Method for Strategic Design in the Food Packaging System: Packaged Product Life Cycle Tool

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Abstract. A research study was conducted in order to understand how food packaging systems are configured in Chile, and what should a method for strategic design within food packaging systems address. Relevant literature about these topics was consulted and analyzed. A series of interviews were conducted with experts on food packaging design. On-site observations were conducted in several food and packaging plants and operations. Data were analyzed using qualitative techniques. The results show the complexity of food packaging systems, the life cycle stages that make up these, and the kind of information that must flow within design teams in order to work on developing such systems. Based on the results, a method and toolkit were developed to help decision making, planning and design in packaging design projects. This article elaborates about the tool named Packaged Product Life Cycle that is part of the method and toolkit.

1 Introduction

1.1 Food packaging from a life cycle perspective

Packaging plays a fundamental role in contemporary food provision globally. It has become indispensable for containing a food product, protecting it, enabling its transport and delivery to the consumer in optimal condition, and communicating relevant information related to the product [1]. The present work focuses on food packaging.

With regard to packaging, primary, secondary and tertiary packaging are often used. Primary packaging is the one that contains the product, or covers this container, finally being sold as a single unit [2]. Secondary packaging contains several units of primary packaging containing products. Tertiary packaging consolidates several units of secondary packaging for handling and distribution [2]. Even though the final consumer of a food product only sees the primary packaging, secondary and tertiary packaging often have been used previously for every product sold.

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A product system has been defined as a "collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product" [3]. Applying this definition to a product being food packaging, provides a systemic view that can be useful to understand its life cycle stages and the processes within them. It also provides some clues that are relevant for the products' life cycle management [4].

The life cycle of food packaging begins with the extraction of raw materials, followed by subsequent transformation steps until being usable as materials for making packaging [5]. Packaging is then packed and transported to a food producer, where it will be used to contain food products. Different operations to pack products may take place until product distribution and sales. Finally, a food product reaches the consumer who eats the food. Some packaging are immediately discarded after the product is consumed, others may be used longer until the food lasts. Returnable packaging can be used to contain new products. This is enabled by a reverse supply chain that should exist in returnables' systems. Packaging that is not returnable will no longer be needed by the consumer. Consumers will need to clean, prepare and maybe transport such packaging to a collecting site for future reuse or recycling, where this is enabled. Some packaging may serve as fuel in an incineration facility, in which case it will not need to be clean but will need to be dry. In some places packaging will be disposed of as waste in landfills or dump sites. The management of post consumer packaging will vary from place to place globally.

1.2 Extended producer responsibility in Chile

Chile has a new extended producer responsibility (EPR) legislation that was enacted in 2016. Since then producers of priority products (products subject to the law) have been preparing for its compliance, which will start in 2023. Post consumer packaging will no longer end up in landfills or dump sites.

In 1996, one hundred percent of household solid waste was disposed of in dump sites [6]. Since the introduction of landfills this situation has changed, but still in 2011 ninety six percent of municipal solid waste was given final disposal, and one fourth of this amount ended up in dump sites [6]. Today, dump sites are illegal in the country, but an uncertain amount of them still exist.

When the EPR starts operating in the country, packaging will be collected at homes' doors in urban areas, as is the case with household solid waste today. Hence, consumers will not need to transport post consumer packaging themselves for valorization. It is expected that with the EPR an increasing amount of packaging will be valorized by means of reuse, recycling or used as alternative fuel in facilities with proper permits to do this.

1.3 The need for strategic design of food packaging

Packaging carries with it costs, environmental impact, and needs to comply with legislation [7, 8]. Packaging represents a non-negligible cost for food producers, who are the ones that pay for all the packaging used for their products (primary, secondary, and tertiary packaging). Packaging causes well known environmental externalities, which is why it is subject to most EPR legislation worldwide [9].

During the design stage of a product, decisions are made that determine its life cycle environmental, social and economic performances [10]. It has been pointed out that design decisions determine more than eighty percent of a product's environmental impact [11, 12]. Life cycle design was introduced by the United States Environmental Protection Agency (EPA) in a guidance manual by Keoleian and Menerey [13]. EPA started the Life Cycle Design Project in order to reduce environmental impact and health risks by the means of

product and process design and development [13]. By focusing on all the life cycle stages of a product, this design approach allows avoiding burden shifting and cross media pollutant transfer [13]. Even though the concept was introduced almost three decades ago, it proves to be valid until today.

Strategic design has been defined as planning activities whose project objective is a system, consisting of products, services and communication, and defined as a product-system [14]. Strategic design and life cycle design have much in common and can complement each other. Both have a systemic approach, and the environmental objectives of life cycle design may well be pursued through strategic design.

Understanding the complexity of food packaging systems, and observing existing food packaging design solutions motivated the creation of a method and toolkit to aid the strategic design of food packaging solutions. The use of this method may provide valid insights to be used for designing packaging as a system, thereby optimizing its environmental, social and economic performance. This optimization can benefit several actors and stakeholders across the food value chain.

2 Methodology

The method and tool presented in this paper stems from the project Development of an Integrated Design Management Model for Packaging Solutions in the Food Industry, Articulated to the Value Chain. This project is one of eighteen projects within the Co-Inventa Innovation Platform for Food Packaging, which is funded by the Corporation for the Promotion of Production (CORFO), within its Strategic Technological Programs, Call for the Development of Food Packaging, Government of Chile.

Within this project a research study was conducted in order to understand and characterize food packaging systems in Chile. The findings of this research were used as input for the creation of a method for strategic design in the food packaging system. The method includes sixteen tools, intended to help in food packaging design processes. This article elaborates on one of these tools, the Packaged Product Life Cycle Tool, which seems to fit the content and focus of the Life Cycle Management Conference 2021. The project comprises two main areas: a research study about food packaging systems in Chile, and the creation of a method for strategic design in food packaging systems which includes the aforementioned set of tools.

2.1 Food packaging research

At the beginning and throughout the project, literature was reviewed about packaging, food products, product life cycle, environmentally responsible design, and design methodologies. Then, a series of interviews were conducted with experts within the industry of packaged food, across value chains and from all food product life cycle stages. In parallel with the interviews, observations were made in factories and other facilities of different sizes within the food and packaging industries.

The data collected were analyzed using qualitative techniques. The results enabled understanding the food packaging system; identifying its life cycle stages, processes and actors; and served as input for the creation of a method for strategic design within food packaging systems.

2.2 Creation of method and toolkit

The method created within this project has a life cycle approach, and is intended to be used during food packaging decision making processes, including packaging planning and design.

A set of sixteen tools were developed to be used with the method. These tools serve a variety of functions that can be classified into three main objectives: diagnose, define and validate. The tools are aimed at gathering information that is relevant to understand a given food packaging system; strategically plan for design solutions based on information that is efficient for the business, environmentally responsible and a good experience for the users; and to validate the strategic planning proposed in order to enable design briefing.

The method can be used mostly by design consultants, design teams within packaging or food companies, other kinds of companies, and academia. Potentially, the most benefited parties with the use of the method would be food or packaging companies.

3 Results

The project yielded results of two kinds. First, we have the results of the research. These results are not reported extensively in this article; rather they served as input for the creation of the method and its tools, which represent the second kind of results of the project. A life cycle scheme was conceived based on research results, identifying the life cycle stages of a packaged food product system, the processes undertaken and relevant input-output information for designing a food packaging system holistically.

A number of characteristics of the food packaging system emerged as important to be considered during packaging design processes. The application of this knowledge might be good for the food producer, in order to identify hot spots and make efficiencies, reduce waste and money spending, minimize the environmental impact of their products, and facilitate compliance with EPR legislation.

Based on the scheme, a method for strategic design in the food packaging system was developed including a toolkit. The toolkit is aimed at describing, analyzing, planning and briefing within a food packaging system. One of the tools in the toolkit is the Packaged Product Life Cycle tool, to be explained as follows.

3.1 Development of the Packaged Product Life Cycle Tool

Working towards sustainable packaging is needed because of the significant amounts of packaging waste generated every year, the scarce amount of land available to deal with this waste, the potential use of valuable materials that are present in this waste, and because EPR legislation mandates to deal with this waste. A hierarchy of waste management was adopted, which addresses reducing waste generation, reusing, recycling, and energy recovery from waste, in the same order. The present work intends to make a contribution to understand food packaging product systems in order to design for the reduction and optimization of packaging waste management. The Packaged Product Life Cycle Tool is presented next (Figure 1).

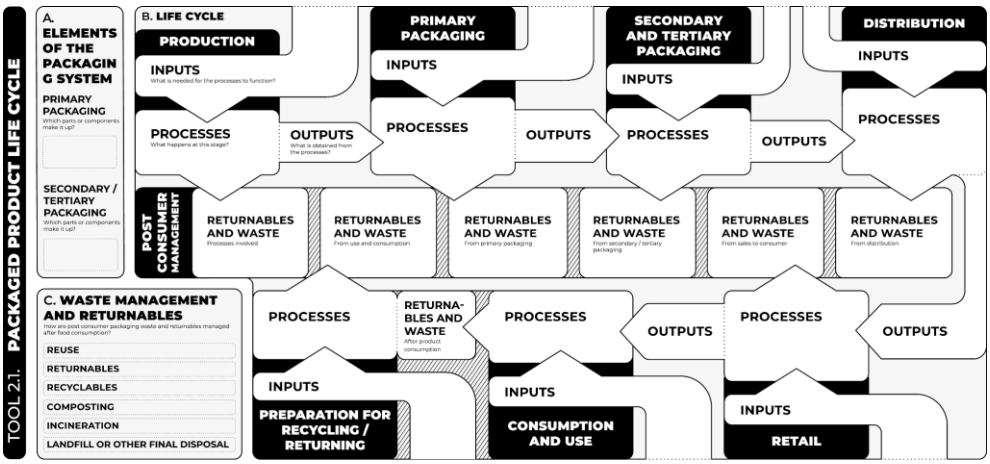

Fig. 1. Packaged Product Life Cycle Tool. The image size has been reduced in order to fit the article's format. A larger image of the tool can be viewed at: https://drive.google.com/file/d/1tWmXl5mb4p1CkxKpOqg-S63HjazZZjIr/view?usp=sharing

This tool is intended to be used as a means to collect and visualize food packaging life cycle information by an interdisciplinary team working on food packaging design projects. To fulfill this function, its original size is A3 (420 mm x 297 mm), and should be printed on paper in black and white. The tool can be understood as a Life Cycle Inventory tool that helps teams to gather and visualize food packaging information from cradle-to-grave. Its use can help teams to establish dependency relationships among the different life cycle stages, the processes involved, and to visualize the corresponding input, output, by-products and waste.

Data must be input to the Packaged Product Life Cycle Tool. Specifically it is requested:
• To identify the components of the food packaging system, and to describe each life cycle stage with the resulting processes and products;
• To identify supplies, products, waste and returnables of each stage, and to identify post-consumer management of waste and returnables.

The information requested must be added in the boxes of the tool that were defined for each topic. For this, sticky notes (e.g. post-it) can be used, or just writing with pencil directly on the paper so that corrections can be made. The tool can be used whether the product has packaging or not yet, in which case it can be used to configure a new packaging proposal.

4 Future work

The next step that the research team is undertaking with regard to this work is the publication of a book that contains the entire method including the complete toolkit. So far the manuscript has been submitted to the publisher. It is expected that the book will be published during 2022.

Future research about the Packaged Product Life Cycle Tool includes testing its use by teams working on food product packaging design projects, real or hypothetical. Once published, the method and toolkit must be tested in order to identify its strengths and weaknesses, so it can be refined for the future.

Acknowledgments. The authors would like to acknowledge the participation and collaboration in the project of the following people, companies and organizations.

Research team stage 2: Oscar Huerta, Ph.D.; Carolina Melo, M.A.; Amelia Tiska, B.A.; and Maximiliano Rubio, M.A.

Research team stage 1: Erik Ciravegna, Ph.D.; Zinnia Silva, M.A.; Denisse Díaz, M.A.; and Silvia Peñaranda, B.A.

Administrative support: Josefina Gaete, B.A.; Andrés Villela, M.A.; Claudio Parra, M.A. and Mariana Pérez.

Sponsors: Chile Transforma Alimentos National Strategic Program, by Corporation for the Promotion of Production (CORFO), Government of Chile; Innovation Platform in Packaging Co-Inventa; Packaging Laboratory (LABEN), University of Santiago de Chile; School of Design, Pontificia Universidad Católica de Chile.

Companies as participants in the study: Watt's; Coexpan; Cristalerías Chile; Integrity; Vollkorn; Fork; Ecológica; SMU; MV Diseño; Imicar S.A.; Cetopan; Gorak; Hydra; Barut; Dolce Pistacchio; and Todo Arpillera.

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