Reverse Logistics Applied to Packaging and Its Contributions to Reducing the Incorrect Disposal

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Abstract. This study addresses customer perceptions of reverse packaging logistics in a Brazilian company in the production and marketing sector of animal nutrition supplements and the challenges faced by the company's management. Carried out in Paraná (Brazil), the research involved a questionnaire for 65 customers and an interview with the company's production manager. The main challenges identified include the cost of correct disposal, the lack of nearby collection points, and the lack of standardization for disposal. Although awareness about sustainable practices grows, many customers still dispose of some waste incorrectly. Most respondents expressed interest in receiving more guidance on re- verse logistics, indicating a willingness to adopt more sustainable practices. However, the company currently does not have direct actions to encourage the correct disposal of packaging by end customers, limiting itself to complying with government regulations. This fact neutralizes its position about developing internal sustainable practices, which could bring benefits such as cost reduction and improving logistics processes.

Keywords: Packing, Waste Management, Reverse logistics, Sustainable Operations, Case study.

1 Introduction

The Industrial Revolution initiated new production models through large-scale industrialization. In this context, factories began to produce intensively using natural resources [1]. Still, in the first steps of the transformation of the industrial scenario, the environment was seen only as a place to obtain and dispose of resources [1] [2]. In this sense, a direct understanding of strategies for reverse logistics of products and packaging has become even more necessary [2] [3].

This perspective has been increasingly incorporated into product and packaging development processes, designed to be easy to recycle or compost, small and light, to reduce resource consumption and waste volume [4]. In Brazil, the implementation and development of the theme began in 1970, with selective collection systems for urban solid waste in some cities. However, it was only with the promulgation of the Nation-

al Solid Waste Policy (PNRS) in 2010 that reverse logistics became regulated and mandatory for some economic sectors", according to Brasil [5].

Reverse logistics systems in Brazil are still challenging to solve, as they present several obstacles, such as the lack of regulation, low adherence by companies, and the lack of awareness in society [6]. In the packaging industry, logistics is an essential strategy for solid waste management, as it allows the reuse, recycling, or composting of post-consumer packaging, preventing it from being sent to landfills or landfills [7]. Another aspect to consider was the increased need for product packaging to cope with the significant increase in Internet sales. This increase had greater emphasis due to the consequences of the COVID-19 pandemic [8].

In this aspect, the general objective of this study is to analyze the perception of customers and companies about reverse packaging logistics in the context of the Brazilian food industry, seeking to understand the main challenges that permeate this topic. Due to the plurality directly related to the theme, the premise of this study is not to define a precise strategy for waste management applicable to companies in different sectors and contexts but rather to provide relevant insights for new applications in va- ried contexts.

2   Research Methodology

The methodology used for this article was a literature review addressing terms that interface with reverse logistics in organizations, based on the objective of this work [4]. Using the SCOPUS database, with the search terms defined in Table 1, guided the previously found and refined results. Table 1 presents the search terms used.

Table 1. Search terms used in the article selection process.

Keywords	(("reverse logistics") AND ("recycling") OR ("reuse") AND ("packaging") OR ("plastic packaging") AND ("national waste policy") OR ("waste management") AND ("product life cycle"))

After an initial search of 162 documents, selection steps were refined to analyze the articles. Many were discarded because they were not relevant or because they addressed non-industrial areas. Most of the remaining articles dealt with circular economy or technology. Therefore, nine works were selected to analyze the gaps in the use of reverse logistics to reduce incorrect packaging disposal. The case study employed a literature review, content analysis, questionnaires, and semi-structured interviews to achieve the results.

The study also investigated the perception of 65 customers of a medium-sized company located in Paraná (Brazil) through the application of a questionnaire with closed questions developed based on the most recurring challenges highlighted in the literature review on reverse packaging logistics. The sampling used was by conglomerates, defined by Silva [9] as a probabilistic approach in which the population is divided into groups, and a random sample of these groups is selected, followed by the selection of some customers within these groups. To increase the response rate, the

questionnaire, formulated in the Google Forms survey management application, was emailed to customers who had previously received a description of the survey objective.

Finally, a semi-structured interview was carried out with the manager of the researched company to understand the studied company's perception of practices linked to the design of sustainable packaging, partnerships with recycling companies, efficient collection systems, traceability and inventory management, consumer education, compliance with environmental regulations and innovation in reusable packaging. An interview is a qualitative research tool that allows the researcher to collect in-depth data on a specific topic. The semi-structured interview allows the interviewer and his interviewee to better understand the subject [10] [11].

3   Literature Review

In this way, we seek to understand what has been published about reverse logistics, product life cycle, packaging, and reverse logistics. Table 2 presents the main gaps addressed by the authors of the articles selected for this research, highlighting the most relevant elements for the subject covered in this work.

Table 2. Gaps found regarding reverse packaging logistics.

Author(s)	Gaps found
Wulf *et al.* (2019) [12].	This study identified the main challenges in implementing sustainable development: the lack of a single definition makes it difficult to compare different Life Cycle Assessment (LCA) studies and many LCA studies focus only on some impacts, such as natural resource consumption and pollution, ignoring other important ones, such as climate change, human health, and biodiversity.
Rebehy (2019) [6]; Lichten-thaler (2023) [13].	Improving legislation: Brazilian legislation on Reverse Logistics (RL) is complex and fragmented, making it challenging to implement effective systems due to inconsistencies between laws and regulations. 2. Increased information and awareness: Responsibility for implementation is shared by manufacturers, distributors, consumers, and governments, but the lack of coordination undermines the effectiveness of the systems.
Cai and Choi (2021) [14]; Pinto *et al.* (2023) [15].	The lack of coordination between Extended Producer Responsibility (EPR) actors can undermine its effectiveness, with manufacturers focused on cost reduction and distributors on logistical efficiency. Collaboration is crucial for comprehensive solutions. Implementation faces logistical, economic, and regulatory challenges, such as the cost of reverse packaging logistics.
Oliveira and Magrini (2017) [16].	The study highlights challenges in obtaining reliable data on the life cycle of products, especially in companies with a possible bias toward presenting an improved image. It concludes that recycling and incineration of plastic oil containers are more favorable alternatives to industrial landfills, with suggestions for improvements. The importance of public and private cooperation and appropriate legislation for effective results are highlighted.
Blass and Cobertt (2018) [17].	This article highlights how Life Cycle Assessment (LCA) and Supply Chain Management (SCM) converge, especially in carbon footprint analysis. Although LCA is the main focus, the issues addressed apply to Industrial Ecology (IE). The interaction between LCA and SCM can improve LCA practice and inform sustainable SCM. Considering the entire product life cycle, this situation includes economic and environmental optimization. Integrating IE and SCM can be facilitated by

	participating in relevant conferences and publications.
Simon *et al.* (2016) [18].	The study evaluates the environmental impacts of beverage packaging and reverse collection systems, highlighting the high impact of glass and aluminum cans. It suggests measures such as prior compression and using light materials to reduce these impacts. It is recommended to explore new materials, involve consumers in selective collection, and use recycled materials in other industries to minimize the impact of beverage packaging.
Islam *et al.* (2017) [19].	This study reviewed the Green Supply Chain Management (GSCM) literature, compiling green practices between 1998 and 2016 to contribute to advancing the field. It identified some limitations, suggesting areas for additional research, such as applicability in specific industries and the expansion of the journals analyzed. Recommends expanding the keywords used in future searches for a more inclusive approach.
Sheriff *et al.* (2017) [20].	The paper proposes a plastic recycling network model to minimize the total cost of collection, using variants of the Comprehensively Resolved Single Product Model (CRSPM). It compares performance with data from a case study in India. It suggests future directions, such as considering inventory costs, stochastic demand, and cross-market coordination in reverse logistics of recyclable plastics.
Accorsi *et al.* (2014) [21].	The paper proposes a framework to Compare Reusable Packaging (CRP) and single-use packaging in the catering supply chain, using Life Cycle Assessment (LCA) and Life Cycle Cost Assessment (LCCA). The environmental impact of manufacturing single-use packaging and the importance of transportation for the CPR system stand out. Despite lower CO_2 emissions, adopting CPR may increase costs.

Based on Table 2, the primary challenge faced by organizations lies in understanding and effectively adopting sustainable practices that intrinsically incorporate processes and can actively contribute to progress and the responsible reuse of resources. They must overcome significant barriers when business management maintains a limited vision, restricted only to the immediate benefits of sustainable development within its structure [22]. However, it is possible to overcome this challenge by implementing consistent recycling actions, optimizing waste transport and efficient use of various materials, and integrating them continuously into the companies' daily practices.

4 Results and Discussions

This section will present the main results and analyzes resulting from the study on reverse logistics applied to packaging in the animal nutrition supplements industry. The company studied is classified as medium-sized, located in Paraná (Brazil), and operates in producing and selling supplements for animal nutrition, with a solid national and international presence. Its diversified portfolio includes 195 national clients. The research sample, made up of 65 customers, was stratified by regions of the country (see Fig. 1).

The total population consists of 271 customers grouped into six clusters. The "international" conglomerate, composed of clients based in other countries, was excluded, resulting in 196 clients for sample validation distributed across regions of Brazil. This exclusion was motivated by the low availability of customers to respond to the questionnaire. However, the study still needs to fulfill its objective of analyzing the perspectives and challenges of national reverse logistics.
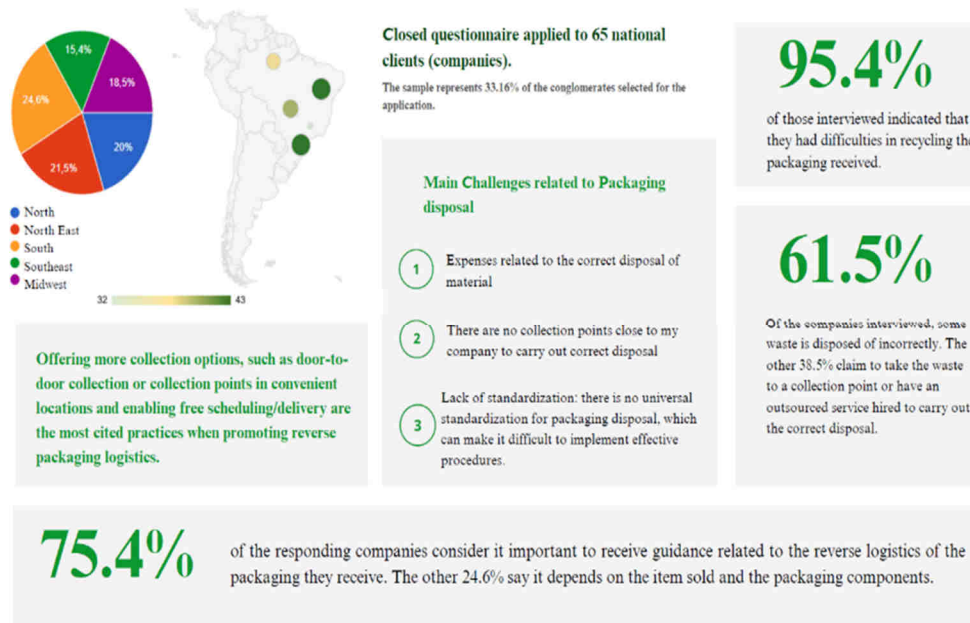
Fig. 1. Infographic - Questionnaire.

According to the data presented in Fig. 1, the main challenges in disposing of packaging include spending on its correct destination, the scarcity of nearby collection points, and the need for more standardization. Of the sample, 75.4% of respondents consider it crucial to receive guidance on reverse logistics for packaging of all types. For 24.6%, the nature of the packaging material and the item purchased influences the need for information on reverse logistics. These challenges complicate the packaging reverse logistics process for around 95.4% of the companies surveyed, leading more than half (61.5%) to dispose of waste inappropriately.

Respondents want more pickup points, such as door-to-door service or convenient locations with free scheduling and delivery. Companies show interest in adopting more comprehensive reverse logistics processes. However, barriers such as costs and location of collection points still raise doubts about making reverse packaging logistics more efficient and structured.

A questionnaire with seven semi-structured questions was developed to understand the perspective of the company manager studied, on the importance and opportunities of reverse logistics in reducing inappropriate packaging disposal and its alignment with factory management. The questions address the implementation of reverse logistics, strategies to control the inappropriate disposal of solid waste, and their adaptation to the company's current maturity, as detailed in Table 3.

Table 3. Answers obtained from the interview with the company manager.

Sustainable Packaging Design: The company recognizes the importance of investing in sustainable packaging to reduce waste, a constant concern. Choosing recyclable or biodegradable materials requires study and caution, especially in the food industry, where packaging directly affects product quality and customer perception. A study was initiated to replace plastic, which makes up 70% of current packaging, with alternatives such as cardboard, already adopted in a product in 2019. However, due to the foreign market, the company is evaluating how to make this transition viable within the technical regulations needed.
Partnerships with Recycling Companies: Establishing solid partnerships with recycling companies is crucial to ensuring the efficient return of packaging. Currently, a company is responsible for collecting and disposing of solid waste but has no direct connection with the products sold.
Efficient Collection Systems: Developing efficient collection systems to recover discarded packaging, including collection points in strategic locations, return programs, or partnerships with waste collection services, are some of the company's objectives, which has tried to align strategic forces and technical knowledge to enable these processes.
Traceability and Inventory Management: Implementing traceability systems to monitor the packaging life cycle would be of great value to the food industry, given the scale of sales and frequency. This not only facilitates reverse logistics, but also allows for effective long-term returnable packaging inventory management.
Consumer Education: Conducting educational campaigns to raise awareness among consumers about the importance of returning packaging is also a point for reflection and possible action by the company, as raising awareness and building a more conscious chain will bring joint growth to all agents.
Compliance with Environmental Regulations: Staying up to date and in compliance with environmental regulations related to waste management and reverse logistics is very important for the company, mainly because the regulatory bodies that guide the food industry are constantly updated and require technical quality standards that allow or not the operation.
Innovation in Reusable Packaging: Exploring the possibility of implementing reusable packaging systems is one of the company's projects, which, in the long term, is studying the possibility of developing deposit and return programs in which consumers are encouraged to return empty packaging in exchange for incentives.

The food industry faces a growing challenge: making its packaging more sustainable. The amount of waste this sector generates is significant and directly impacts the environment.

In this context, the company, taken as a reference for this study, stands out for its commitment to sustainability, implementing several initiatives to reduce the environmental impact of its packaging, such as those related to the design of its packaging. It is carrying out a study to change its packaging material, which is currently plastic in 70% of cases. This initiative demonstrates the company's commitment to sustainability and the search for innovative solutions. The experience with cardboard packaging in one of the products developed in 2019 is an example that the transition to more environmentally friendly materials is possible.

The research found that companies still face challenges in operationalizing more sustainable packaging reverse logistics chains. Such challenges are directly related to the perception that it is sustainable according to different market sectors. Implementing new methods and identifying partners to operationalize such reprocessing become points of dispatch for decision-making linked to the topic. The findings corroborate the work of Wulf *et al.* (2016) [12] and Oliveira and Magrini (2017) [16], which explain the difficulty of defining sustainability, making the comparison of operations,

often in the same segment, less concrete, given the different interpretations of the product life cycle.

5   Conclusions

Research on reverse logistics applied to packaging in the animal nutrition supplement industry provides a comprehensive and meaningful view by relating results to similar studies. This highlights the impact of knowledge gained by identifying similarities and differences in reverse logistics practices. This comparative analysis enriches the understanding of reverse logistics operations and highlights the importance of adjusting and innovating in business practices. By finding points of convergence and divergence with other work, it becomes possible to identify opportunities for improvement and adaptation that can be implemented to optimize the efficiency and sustainability of operations.

An overview of the study shows that customer perception and discussions with the company manager are fundamental in guiding the information collected toward a common objective. Understanding customer expectations and concerns and aligning them with the manager's strategic vision can effectively address the challenges and deficiencies identified in the study. This collaborative approach allows you to develop strategies that mitigate negative impacts and enhance positive aspects for both the company and customers. For example, resolving problems related to reverse logistics can improve the customer experience, increase satisfaction, and strengthen the company's reputation in the market.

Implementing greater packaging reuse holds the potential for a series of significant benefits to the company. In terms of costs, reusing packaging can result in reduced operational expenses, as it reduces the need to produce and purchase new packaging. Furthermore, environmental impact is minimized, contributing to more sustainable practices that meet legal and regulatory requirements. In the Brazilian context, this practice is especially necessary due to the growing demands for sustainability and increasingly stringent environmental regulations. Promoting packaging reuse helps meet these requirements and positions the company as an agent of positive change in society, highlighting its commitment to sustainability and social responsibility.

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