging system needs to meet certain conservation requirements: Maintain the product's default temperature for approximately 30 to 45 minutes, Preserve the product in optimal conditions and protect it against falls or external agents that modify the physical composition predetermined by the producer, Facilitate handling when moving the product.

The existing product is a square corrugated cardboard box 35x35x4 cm, which allows heat to be retained, as well as protecting the food from contaminants and dirt. The box retains the original color of the cardboard, and is printed in one color.

Non-gluten pasta

Packaging for a gluten-free pasta produced by a small company, for the sale of its product on supermarket shelves. The company's product line is a series of Italian-style preparations, ready to serve and a respectable shelf life if stored refrigerated between 4°C and 8°C.

The actual packaging consists of a black Nº5 PP tray container to place a portion of 500 grams of fresh, 3 self-adhesive labels with nutritional information, expiration dates and preparation advice, as well as a plastic film to seal the product. The products are placed in a cardboard box and are packed on a wooden pallet with corner protectors and stretch film.

Chocolate covered marshmallows

A marshmallow product, with fruity flavors bathed in chocolate coating. The format chosen for the project is the 250 grams equivalent to 36 units inside the bag. The product is wrapped in coloured aluminum of 12 microns in five different colors, imported from China. The outer packaging is a bag made of 5 flexible pp, full printed with a window to view the product.

The products are stored and transported in a cardboard box in which it is possible to store 8 bags. To transport the boxes to the sales point they are placed in a wooden pallet with 120 boxes wrapped in stretch film. The nutritional information is printed in the bag. It requires to be kept at room temperature, no more than 24 degrees.

Table 4 compares the relevant aspects of the projects:

Table 4. Summary of the ecodesign process of the three selected cases.

Packaging System and purpose of the team	Team insights during the course	Strategies and/or actions used by the team	Proposed strategies and actions	highlights of the solution for ecodesign improvement
Pizza packaging system Purpose: Minimize the need for content manipulation and ensure that it is safe to share a pizza.	A problem with recycling pizza boxes is that oily food residue adheres to the cardboard. Sharing a pizza in the context of Covid 19 is not safe. Actual packaging system is not designed with a sustainable approach in mind.	After analyzing the actual packaging using the Van Hemel wheel, one of the main problems detected is the low optimization of the useful life, due to food contamination. The optimization of the end-of-life system is insufficient for the same reason. Other weak points: reduction of the impact during use and the distribution system.	Optimize the useful life by changing actual materials for others that have a higher percentage of recyclability. Include a paper that works as an insulator of food waste.	The solution proposed by the team is a round box of eight portions for four people in a primary container based on molded pulp (100% recycled material and 100% recyclable), with a pre-cut to divide the portions without the need to touch the product. A paper with seeds is incorporated to isolate the pizza from the box and prevent it from being contaminated with oils and food remains. The new materials are 100% biodegradable and recyclable.
Non-gluten pasta Purpose: Optimize the product's useful Life / better barrier / less materials. More efficiency in labeling and distribution.	It is not 100% recyclable, as it is made up of different materials, plastics, paper and adhesives that are not easily separable from each other (the PP tray alone is 33%). It is for single use, that is,	By analyzing the life cycle of this product and observing in detail the core of the process as well as the upstream and downstream aspects of the business, several problems were detected among the components of the system.	Reduce the size of the primary container to optimize costs and disposal on shelves. Portion the product in the container, to allow only the necessary consumption.	Green that optimizes space in relation to content. Produced with a higher barrier to increase the useful life of the product and reduce potential food waste. This packaging contemplates 90% less plastic than the current one. The upper part of the tray is made up of a PE EVOH sheet classified as

	once used it cannot be re-used. It is not reseal-able, so once it is opened, the product must be consumed in its entirety or the packag-ing must be changed so that the prod-uct maintains its freshness for a few more days.	The use of the Van Hemel wheel ena-bled the team to identify possible solution ap-proaches to the de-tected problems.	Communicate relevant aspects for the celiac target audience. Consider waste as a resource. Encourage recy-cling (mono re-cycled and recy-clable material). Use a sealing technology com-patible with con-ventional sealing machines such as the client's current one, since the sealing mouth is similar to its PET tray format.	a nº4 film, which is lami-nated with a printable kraft cardboard tray by pulling and removing the sheet. The packaging becomes 100% recyclable, ecological, practical, light, protective, safe, dy-namic, clean, and re-sistant.
Chocolate covered marshmal-lows Purpose: Improve the final dis-posal of waste, and waste man-agement ideally, moving from the garbage to the sanitary landfill.	Although both materials (flexi-ble PP and alu-minum) used today can be recovered, in reality they are of low recycla-bility and usu-ally end up in landfills. Flexible PP's recycling pro-cess is cur-rently weak, both in home recycling ser-vices and in clean points.	By analyzing the packaging system life cycle the team discovered that in the wrapping pro-cess, 5 machines are used to wrap the product with the five different colors (green, blue, yellow, red and or-ange) which in-volves excessive energy, time and labor. There is plenty of operational loss of aluminum in the packaging process, it breaks easily, there are also	New Concept Development: Dematerializa-tion of the prod-uct; by eliminat-ing aluminum and flexible PP, which brings the following bene-fits; Elimination of material import costs. Automatic re-moval of 5 wrapping ma-chines reduces energy.	By replacing flexible PP as secondary packaging for another material that is 100% recyclable in Chile, it is possible to re-duce this waste in sani-tary landfills, optimizing the product's end-of-life treatment. The new packaging pro-posal will follow the "self-exhibiting" concept, by giving the container the new function of dis-playing the product in a selling point. Boxes used for transpor-tation will be "generic" to give new functionality to the box. They will be used for the transport

	Aluminum's recycling process is also weak, given that it is a container that remains for a short time after consumption and that there is no installed system to recycle it. Economic and carbon footprint savings could be eliminated by not bringing imported aluminum from China.	breaks that are also declared as shrinkage.	Elimination of material waste between processes. Functional optimization of the product.	and display of other products of the company.

Overall, the qualitative assessment confirms the results of the quantitative evaluation. All of the design teams could reduce the environmental impact of the product they chose to redesign by using the Ecodesign Strategy Wheel to visualize opportunities to intervene or modify existing conditions. The ecodesign wheel is a useful tool to ideate possible strategies to improve the life cycle of the packaging systems, as the list of strategies is applicable to any product or service, guiding teams to quickly implement concrete actions and measures at different points of the packaging system. Results may also be related to the way in which the wheel was introduced during the course, where the instructors shared a series of cases of packaging ecodesign, in which each of the proposed strategies in the wheel was exemplified. Connecting strategies to real actions for concrete situations placed participants in a real perspective, which enhanced their creativity, and opened up their ideas of solutions.

In addition, by analyzing the actual packaging system in its core, upstream and downstream, the teams were able to identify diverse problems that could be solved without major changes in the productive processes actually used by the companies. Some of the design decisions of the teams were focused for example on transportation, storage and exhibition adjustments that impacted negatively on the whole packaging system.

6. Conclusions

The course achieved the integration of theory and professional experience from different disciplines into a strategic and collaborative design process. This process enabled teams to discover problems or opportunities beyond the requirements of the EPR. They could also fulfill the goals that were established for the recovery of packaging materials.

During the Diagnose stage of the design process followed in the workshop, students could visualize a series of factors that directly influence the environmental impact of food products and that are not always included in what is considered to be “packaging design”. These factors were evidenced with the use of the life cycle diagram, as a qualitative analysis tool that showed them how in the packaging system, these aspects are interrelated. Making the packaging system visible enabled a comprehensive vision of the problem, thus improving 'problem framing'. On the other hand, understanding packaging as a system and proving how small modifications throughout the different levels of the system (core, upstream, and downstream) can significantly reduce the waste generated by food packaging products.

Combining theoretical content with an applied project in the form of a workshop was a good opportunity for participants to put their knowledge to work in favor of the diverse and sometimes extremely technical aspects of packaging design. The projects developed by these multidisciplinary teams were a contribution to the redesign of each product. By observing the resulting products, it is evident that convening professionals of different disciplines who work in the various stages of the product life cycle, led to the integration of the requirements demanded by the various actors of the packaging-system value chain. Although many companies have a wide variety of professionals and technical experts in their areas of development, production, distribution, and sales, it seems that the design processes within companies are not entirely collaborative, or at least they do not consider all variables in a systemic and strategic way.

This research can inform a variety of audiences that are concerned with food packaging solutions. First, for companies making packaging products that will be used by food producers that need to comply with EPR legislation, this experience can show how solutions for this task are technically feasible and can become a good business opportunity based on the increased demand that is expected. Then, for companies making food products, this experience can show that potential solutions for them to comply with the EPR are at hand, and can be implemented by working closely with packaging providers.

A very interesting surprise for the research team was the enormous positive impact that can be achieved by implementing simple and even imperceptible modifications along the packaging-system life cycle. In Chile, EPR compliance can be an opportunity to innovate in food packaging design and at the same time a way of taking responsibility for the waste we generate.

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