A Systematic Literature Review on Packaging Sustainability: Contents, Opportunities, and Guidelines

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Abstract: The relationship between packaging and sustainability has caused the evolution of literature towards the minimization of environmental damage. The task of packaging professionals is becoming more demanding, as they need to collect information from distinct topics to stay up to date. The aim of this research is to gather information on packaging in the sustainability context to provide a systemic view of the contents, to identify opportunities, and define guidelines for packaging design. A systematic literature review of 472 papers was performed. The first step was a bibliographic search using Pack *, Sustainab *, and eco * as keywords. Secondly, the content analysis revealed the emergence of nine categories grouped in four clusters. These categories and nineteen subthemes were considered research opportunities. Going beyond the coding units of the content analysis, we have used context units to propose (i) the gathering of technical procedures to support the design phases of sustainable packaging; and (ii) the proposition of a framework based on the life cycle stages and design phases. At last, we have provided insights and guidelines that can be useful for packaging professionals.

Keywords: packaging; sustainability; circular economy; systematic literature review; design guidelines

1. Introduction

Packages are envelopes, containers, or any form of covering, removable or not, intended to enclose, protect, maintain the products in use for longer periods, or facilitate their marketing. Packaging is a complex technical and commercial system whose objective is to protect a given content from the production process to consumption, aiding its identification, promotion, and negotiation [1–3].

Sustainability has become one of the functions of packaging, along with ensuring products’ quality and safety, enabling product communication, and facilitating transportation and logistics [4]. Considering the development of sustainable packaging, the environmental sustainability pillar is especially relevant [5]. Moreover, sustainable packaging contributes to minimizing the ecological footprint of companies and saving their resources [6].

In 2019, the total value of packaging worldwide was estimated to be approximately USD 917 billion Smithers [7]. A study published in “The Future of Global Packaging to 2024” shows that demand for packaging will grow 2.8% per year and peak at USD 1.05 trillion in 2024 Smithers [7]. According to studies of the World Packaging Organization, the food sector alone will reach USD 400 billion in packaging production by 2025 WPO [8]. The Global Packaging Trends 2020 from Mintel [9] listed two sustainability-related packaging trends. The first trend is that packaging manufacturers and brands must continue developing and commercializing innovations with recyclable materials. The second trend is in-store refills; with the rapid growth of independent package-free stores. This is leading retailers in the entire sector to consider creating opportunities to refill products instead of using disposable packaging Mintel [9]. The same study reveals that ‘responsible’ packaging will reinforce the ‘sustainable’ packaging concept, since there is a relationship between responsibility and...
the social pillar of sustainability. This constitutes a practical approach that brand owners must promote and defend. Consumers have to act accordingly by valuing the adequate use and disposal of packaging. Once a more responsible packaging choice has been made, brands can use messaging to make consumers aware of why a specific packaging format or material has been used. More importantly, they may use the same strategy to educate consumers on what action they can take towards reuse or proper disposal [9].

According to Lu et al. [10] packaging excess on the planet challenges the sustainable development of our society. Under the perspective of the circular economy approach, the waste problem has to be addressed from the early design stage, which includes packaging projects Ellen Macarthur Foundation [11]. Additionally, the circular model is founded on economic, natural, and social capital concepts, always supported by a transition to renewable energy sources. Therefore, it is evident that the responsibility of packaging developers, manufacturers, and other professionals involved in packaging development is to respond to the ever-increasing demands of the current scenario.

Although packaging seems simple from the structural standpoint, it is highly complex from the systemic life cycle point of view. Project definitions concerning the type of materials and format, for example, may impact its function, production stages, distribution, commercial actions, its adequate use/discard by consumers, and ultimately the environmental damage. Petljak et al. [12] reinforce that the materials used in packaging and their waste have a very harmful influence on the environment, and they explain the tendency to develop efficient and effective biodegradable packaging.

Packaging complexity is also revealed by the fact that it does not belong to a particular area of expertise. It is explored in design and communication [13,14], engineering [15,16], and chemistry [17,18], among others [19]. The number of systematic literature reviews about packaging evidence the complexity of packaging. Some of these literature reviews focus on materials [20–24]. Other reviews focus on food packaging [25–29]; while others explore the dimensions or triple nature of sustainability [30–34]. Some packaging reviews are not specific [6,35–38]. Considering that such research and reviews are spread over different literature domains, the systemic analysis of the knowledge is an essential and challenging task for professionals in the packaging field.

The starting premise is that packaging must be designed to cause the least environmental impact possible. The project must be supported by tools similar to the life cycle assessment and inventories that minimize its carbon footprint and environmental impact. Packaging must meet market criteria and be developed within acceptable financial costs. It has to be socially and culturally appropriate (reflecting, for example, the target audience’s lifestyle), with a social enabler that encourages consumers to find alternative uses for it. If the package design fails to provide alternative uses, consumers must be able to dispose of it in an environmentally correct way [12,39,40]. The circular economy concept is relevant in the search for solutions to the problem of packaging waste generation. The transition from a dominant linear economy to a model based on circularity and design by intention may create a new basis that is essential for the market economy and use of packaging [41]. Considering the extent of the problem presented, the following research questions arise:

RQ 1—What has been discussed, in the literature, about sustainability strategies applied to the packaging life cycle (extraction of raw material, raw material transformation, graphic and structural design, packaging manufacturing, filling process, sale, use, and post-use)?

RQ 2—How has the literature supported packaging professionals’ practice in the context of the circular economy and sustainable packaging?

RQ 3—What research opportunities can emerge from the current literature on sustainable packaging?

The authors ground their research on the premise that gathering knowledge from the extant literature on sustainable packaging may provide a systemic view to professionals and researchers and provide the foundations for developing new types of knowledge.
2. Materials and Methods

The method adopted is the systematic literature review (SLR), with an emphasis on publications that addressed packaging in the sustainability context. The documents identified were analyzed according to the following two approaches: (i) bibliographic analysis, which provided a quantitative view of the main titles of journals and publications [42], and (ii) a qualitative study using content analysis adapted from Bardin [43], Bickman et al. [44] and Moraes, [45].

2.1. Systematic Literature Review

The protocol recommendation of Moher et al. [46] was used as a basis for the SLR. It consists of four steps (Figure 1) that aim to support the authors in improving the reporting of systematic reviews and meta-analyses. The items considered for the bibliographic analysis were publication year, journal, area of knowledge and repository, countries, universities, and research method adopted. The authors used the VOSviewer® software, version 1.6.18, created at Leiden University, Leiden, The Netherlands, for keyword analysis, and authorship and co-authorship analysis. This tool allows constructing and visualizing bibliographic networks.

Figure 1. Systematic literature review protocol.

The search string was composed of the following keywords and Boolean operators: “Pack * and Sustainab * and eco *.” We adopted a reduced keyword search to retrieve the largest number of publications about the topic from the searched sources EBSCO, Emerald, Science Direct, Springer, Web of Science, and Willey. Based on the eligibility criteria defined, only articles published in English were selected. Due to the generalization of the term Pack *, the word was considered only in the title to restrict the search to the defined purposes. A set of 10 articles did not present their full text; hence, they were excluded from the retrieved set. In the first search, the total number of articles retrieved was 3009. After applying the exclusion criteria, 472 articles were selected (Figure 1). The links to all the articles retrieved in the search and all phases of the SLR protocol are presented in Appendix A.

In phase 1 (identification), the articles that failed to meet the research topic were excluded. For instance, they were removed whenever they focused on tourism packages, service packages, software packages, quantitative study packages, statistical packages, en-
ergy packages, economical packages, technological packages, guidelines packages, control packages, benefits packages, policy packages, intervention packages, work packages, logistical packages, fiscal packages, energy packages, simulation packages, legislative packages, benefits packages, and healthcare packages.

Preliminary searches have indicated that the number of articles increased after 1990. Therefore, this analysis comprised 30 years of publications, starting in 1990. The search was performed from April to May 2020, when the gathering ended. The results and search criteria in each database and publishers are described in Table 1.

Table 1. Results and search criteria in each source.

<table>
<thead>
<tr>
<th>Sources</th>
<th>Search Criteria</th>
<th>String</th>
<th>First Search</th>
<th>Excluded</th>
<th>Analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBSCO</td>
<td>Time range: all years; article part: Pack * in title and Sustainab * and eco * in abstracts; documents: article; areas: all; the search criteria of containing the word “packaging” in the title was added to reduce the high number of articles (12,204).</td>
<td>Pack * AND Sustainab * AND Eco *.</td>
<td>140 articles</td>
<td>79 articles</td>
<td>61 articles</td>
</tr>
<tr>
<td>Emerald</td>
<td>Time range: all years; article part: Pack * in abstract and Sustainab * and eco * in all the articles; documents: articles; areas: all; search.</td>
<td>Pack * AND Sustainab * AND Eco *.</td>
<td>552 articles</td>
<td>489 articles</td>
<td>63 articles</td>
</tr>
<tr>
<td>Science Direct/Elsevier</td>
<td>Time range: all years (1978 to 2020); article part: all articles; documents: articles; areas: all; the criterion of containing the word “packaging” in the title was added to reduce the high number of articles (12,204 articles).</td>
<td>Packaging AND Sustainabity AND eco (this base does not accept asterisk but considers similar words).</td>
<td>204 articles</td>
<td>27 articles</td>
<td>177 articles</td>
</tr>
<tr>
<td>Springer</td>
<td>Time range: all years; article part: all; documents: articles and conference articles; areas: all; search string.</td>
<td>Pack * AND Sustainab * AND Eco *; containing pack * in the title.</td>
<td>274 articles</td>
<td>147 articles</td>
<td>127 articles</td>
</tr>
<tr>
<td>Web of science</td>
<td>Time range: all years (1945 to 2020); article part: topic (title, abstract, author keywords and keywords); documents: articles and reviews; areas: all; main collections of Web Science.</td>
<td>Pack * AND Sustainab * AND Eco *.</td>
<td>1374 articles</td>
<td>970 articles</td>
<td>404 articles</td>
</tr>
<tr>
<td>Willey</td>
<td>Time range: all years (1957 to 2020); article part: abstract; documents: article; areas: all.</td>
<td>Pack * AND Sustainab * AND Eco *.</td>
<td>465 articles</td>
<td>374 articles</td>
<td>91 articles</td>
</tr>
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</table>

In phase 2 (selection), 923 articles were considered, and 149 duplicated articles were excluded. In phase 3 (Eligibility), based on the criteria defined and after the full reading of the articles, 302 articles were excluded out of the 774 because they did not address the research topics of packaging and sustainability. In phase 4 (inclusion), a total of 472 articles were selected for the literature review. The bibliographic references and content extraction from articles were managed using Mendeley® software, version 2.70.0, create to Elsevier Inc., Amsterdam, The Nederlands. Appendix A presents the link to access the articles and notes. The analyses of keywords, authors, and coauthors were performed with VOSviewer® software, version 1.6.18, create to Leiden University, Leiden, The Nederlands.
2.2. Content Analysis

The content analysis’ objective was to guide information exploration and reduce subjectivity in the qualitative analysis [44]. The content analysis was developed grounded on the following two coding units: (i) sustainability, and (ii) circular economy, terms that were included in the search string. We used as context units (i) packaging life cycle stages and (ii) the packaging design stages. These context units were selected because they are the guiding dimensions in the creative process of packaging design. The decision for two levels of analysis allowed for a more targeted reading focused on our study objective, thus, serving as classification categories for the findings. Lastly, while reading the 472 articles selected, other units emerged and were used as classification subcategories. More details on article classification are described in Sections 3.2 and 3.2.1.

3. Results

A growth trend was observed in the publications on the subject of packaging over the years. Considering the current protocol, no publications were identified in 1991, 1992, 1994, and 1995. In 1993 and from 1996 onwards, few publications emerged each year, and a continuous growth started in 2013. The period from 2013 to 2020 constitutes 82% of the articles retrieved, revealing the growing interest of scholars on the subject in the last years. An illustrative chart of publications by year can be observed in Supplementary Material—S1.

3.1. Bibliographic Analysis

The classification of articles by areas of knowledge is presented in Figure 2, based on the proper categories indicated by the journals’ editors. Research topics specific to each article were reported using electronic spreadsheets (Microsoft Excel®). In a second classification, journals were grouped by knowledge areas, resulting in 21 general areas, published in 20 digital repositories. The detailed table can be observed in Supplementary Material—S2.

![Figure 2. Classification of articles by knowledge area.](image-url)
Figure 2 confirms that the topic “packaging” is distributed in various knowledge areas. This finding reinforces the initial premise of our study and emphasizes the multitude of professionals involved in the subject of “packaging sustainability”. Hence, we aim to provide a panorama of the main practices, methods, and tools studied within this context.

Thus, the “sustainability” analysis unit constitutes the largest number of publications, with 151 research articles (32%). The “circular economy” analysis unit encompasses approximately 5% of the articles. Such a smaller number of publications is not surprising, as this terminology is relatively new. Although the circular economy concept has existed since the 1970s under other terminologies, it is rising, and packaging is a relevant item within this context.

The analysis with VOSviewer® revealed 92 clusters, which are groups of keywords formed based on similarities or proximity. The largest cluster included 37 items, covering relevant topics, such as materials, food, and the transformation process. The association among these topics is coherent since the selection of materials and processes for the quality and safety of food packaging has been a relevant investigation challenge.

The “occurrences” column in Figure 3 indicates the number of articles in which a term occurs at least once.

The analysis reveals the subject trends gravitating around the term packaging. Considering the large number of articles returned (472), the density of occurrence of keywords guided the definition of categories for content analysis in the next step. The grouping of terms in VOSviewer® considered how terms were originally written; therefore, the total number of occurrences for life cycle assessment (LCA) was 51 (27 + 13 + 11), which places this keyword in the second position, after packaging.

Another keyword worth mentioning is Active Packaging. The occurrence of this keyword reveals the importance that some technologies are gaining in the food packaging literature. This strategy will be further discussed in Section 3.2.1. The full density of keywords can be viewed in Supplementary Material—S3.

Figure 4 reveals the number of publications by country of origin of the first author in each article. The articles selected in this SLR were from 53 different countries. Figure 4 describes the list of publications by continent and the country with the highest publication in each of them. Europe constitutes the largest number of articles (53%), followed by Asia (24%) and North America (10%). The table containing all countries can be viewed in Supplementary Material—S4.
Figure 3. Density of keyword occurrence in articles (https://www.vosviewer.com).

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Figure 4. Classification of articles by continent.

Figure 5 lists the ten research methods described in the articles.

Figure 5. Classification of articles based on the research method.

Experiments were mentioned in 32% of the articles, with emphasis on the analysis of materials. The literature review approach ranks second place (19%), with an emphasis on materials. The reviews focused on descriptions of the physical-chemical behavior of the resources, their biodegradability, and other specificities. Properties of materials, such as aluminum, polymers, and other related knowledge are valuable information to be consulted by packaging developers. Life cycle assessment was cited as an approach in 14% of the articles. The content analysis in Section 3.2 will reinforce its relevance in the packaging context and the existing interdependence between life cycle assessment and other approaches.

3.2. Content Analysis

The content analysis was performed to clarify the three research questions mentioned before. Coding units and context units were described in Section 2.2. The articles were grouped and may be consulted in Supplementary Material—S5.

3.2.1. Categories for Classification of the Articles Analyzed

The consensus of nine categories (Figure 6) was reached by comparing the groups named by the authors with the keywords previously observed in the VOSviewer® map (Figure 3).
As a general rule, each research article was classified in a given category, taking into consideration the main objective of each article. For example, the article was classified in the “life cycle assessment category” if the author’s primary investigation goal was the LCA tool. If LCA was applied as a means to reach the goal, not as an end, the article was classified in another category. For instance, LCA was used as a measurement in some circular economy investigations. In such articles, the aim resided in studying the circular economy itself; therefore, circular economy was the category of choice for their classification.

Considering the nine categories, the content analysis presented subcategories described on a case basis in Section 3.2.1. Figure 6 shows that categories 3 (dimensions of sustainably), 6 (materials), and 9 (sustainable practices) were subdivided into three subcategories. The subdivision emerged from the initial reading of titles, and it helped in the analysis of the articles. The articles and their classifications are shown in Supplementary Material—S5.

The authors did not intend to make an exhaustive transcription of the content analysis of the articles since it would be impossible to summarize them in the body of a single publication. After analyzing all the contents, some articles were described in tables to provide an overview of specific and predominant topics in the SLR. (The tables can be evaluated in Supplementary Material—S6). These articles were selected according to the quality, current level of the contributions brought to the research, and journal relevance.

Each table presents five subcategories of classification, including (i) article objective, (ii) authors, (iii) main findings, (iv) life cycle stage, and (v) strategy applied to the packaging life cycle or to support professionals’ practice. Subcategories (iv) and (v) were created to address RQ1 and RQ2, respectively.

For the (iv) life cycle stage subcategory, articles were classified as “filling process,” for example, based on the packaging application reported in the article. If no specific type of packaging or application context was reported, the criterion was the life cycle stage name itself. Reference [47] for instance, studied the sectorial agreement of reverse logistics (RL) of packaging in Brazil; therefore, the RL process was the main theme, and the article was classified as “post-use.” The same logic was used in all nine tables for classification in subcategories.

Finally, regarding RQ3, the symbol (Op#) indicated opportunities that emerged from content analysis.

3.2.2. Categories in the Context of Sustainability

Category 1, “circular economy” (CE), included 20 articles (4.2%) published between 2016 and 2020. Selected publications in each of the nine categories can be viewed in Supplementary Material—S6.

According to Foschi and Bonoli [48], plastic packaging has become an important driver to the transition towards circular economy models due to the industry’s commitment to
European policy European Commission [49]. At least two trends were observed in circular economy articles.

The first trend, namely the design/redesign of packages, is a proactive approach that is in alignment with the CE principle of “designing out waste and pollution”. Concerning the frameworks for redesigning packaging, Niero and Hauschild (2017) compared the benefits and limitations of combining the cradle-to-cradle design protocol, the material circularity indicator, and the life cycle sustainability assessment (LCSA). The authors recommended using the LCSA framework to evaluate circularity strategies, since it is considered the most comprehensive and still operational framework with very broad coverage of impacts. They argue that with its life cycle perspective, it is best at preventing burden shifting between stakeholders in the value chain.

The second trend was the packaging waste valorization and management. Concerning the waste valorization studies, they have revealed the relevance of “people” and “environmental education” in the circular economy. Abuabara et al. [50] applied value-focused thinking (VFT) and analytic hierarchy process (AHP) methodology to prioritize (RL) strategies according to interviewees’ values. Buil et al. [51] demonstrated the positive effects of childhood education in the circular economy by teaching sustainable practices in the case of aluminum packaging recycling.

Considering the studies on packaging waste management, they have addressed the circularity of materials such as plastic, polystyrene, aluminum, and they recurrently reported the need for assessment metrics [52]. Waste management was the largest subcategory in the circular economy, which is explained by the strong concern on reducing the large amount of packaging disposed of in the environment. This end-of-pipe approach is aligned with the circular economy principle of “circulate products and materials”.

Generally, waste management covers all aspects of waste, including waste reduction and the collection, transportation, handling, and disposal process. This group of articles analyzed restricted segments, such as a supermarket [53], or broader contexts, such as cities, with an emphasis on packaging’s end-of-life. Jang et al. [48] have examined the current efforts on recycling waste by extended producer responsibility (EPR) in cities of South Korea and other countries. In both articles, the authors reveal the urgency of recycling waste. In South Korea, for example, approximately 6.6 million tons of CO$_2$eq could be avoided by material and packaging recycling.

In both situations, packaging redesign and waste management categories, LCA assumed a relevant role as a performance tool. For instance, LCA was used to compare a previous packaging material and the redesigned one. The CE principle “circulate products and materials” was achieved by redesigned packaging that extended product life. Therefore, end-of-life LCA allocation methods gained relevance for driving decisions during packaging design. Niero and Olsen [54] have also used LCA to quantify the environmental performance of aluminum cans in multiple loops.

The LCA method was used in combination with the eco-design methodology to identify the life cycle stage that causes less harm to the environment. For instance, Civancik-Uslu et al. [55] argue that in the case of plastic cosmetic packaging, the production stage is a major contributor to environmental impact, due to energy consumption and transportation. These findings rise the following opportunity (Op#).

(Op#1) The packaging should be planned in a systemic perspective over the entire life cycle (including production, transportation, etc.) and analyzed in terms of environmental impact on a case-to-case basis to meet circular economy objectives.

Schmidt Rivera et al. [56] have used a set of circularity indicators and life cycle-based indicators to advance the assessment of circular economy strategies in a study of beer packaging and Albuquerque et al. [57] used an alternative approach for LCA named LCC. The results obtained through the LCC concept and externalities indicated an economic benefit and CO$_2$ reduction in their study on the circular economy system of aluminum packaging and tinplate.
(Op#2) Life cycle cost (LCC) seems to be an important alternative to reduce costs throughout the value chain and an opportunity to complement LCA studies on packaging in the context of circular economy.

The third principle of circular economy, “regenerate natural systems,” was observed in studies that proposed the development of food packaging from food processing waste to create business opportunities for food industries [58]. Guillard et al. [59] proposed the production of microbial biodegradable polymers from agro-food waste residues. This approach is a way to create an innovative, more resilient, and productive, waste-based food packaging economy by decoupling the food packaging industry from fossil feedstocks and allowing nutrients to return to the soil.

(Op#3) The following gaps in this research area should be studied: (i) the lack of tools and approaches to properly design and adapt food packaging to food needs; (ii) mathematical simulation, based on modeling of mass transfer and reactions into food/packaging systems. [59]

A broader perspective on the circular economy was provided by the articles covering the study of supply chains. Meherishi et al. [60] have demonstrated that the circularity of packaging may be independent of the product itself, mainly concerning secondary and tertiary packaging at the pre-consumption stages of the life cycle. Primary post-consumption packaging may also have an independent return flow.

(Op#4) Frameworks/methods may be developed to support researchers in circular economy studies. Frameworks must clearly define the following aspects: (i) the function of packaging (primary, secondary, tertiary), the portion of the chain (pre-consumption or post-consumption), and if the reverse flows of the package include the product itself or not.

Meherishi et al., [60] have also identified three organizational theories that support and drive sustainable packaging supply chain management (SPSCM), the institutional theory, stakeholder theory, and ecological modernization theory. These theories are complementary and have driven the development of a circular economy framework for packaging. Additionally, the study of Batista et al. [61] revealed managerial recommendations that can facilitate the implementation of circular supply chains by other businesses.

(Op#5) To improve the circular flows of materials recovered after use, it is recommended to develop and promote collaborations with third-party organizations beyond the boundaries of the focal company’s operations, including the cascading of materials into supply chains.

Category 2, “design”, encompassed 21 articles (4.5%) with topics related to packaging design published between 1998 and 2019. An increase in publication was observed in the last five years. The articles brought different perspectives on the design of packaging, such as communication, eco-design education, and project tools.

Starting with Holdway et al. [62], who stated decades ago that being “green” is no longer optional and professionals should seek strategies, practices, and procedures that could promote sustainability in packaging projects. This group of articles was classified in the graphic and structural design phase of the life cycle, describing the strategies applied to packaging design.

The articles that addressed aspects related to the communication subcategory in this category brought graphic design elements, i.e., “ecolabels,” to attract consumers’ interest [63].

(Op#6) Jerzyk [13] argued that manufacturers seek solutions on the market, which are often based on intuition rather than knowledge. This finding reveals an opportunity to approximate the academic community to the manufacturers and developers of packaging.

Manufacturers have used eco-arguments for their packaging to affect consumers’ perceptions and influence their behavior. Buelow et al. [64] argue that there has been little research on the role and adequacy of labeling in driving consumer-recycling behavior. Regarding the design practice with a sustainable focus, eco-design methodology stands
out. Ma et al. [65] affirm that designers have made efforts to mitigate the environmental impacts of packaging; however, many packaging designs are still far from achieving their sustainability goals.

Regarding design practices, the structural design of packaging (which comprises the shape, texture, materials, and the capability of delivering product packs) was considered a popular way of differentiating products, protecting them from imitation, and adding consumer benefits through improved product delivery and conservation [36]. Nevertheless, nowadays, company managers are looking for alternatives in more sustainable structural projects. In this context, refills show positive results, representing good value, while radically reducing the amount of packaging manufactured and distributed. The customization of packaging design is a recurring subject in the design literature analyzed. In this case, the packaging properties can be improved from several points of view, including functional, aesthetic, economic, and ecological [66].

(Op#7) Articles focusing on the design category have emphasized functions, communication, labeling, and structure to achieve environmental requirements. The focus remains on the environmental aspect, so there is opportunity for social and economic investigations.

Another finding in this group is the evidence on the close relationship between packaging and product. Bucci and Forcellini [35] highlight that the product development process is only complete when the packaging is developed.

Category 3, the “dimensions of sustainability”, comprises 45 articles (9.5%), 5 of which were related to the economic dimension, 25 articles addressed the environmental dimension, and 15 addressed the social aspects related to packaging. They were published between 1993 and 2020 with the highest incidence in the last 3 years.

Several approaches have been used to meet the sustainable development goals, including those addressing packaging issues. Such goals consider multiple aspects of sustainability, such as social, economic, and environmental sustainability [67]. The articles that addressed the economic dimension presented themes related to the financial impacts on the packaging recycling chain in the public and private contexts. In Europe, for instance, while each country currently has their own packaging waste management system, there is still a lack of evidence regarding the real costs of recycling and how these costs are distributed among stakeholders [68].

The articles on the environmental dimension of sustainability encompassed themes of packaging recycling, the economic and social impacts related to pre- and post-consumer waste, and strategies to reduce food waste. Systemic changes in packaging projects can minimize waste and reduce the consumption of materials and energy resources in the packaging production cycle, generating environmental benefits [19]. Therefore, the literature suggests approaches to minimize packaging waste, such as the concentrated efforts from private and public stakeholders to reduce packaging throughout supply chains.

(Op#8) Considering contexts such as the health products, in which the elimination of packaging is not feasible, researchers have recommended the creation of global policies on the use and disposal of packaging materials and the education of consumers. [69]

(Op#9) The joint interest of public and private sectors can boost studies on product-service impact and unveil novel alternatives to reduce the environmental impacts of packaging systems. [70]

The social dimension brought to light problems related to hunger and food waste, legislation, and the social responsibilities of companies. The emphasis on developing packaging that is useful to save food will be important to fulfill the United Nations Sustainable Development Goals. The literature suggests splitting global food waste per capita at the retail and consumer levels and reducing food losses along production and supply chains [71]. As a general rule, the government must play a leading role in improving the policies of waste management regulation [30].

Researchers have adopted a systemic perspective on their studies in both categories and used LCA in environmental investigations. However, in a circular economy, the
proposition of new packaging design and indicators to analyze performance along the packaging life cycle were predominant. The environmental dimension was more frequent than the social dimension in both categories, even though findings show that research papers in category 3 tend to bring a more managerial perspective and category 1, a more operational perspective.

Category 4, “life cycle assessment (LCA)”, encompasses 50 articles (10.6%) published from 2001 to 2020. Life cycle assessment is a process of evaluating environmental responsibilities associated with a product by calculating the energy and materials used and the wastes and emissions released over the entire life cycle [72]. Regarding sustainable packaging, it is important to analyze the entire life cycle and to assess multiple impact categories to avoid responsibility shifting. Packaging systems consume natural resources and energy, generate waste, and emit pollutants [73]. Therefore, LCA has become a popular decision-supporting tool in packaging design [74,75], as observed in category 2 (design). Life cycle assessment is a method that may be applied alone or, depending on the objective of the analysis, it can be used with the assistance of other artifacts or in specific contexts, such as the circular economy. Discussion in category 1 has illustrated the types of LCA and the tool’s relevance in the circular economy context (see category 1).

Applications of LCA in category 4 articles have been predominantly classified in the filling process, and they are described next. Madival et al. [76] studied the development of new raw materials and applied LCA to compare their impact on the environment. Niero et al. [77] used LCA to analyze a beverage filling process, and Simon et al. [78] studied the impact of collecting bottles after consumption. In this category, comparative studies between material and process cycles predominated [79–81]. The category also brought articles on environmental impacts, losses, and the study of scenarios [75,82,83]. LCA was also applied to test different management approaches. Niero et al. [72] compared the environmental impact associated with different levels of two cradle-to-cradle (C2C) certification requirements.

The life cycle assessment tool is adequate to analyze the environmental impacts caused either by a product, service, or process, and its corresponding packaging (primary, secondary, or of other order).

Managers seeking to reduce the environmental footprint of their products and supply chains face significant informational challenges. Toyota Motor Sales faced this dilemma while reducing the environmental burdens generated by the packaging and distribution of its vehicle service parts and accessories. However, they lacked the information required to quantitatively assess and compare the environmental impacts of different packaging and shipping options and the time or training necessary to conduct the assessments and interpret their results [73]. To facilitate decision-making on assessing packaging impacts on the productive process, Toyota Motors Sales has developed a tool to assess the life cycle and cost cycle simultaneously (named EPIC). Therefore, an explicit design goal of EPIC was to create a simple input–output interface that is operable by packaging engineers who are completely unfamiliar with LCA theory and practice. The calculator is intended to be used both internally by packaging engineers at Toyota Motor Sales, and externally by packaging engineers with parts suppliers [73].

Life cycle assessment reveals important factors to be considered to reduce the environmental impact of reusable packaging, such as the transport of the packaging from the users to the industry and the disposal of the solid residues contained in the packaging. Thus, it is important to address the behavior of the users that should use all of the content of the packaging before discarding it and sending it to reconditioning. Other processes that cannot be neglected are the electricity consumption of the reconditioning plant, the heating of the washing water, and the use of solvents [84]. Many environmental concerns lie on the packaging, and life cycle assessment (LCA) is considered one of the most comprehensive and complete tools for assessing environmental profiles [70,85].

Category 5, “marketing”, encompassed 56 articles (11.9%) published from 1993 to 2020. The articles revealed different perspectives on packaging marketing, exploring actions
related to communication, advertising, the promotion of product sales, and the analysis of consumer behavior.

The role of marketing in society was increasingly debated in the late 1980s and the 1990s, which generated the new concept of green marketing. This concept expanded the role of marketing on sustainability by discussing the sustainability of the marketing mix with green products, green packaging, green logistics, green pricing, and green promotion [86]. Packaging became an attribute to support marketing, offering improved opportunities for better information and communication with the consumer. However, developers must analyze innovative packaging solutions considering their possible increase in costs and influence on the environment [87].

Understanding consumers and satisfying their needs is the basis of marketing theory. Consumers have different needs; therefore, treating them all alike may not lead to their satisfaction. Consequently, it is important to determine who the environmentally oriented consumers are and place “green” products in the right market position [88]. In line with that, sustainable packaging can promote a product brand. The emphasis on the importance of packaging and brand is relevant because studies have recognized packaging’s role in increasing people’s desire to buy products [89].

(Oper#10) Concerns about the environment and consumers’ health are two major reasons for buying food products with ecologically sustainable packaging. [12]

The articles in category 5 address aspects related to the sale and use phases of the packaging life cycle. At these stages, the package is in contact with the consumer, playing an important role as a silent marketing agent in the retailer.

(Oper#11) Consumers often make their first judgments about brands and products based on their packages, but brands recognized for following environmental and ethical principles are usually better valued by consumers. [90]

Packaging’s graphic and structural design provide room for communication with the consumer. Consumers are increasingly concerned about the environmental impact of packaging. Therefore, managers are pressured to adopt eco-friendly packaging for their products. Consumers’ perceptions of eco-friendly packaging are guided by choice of packaging materials and manufacturing processes, as well as by their market appeal [91].

Category 6, “materials”, was the largest in number of articles, with 201 in total (42.6%). The publications ranged from 1996 to 2020, progressively increasing the volume after 2007. This category was split into the following three subcategories: (i) packaging composition, related to raw materials, with 132 articles; (ii) nanotechnology, with 48 articles; and (iii) new technologies, with 21 articles.

Packaging composition included most of the articles and addressed solutions for food packaging, biodegradable materials, and components to accelerate the polymer biodegradability process. Masmoudi et al. [92] proposed the polyethylene terephthalate (PET) valorization from postconsumer bottles by optimizing the most suitable virgin and recycled PET mixture to be used as food contact packaging. Combinations of these materials were elaborated by extrusion and injection molding using different recycled PET rates.

Many articles have proposed biocomposites from different organic materials, such as vegetable oil-based biopolymers [93]; coffee grounds extract [94]; bird feathers [95]; shrimp residue [15]; sugarcane bagasse [96]; egg white [97] among others.

(Oper#12) The development of biocomposite materials from renewable resources is an attractive alternative to substitute synthetic and non-biodegradable plastics. [98]

Nanotechnology is the ability to work on a scale of about 1–100 nm to understand, create, characterize, and use material structures, devices, and systems with new properties derived from their nanostructures. In the nanoscale range, materials may present different electronic properties, which affect their optical, catalytic, and other reactive properties [99]. Nano-enabled materials have been widely used in packaging for food products and may contain antioxidant, antibacterial, and antifungal properties, and mechanical barriers. Food
packaging is revealed to be a multidisciplinary area that encompasses food science and engineering, microbiology, and chemistry. It has raised interest due to its capability of maintaining the freshness and quality of foods and their raw materials from oxidation and microbial spoilage.

(Op#13) With the advances in the packaging industry, packages could be engineered as easy-to-open, resealable, active, as well as intelligent with the incorporation of sensory elements, while still offering the desired barrier properties against oxygen and water vapor. They could be even engineered to provide nutraceuticals to food, or antioxidant, antimicrobial, or antifungal protection to packaged food. [100]

Another study explored nanotechnology due to its large impact on food packaging applications. Reference [101] used different techniques for synthesizing metal and metal oxide nanotechnology, such as coprecipitation, hydrothermal synthesis, microemulsion, microwave-assisted synthetic methods, and others.

Moreover, the articles selected in the “new technologies” subcategory addressed innovative solutions for bioplastics and new materials, new technologies for safety, conservation, increased food shelf life, and the use of sensors.

(Op#14) The collaboration between the bioplastic packaging producers and the product manufacturers should, therefore, improve product functionality and innovation in packaging technologies. [102]

Innovation activities for food packaging have gradually expanded towards the development of intelligent packaging. This evolution reflects the emerging need for new and efficient ways to diminish business processes, solve supply chain safety and quality issues, and reduce product losses [29]. Food intelligent packaging (IP) technologies are reviewed with a particular emphasis on the possibilities of radiofrequency identification (RFID) and surface acoustic wave (SAW), which are technologies for developing the food IP concept. Passive RFID and SAW technologies are the most promising ones to achieve a food IP that can wirelessly communicate the food quality to the different agents of the food chain [103].

Most articles on materials have been sorted under the “transformation of raw material” life cycle stage. Articles in this category address topics related to the composition of new materials, both nanotechnological and innovative. Moreover, some review articles explored metal-based packaging materials that provide superior barrier properties, which are widely used in food packaging. Metals such as aluminum, tinplate, tin-free steel, stainless steel, as well as metal-based packaging material in both rigid and semi-rigid forms, such as cans, foil wraps, and retort pouches, are the most used for food packaging applications [104].

Active packaging is a solution in which the packaging, the product, and the environment interact [105]. The following active packaging systems are used in the food industry: oxygen, carbon dioxide, ethylene scavengers; carbon dioxide emitters; odor emitters and absorbers; relative humidity regulators (water content in the packaging atmosphere); antibacterial substances and antioxidants [105]. The largest group of emitters consists of antimicrobial substances inside the packaging. These substances may be added to packaging in different formats, such as sachets or mats with volatile antimicrobial compounds; active substances embedded in the polymer structure; active substances applied to the polymer surface; active substances immobilized on the polymer using ionic and covalent bonds; packaging films with antimicrobial properties (e.g., chitosan-based films) and edible food coatings.

(Op#15) Due to the growing interest of consumers in consuming fresh products with extended shelf life and controlled quality, manufacturers must provide modern and safe packaging. Active packaging is a promising solution for this.

Category 7, “reverse logistics (RL)”, encompassed nine specific articles (1.9%). They were published from 2013 to 2020 and explore packaging used as new raw material and studies about their logistics process. The articles in this category brought different perspectives on packaging RL, such as decision-making tools, regulatory matters, agreements,
and packaging design for RL. They also address other packaging classes, such as primary, secondary, and tertiary, at different product life cycle phases.

As RL can occur at diverse stages of the product life cycle, Silva et al. [106] studied the advantages of replacing the packaging of an earphone device with a creative returnable packaging at the “pre-consumption” logistics phase of the earphone manufacturing. Lagarda-Leyva et al. [107] studied the RL of tomato pesticide packaging at the “post-consumption” phase of the pesticide packaging (end-of-use).

These analyses shed light on the fact that RL is a broad field, and that packaging RL is just a part of it. This observation reinforces the findings from category 1, circular economy. It highlights the parallelism between the product life cycle and its packaging life cycle and the independent reverse flows that the product and its package must take during post-consumption (see Op# 4 and Meherishi et al. [60]. RL processes may comprise primary, secondary or tertiary packaging. Therefore, scholars must delimitate the scope of investigation when addressing packaging RL.

The decision-making methods in this group of articles ranged from multicriteria techniques to simulation, using different approaches, such as mathematical techniques and systems dynamics. Couto et al. [108] applied an objective function to support decisions on the geographical location of screening and valorization centers for packaging, highlighting parameters that influence the sustainability of these sites. Additionally, Lagarda-Leyva et al. [107] used systems dynamics to simulate the RL process.

Decision-making through mathematical methods leads to fewer costs, time, and involved risks when compared to the real implementation of RL packaging. Therefore, mathematical models can be used to analyze the supply chain.

Concerning multicriteria decision tools, Li and Huang [109] used the analytic network process (ANP) to decide the geographical location of recycling centers and garbage factories. As an advantage of ANP, the criteria are analyzed interdependently. Therefore, ANP can reflect the overall situation of the RL system. In other words, it will reflect the fixed and variable costs and ultimately find the best facilities’ location and construction size, as well as the flow of each link. Thomopoulos et al. [16] applied multi-criteria reverse engineering (MRE). MRE has arisen from the interaction of advances in mathematics and shifts in social demand.

In their study about returnable transport packaging (RTP), which is a part of the broader concept of (RL), Yusuf et al., (2017) confirm the positive business performance results of RTP. Nonetheless, despite the advantageous nature of packaging RL, the authors also highlight financial constraints and the drawback of packaging wear and tear due to reuse. These constraints are barriers to adopting RTP implementation, mainly by small and medium companies, based on data drawn from developed countries [110].

Another perspective that emerged in this group of articles was the need to design packaging for RL purposes to address the second principle of circular economy, namely “keeping products and materials in use”. On the one hand, Silva et al. [106] focus on the type of “returnable packaging project” itself for comparison purposes, while Zouari [111] focuses on the “design methodology of the package” through the combination of eco-design, resource commitment, and RL. Zouari [111] argues that collaboration along the process leads to positive and better results. His findings show that a cardboard-based packaging submitted to eco-design requirements and a structured resource commitment positively affects RL. However, the stakeholders analyzed did not consider the entire life cycle of cardboard production, which might consume more energy than other materials.

The performance analysis of new packages for RL should be conducted together with techniques such as life cycle assessment (LCA) to compare the scenario with new and former packages.

In this group of articles, the circular economy was frequently mentioned in different situations, since RL is a circular economy strategy. Guarnieri et al. [47] studied the Brazilian sectoral agreements for packaging RL in search of opportunities for the circular economy.
The authors concluded that the agreement development was guided by circular economy principles, although the concept was not mentioned in the agreement text.

Category 8, “supply chain”, encompassed 29 publications (6.1%). They ranged from 2003 to 2020, exploring themes of the supply chain context. The articles studied the feasibility of using returnable packaging in the supply chain. They analyzed strategies to reduce the environmental impacts caused by the movement of goods and raised questions about the effect of packaging on the logistical process.

A company’s supply chain needs to ensure that the right product will be delivered at the right time and cost. It also still needs to consider an additional responsibility of fulfilling the environmental requirements [6]. The packaging system’s design has a major impact on the environment, but the impact is not easily assessed due to the complex coupling between package design, logistics costs, and environmental impact [112].

Storage space utilization and conveying information are important in packaging design due to their impact on packaging logistics and other aspects of the supply chain system.

In this group, quantitative and qualitative strategies were used to answer the research questions raised in the articles. Bortolini et al. [113] present an integrative mathematical model with a deep focus on the role of packaging containers for fruit and vegetable distribution, considering reusable and disposable alternatives. These alternatives may coexist; therefore, the decision-maker may choose among a supply network based on disposable packaging containers, reusable packaging containers, or their combination. The model proposed is useful for supporting such strategic decisions.

Due to the complexity brought by the supply chain, some solutions can arise via the approximation of one or more strategies. For instance, Gardas et al. [114] present fourteen critical success factors (CSFs). The interpretive structural modeling (ISM) approach was applied to explore the mutual influence between the identified CSFs. The ISM methodology was supported by the total interpretive structural modeling (TISM) approach to strengthen its interpretation. Furthermore, to identify the factors with high driving power, the “Matrice d’Impacts Croisés Multiplication Appliquées à un Classement” (MICMAC) analysis was employed. Wang et al. [115] present an alternative to contribute to the complexity of the sustainable supply chain via decision making trial and evaluation laboratory (DEMATEL). Using DEMATEL, the authors have extracted the interrelationship between multiple factors in a problem. DEMATEL is a multi-criteria decision-making instrument that allows converting a qualitative design into quantitative analysis.

It is important to emphasize that, in addition to the packaging residue, goods movement contributes to the generation of environmental impact caused by CO2 emission into the atmosphere, loss of goods, or design inadequacies between the packaging and the product. Hence, changing the packaging system design and logistical system may reduce these impacts. The articles selected for this category comprise all packaging life cycle stages. Moreover, it is important to reiterate that the supply chain involves all the flows necessary for the development, manufacturing, commercialization, use, and disposal of the product and its packaging.

Lastly, category 9, “sustainable practices”, encompassed 41 articles (8.7%). They ranged from 2001 to 2020, and 23 were related to recycling practices; 13 articles addressed waste reduction, and 5 addressed packaging reuses. Sustainable practices still need to be improved to reduce waste further, increase recycling and reuse, and manage waste efficiently [19]. In this group, practices such as recycling, reducing, and reusing were explored. Recycling plastics is motivated by the need for closing material loops to preserve natural resources when moving towards a circular economy. It is also motivated by the problems derived from plastic scrap in oceans and lakes. The packaging industry uses the highest number of plastics; hence, plastic waste is predominated by packages [116].

The articles that address waste reduction practices seek solutions to decrease the use of materials and renewable sources, as well as to minimize environmental impact. An experiment conducted with 218 consumers demonstrates that non-environmentally conscious
consumers chose the over-package competing product because the non-overpackage product seems less safe or practical [117]. One approach suggested to address these concerns is “zero waste”. However, transforming today’s over-consuming activities into zero waste is still challenging [34]. There have been many actions to eliminate packaging waste through open dumping and burning, landfill, incineration, etc. However, little attention has been paid to reuse, even though it is the simplest way to reduce waste.

Reuse is an essential solution, which should be considered before any other approaches [118]. Nevertheless, packaging reuse is limited in health and food segments. The use of solid packaging waste in sustainable construction has received much attention due to the lower cost of waste, along with the saving of space in landfills [119]. Nevertheless, reusing is more difficult, even in this case.

Most of the articles address the post-use life cycle phase. Sustainable practices are more related to waste management, covering three dimensions (economic, environmental, and social). Few articles addressed the raw material transformation, graphic and structural design, packaging manufacturing, and filling process phases.

Agrochemical packaging must be decontaminated before its recycling. Such reprocessing can allow large amounts of these materials to feed the production cycle. On the other hand, plastic recycling in the agricultural sector presents financial, managerial, and technical barriers [120].

Lu et al. [10] expands the research area to e-commerce and confirms the importance of user preference in overpackaging solutions. The authors argue that consumers prefer technical solutions to optimize the packaging strategy. However, they have a low preference for material improvements. Consumers generally believe that technology can improve efficiency, enhance quality, and avoid unnecessary waste, fundamentally reducing overpackaging [10].

The overarching aim of the circular economy is to maintain the value of products, materials, and resources for as long as possible, and the reuse of packaging can play an important role [121]. A method to collect data on reusable packaging was applied in the Italian context. The authors identified 38 types of packaging currently reused in the Italian territory [121], resulting in a preliminary qualitative and quantitative assessment of the packaging reuse practice.

The categorization into coding units allowed answering RQ3. As listed in each of the last nine categories under the symbol (Op#), the opportunities ranged from strategic actions, designer tasks, and product management processes towards themes such as integration among interdependent stakeholders and collaboration. The opportunities were not restricted to this list, as they were mentioned throughout the rest of the article. Figure 7 describes the distribution of articles per year, and the shades of orange represent the number of articles in each category.

![Figure 7. Distribution of articles per year in each category.](image-url)
The analysis of Figure 7 shows four clusters. Cluster 1 includes articles on the dimensions of sustainability, materials, and marketing that have predominated over the years with publications since the 1990s. Environmental issues play a central role in this cluster as a common ground for all categories, boosting the development of new materials. Cluster 2 includes life cycle assessment, supply chain, and sustainable practices. These themes have evolved significantly after 2000. LCA was found to be a tool of wide application to compare materials’ performance, develop supply chains, and test the efficiency of sustainable practices.

LCA has proved to be relevant for the analysis of the circular economy and RL, the two last categories in Cluster 3. There are some similarities between content in category 1 (circular economy) and category 3 (dimensions of sustainability). Both categories emphasize topics on the environmental, social, economic-financial, and waste management dimensions. Circular economy studies have involved more innovative solutions to avoid waste generation, while articles classified as sustainability studies presented a more strategic and managerial perspective on the packaging system development. RL is part of the circular economy process. Hence, a cluster with these two categories was created.

The design category has a different approach, which was included in Cluster 4. The group of selected articles showed relatively few publications over the years, which suggests an opportunity for deepening the investigation on this topic.

Many combinations of categories are plausible due to the interdependencies existing among them. Next, to answer RQ1 and RQ2, the authors have analyzed the units of context presented in Sections 3.2.3 and 3.2.4. The purpose was to explore interdependencies to find other meanings to the vast content.

### 3.2.3. Packaging Life Cycle Stages as Context Units

The search for meaning inside content analysis advocates for using context units. The context unit “packaging life cycle” was used to answer RQ1. We have defined “sustainable strategies” as the techniques, methods, tools, or processes used by researchers to leverage the sustainable condition of packaging systems. Our aim was not to judge the strategy’s efficiency; rather, we intended to create a logical repository of intuitive and easily accessible information. Thus, the packaging life cycle stages were chosen as a reference due to the systemic view they provide, which is necessary for designing sustainable systems. The articles were analyzed and re-classified into one of the eight life cycle stages (Figure 8) based on their contribution to that stage. Considering the packaging as something created and developed as a product, it can be defined by its life cycle. The eight-stage model (Figure 8) was adopted from models proposed by several authors [54,70,79,82,122–126].

![Figure 8. Classification of the articles according to the packaging life cycle stages.](image-url)
Supplementary Material—S6 describes the sustainability strategies presented in each article, followed by their classification in a life cycle stage. The first strategy, “definition of sustainability agendas to the commitment of raw material leading companies” by Hillier et al., [127] addresses strategic actions for the extraction of raw materials. Therefore, it was re-classified in the life cycle stage as “extraction of raw materials”. The second strategy, “search for a new composition of packaging raw materials” as presented by Iahnke et al. [98] addresses the transformation of raw materials, and it was classified in the life cycle stage as “raw material transformation”. The same analysis was conducted for all the articles.

Context units are important strategies to unveil the complexity and bring meaning to the content on sustainable packaging. The professionals and researchers from every industrial segment (food, chemical, raw materials, and energy) interested in more details about the knowledge gathered in this SLR can explore the information using the life cycle stages as a reference, according to their content interests.

Although packaging seems simple from the structural point of view, it is highly complex from the systemic point of view. The design of sustainable packaging demands a thorough and time-consuming information search.

Moreover, the reclassification revealed some patterns. Research efforts mainly concentrate on stage 2, raw material transformation, and stage 8, post-use. This demonstrates that researchers have been motivated to research these topics due to the urgency imposed by the huge environmental impact of packaging. Furthermore, the food industry has analyzed the composition of raw materials for packaging, technologies, and intelligent packaging. The reason for this leadership is portrayed by Deshwal et al. [128] when they discuss various health and environmental issues concerning food packaging. Although opportunities for food packaging were more frequent in Section 3.2.2 (see Op#13, 15), other frequently regulated packaging segments include beverages, pharmaceutical, and medical.

The existence of many articles classified in the last life cycle stage (post-use) does not necessarily mean that researchers were not concerned about giving a systemic perspective to their research. On the contrary, studies in this group use methods that provide a systemic perspective, such as systems dynamics, different types of life cycle assessment tools (LCC, LCS), RL optimization algorithms, etc. Nevertheless, opportunity 1 (Section 3.2.2) showed that researchers must systemically understand packaging regarding packaging function, supply chain link, and the package and/or product flows.

The amount of packaging polluting the environment may indicate that the reality is different from research, as reinforced by Jerzyk [13]. The articles classified in life cycle stages 3, 4, and 5 apply methods to compare environmental solutions in the filling process, manufacturing, and design operations. The changes made to the different packages and other variables tested in such investigations reinforce the perception that current packaging designs were not developed to facilitate pre-consumption and post-consumption sustainable practices. Moreover, eco-design, design for sustainability, and cradle-to-cradle are sustainable design methods not specific to designing packages. The life cycle stages with fewer articles were the extraction of raw material and use.

(Op#19) Researchers should emphasize formal methods to develop tools that support packaging professionals to integrate the information from life cycle stages in the phases of packaging design.

As expected, marketing articles were distributed between the “use” and “sale” life cycle stages. More discussion on contents may be observed in Section 3.2.2 (marketing).

3.2.4. Packaging Design Phases as Context Units

The design phases were used as context units to answer RQ2. Therefore, the five-phase model (briefing, planning, design, implementation, and validation) was adopted from the models proposed by several authors [1–3,129–133]. Figure 9 shows the reclassification of publications according to the phases of the packaging design. Table 2 explains the structure of the analysis.
Figure 9. Classification of the articles according to the packaging design phases.

Table 2. Classification of procedures that support the practice of packaging professionals according to design phases.

<table>
<thead>
<tr>
<th>Packaging Design Phases</th>
<th>Examples of Tools, Methods, Practices, and Data to Support Packaging Professionals Regarding Circular Economy and Sustainable Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Briefing</td>
<td>Use of structural, graphical, and informational cues [90]</td>
</tr>
<tr>
<td></td>
<td>Analysis of sectoral agreements and regulations by packaging managers [47]</td>
</tr>
<tr>
<td></td>
<td>Design of the supply chain network [113]</td>
</tr>
<tr>
<td></td>
<td>Definition of raw material for packaging such as non-biodegradable plastics; biocomposites from vegetable oil-based biopolymers</td>
</tr>
<tr>
<td></td>
<td>Use of nanotechnology to extend product shelf life, improve biodegradability, or due to other demands (ex., food packaging, health packaging, etc.)</td>
</tr>
<tr>
<td>Planning</td>
<td>Use of new technologies for packaging sustainability (active systems, intelligence)</td>
</tr>
<tr>
<td></td>
<td>Use of system dynamics to plan packaging’s end of life [107]</td>
</tr>
<tr>
<td></td>
<td>Analysis of sectoral agreements and regulations by the packaging team [47]</td>
</tr>
<tr>
<td></td>
<td>Use of algorithm for reverse logistics optimization [34]</td>
</tr>
<tr>
<td></td>
<td>Use of LCA to analyze the impact of production during the project stage [134]</td>
</tr>
<tr>
<td></td>
<td>Identify raw material suppliers committed to packaging sustainability [127]</td>
</tr>
<tr>
<td>Design</td>
<td>Strategy for private labels [38]</td>
</tr>
<tr>
<td></td>
<td>Visualization tool, which focuses on different parts of the participant’s view and experience of the development process in the project [5]</td>
</tr>
<tr>
<td></td>
<td>Project of eco-labels using eye-tracking glasses [63]</td>
</tr>
<tr>
<td></td>
<td>Requirements for a better packaging design/redesign Technical improvements; attention to external demands, management practices [61]</td>
</tr>
<tr>
<td></td>
<td>Use of life cycle assessment for comparison of the performance of packaging materials [135]</td>
</tr>
<tr>
<td>Implementation</td>
<td>Use of cost analysis techniques to implement packaging productive systems [91]</td>
</tr>
<tr>
<td></td>
<td>Use of best-worst scaling experiment in packaging project [10]</td>
</tr>
<tr>
<td>Validation</td>
<td>Consumer’s perception of eco-friendly packaging: in terms of packaging materials, manufacturing technology; marketing appeal [91]</td>
</tr>
<tr>
<td></td>
<td>Routine of tests of innovative packaging systems [106]</td>
</tr>
</tbody>
</table>

The organization of Table 2 was conducted based on the description of the tools, methods, and practices from articles described in Supplementary Material—S7. The information on the procedures applicable to sustainable packaging development was consolidated in Table 2. The reasoning underlying the reclassification is explained next. The first phase, “briefing”, concerns the definition of requirements from all stakeholders. Then, packaging managers and team members must analyze the packaging context of usage, interview users, understand the needs to define the objective of the project, the main functions, and elicit requirements. Therefore, in the first line, “briefing”, the practices, methods, and
tools that emerged from the analysis made in Section 3.2.2 were classified. The aim was to create a logical repository of information with easy and intuitive access, following the design phases.

This literature analysis indicated that 13% of the articles are associated with the “briefing” phase. Information on sectoral agreements, supply chain network analysis, and structural/graphical cues are important data types for the briefing process. Wikström et al. [136] highlight that the briefing process is critical because the design objective is formulated and communicated to the design team in this step. Packaging managers should develop clear briefings because the influence of ecological design elements on preferences strongly depends on the consumers’ level of environmental concern [137].

Therefore, professionals should collect data that support the problem identification, the definition of functions, adopt sustainable objectives for the packaging project [138,139], conduct field studies to guide their actions [51,140] or analyze the appropriate requirements [27,141].

The present literature review demonstrated that 75% of articles are associated with the “planning phase”. This is explained by the fact that materials and packaging manufacturing processes are chosen in the planning phase [39,142], in addition to the technical and feasibility analysis [134,143]. However, most articles are in the food packaging field. Usually, the choice of a packaging that best suits fresh food requirements is driven by issues such as cost, shelf life, safety, practicality, and environmental sustainability [134].

The “design” phase constitutes 6% of the articles, mainly on structural design and graphic projects [35,135,144]. Eco-labels, visualization tools, requirements, LCA, and best-worst scaling are procedures that can support professionals in the design phase. Opportunities through refills and techniques for comparing solutions in the design phase were discussed in Section 3.2.2 (design) and Section 3.2.3.

Some procedures may be used in more than one design phase, since the objective of the application may change based on the purpose of the phase. Moreover, phases 3, 4, and 5 must be conducted iteratively, seeking to optimize the packaging development. The implementation phase (phase 4) is composed of 1% of the articles and comprises the final packaging solution, prototyping, tests, manufacturing trials [145,146], and viability [147]. The viability (phase 5) encompassed 3% of the articles. It addresses the monitoring of the packaging in the market [106,111,148] and provides information for possible adjustments in the next production cycle.

Based on the classification according to the packaging design phases, our results show how the tools from the literature may support designers in designing sustainable and circular packaging (Table 2).

Section 4.1 and Table 3 expand the discussion on design phases with insights from the literature and guidelines for professionals.

Table 3. Insights and guidelines for professionals in the multiple areas of packaging design.

<table>
<thead>
<tr>
<th>Triangulation DP—CAT and LCS</th>
<th>Insights</th>
<th>Guideline Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Briefing—circular economy (CE) and post-use</td>
<td>Briefing is more than the scope or requirements demanded by stakeholders for the packaging</td>
<td>Understand all stages of the packaging life cycle and the critical intersection points with the product life cycle</td>
</tr>
<tr>
<td>Briefing—sustainable practices and post-use</td>
<td>Briefing is the right moment to consider eliminating packaging</td>
<td>Analyze the packaging life cycle and promote the reduction or non-use of packaging within the supply chain. Understand the packaging needs of each product</td>
</tr>
<tr>
<td>Planning—dimension of sustainability and post-use</td>
<td>Sustainable education for packaging is as dependent on public policies as they are dependent on clear actions from the packaging planning phase</td>
<td>Identify global policies for the use and disposal of packaging materials and consumer education from the packaging planning phase</td>
</tr>
</tbody>
</table>
Table 3. Cont.

<table>
<thead>
<tr>
<th>Triangulation DP—CAT and LCS</th>
<th>Insights</th>
<th>Guideline Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning—life cycle assessment and post-use</td>
<td>What is not measured over the entire packaging system cannot be improved</td>
<td>Observe, collect, and analyze demands from all stakeholders throughout the life cycle. Good integration between packaging and its contents, i.e., start with planning and must filling process and logistical specifications</td>
</tr>
<tr>
<td>Planning—material, extraction of raw material, and transformation</td>
<td>It is increasingly necessary to include in the packaging planning phase the search for recent materials and technologies to replace polymers</td>
<td>Consider the use of biocomposite materials from renewable resources to replace synthetic and non-biodegradable plastics</td>
</tr>
<tr>
<td>Planning—reverse logistics and filling process.</td>
<td>The type of waste and impact potentially generated by a package that already exists on the market is an important reference to start planning a new package</td>
<td>Start the planning at the packaging’s end of life to avoid a similar impact. Promote reverse logistics for new packaging and use techniques such as life cycle assessment (LCA) to compare the scenario with new and old packaging</td>
</tr>
<tr>
<td>Design—design stage and graphic and structural design</td>
<td>Graphic and structural design are more than creative actions. They must integrate the information gathered in the briefing and planning phases</td>
<td>Optimize existing designs or create lean packaging Reduce the use of materials (paints and special finishes), take advantage of useful areas, and reduce the number of scraps</td>
</tr>
<tr>
<td>Implementation—supply chain and packaging manufacturing</td>
<td>Implementation is more than manufacturing the packaging. It must integrate information gathered in the previous phases to avoid negative impact in the subsequent phase</td>
<td>Optimize packaging use along the supply chain. Understand impacts on packaging logistics and other aspects of the supply chain system</td>
</tr>
<tr>
<td>Validation—marketing, sale, and use</td>
<td>The packaging communication space can be better exploited to convey information about disposal, type of material used, and consumer awareness</td>
<td>Prioritize prime spaces on labels and packaging to include sustainable information. Highlight information about the materials used in the packaging, and their correct disposal</td>
</tr>
</tbody>
</table>

4. Triangulation of Categories and the Two Units of Analysis—Practical Implications

The triangulation in Figure 10 is supported by the degree of association existing between the category (CAT), the life cycle stage (LC), and the design phase (DP). We have used the objective of each design stage as a guideline for triangulation.

The lower part of Figure 10 simulates the reasoning of a packaging designer. Therefore, the emphasis is on the packaging design phases (1—briefing to 5—validation). While progressing through the design stages, designers may have to go through the eight life cycle stages systematically and the nine thematic categories to gain insight into their creative process.

In this proposition, the nine categories of information were arranged considering the objective of the design phase. For example, the objective of the briefing phase is to define project specifications. Therefore, the designer must collect demands from all stakeholders over the entire life cycle. With the purpose of “avoiding waste generation”, the designer must bring the “principles of circular economy” as a guideline or “environmental demand” during the briefing phase. Consequently, the dotted line in the lower part of Figure 10 shows the relationship among briefing, post use, and circular economy.

The elements in Figure 10 may be arranged in another order or combination, depending on the nature, purpose, or degree of innovativeness of the sustainable packaging under design.

The framework in the lower part of Figure 10 presents at least three main benefits. First, it creates a systematic procedure that highlights the need to incorporate the life cycle as a systemic perspective, following each phase of the packaging design process. Second, the nine-category repository organized via this SLR (Section 3.2.2) provides the content...
corresponding to each life cycle stage. Third, procedures from Table 2 (Section 3.2.4) provide the methodological approaches necessary for the packaging creation and assessment.

Figure 10. Triangulation among the categories and the two units of context.

4.1. Insights and Guidelines for Practitioners

Finally, Table 3 presents insights and guidelines for packaging professionals. They are the different types of specialists who participate in the project activities over the entire sustainable packaging life cycle process. The analysis was guided by the triangulation among design phases (DP), the life cycle stages (LC), and the categories (CAT) from the lower part of Figure 10. We aim to illustrate how insights may arise from the framework application; therefore, the authors do not intend to be exhaustive in Table 3. Guidelines were proposed based on the findings from former sections and the articles of this SLR.

For example, considering the rationale of triangulation between briefing, circular economy, and post use, the following insight arises: “Briefing is more than the scope or requirements demanded by the stakeholders for the packaging”. Regarding the literature analyzed in this SLR, the following guideline arises: “designers must understand all stages of the packaging life cycle and the critical intersection points with the product life cycle.”

The triangulation flow (Figure 10) exemplified in Table 3 may guide the collaborative discussion among professionals, since it encompasses multiple aspects of the design phases. The framework may be used for (i) defining types of trustable information to be elicited
and (ii) to support decision making. The proposed framework can be a starting point for developing a tool centered on repositories that support professionals.

This SLR has revealed four categories of opportunities for investigation. The first category for designers and researchers is “new methods, tools, and packaging performance” (op#1, 2, 3, 4, 7, 16, 17 and 19 in Sections 3.2.2 and 3.2.3). The second category “collaboration for innovation in the packaging supply chain” (op#5, 6, 9 and 14) may concern all the lifecycle stakeholders. The third category is “policies, education and consumer perception” (op#8, 10 and 11) and the fourth category is “materials and technologies” (op#12, 13 and 15). All the categories are interdependent and experts inside the academy, government, or industry may find an occasion to develop innovative solutions to fill these gaps.

5. Final Considerations

The academic literature comprises some systematic literature reviews on the packaging subject. Nevertheless, our study was designed differently with a reduced keyword search to recover the largest number of publications on sustainability and packaging. The purpose was to cover 30 years of investigation to gain a broad perspective of what has been researched so far.

The methodological strategy used in this SLR brought benefits and limitations to this SLR. The main benefit was to provide an updated repository of information to support packaging researchers and professionals. We analyzed the content of the 472 articles to answer RQ 1, which was as follows: “What has been discussed, in the literature, about sustainability strategies applied to the packaging life cycle?”. An analysis of the literature revealed nine categories of themes organized in four clusters. The first cluster included the topics dimensions of sustainability (9.5%), materials (42.6%), and marketing (11.9%), published from the 1990s onwards. The second cluster included articles published ten years later (2000) regarding life cycle assessment (10.6%), supply chain (6.1%), and sustainable practices (8.7%). The third cluster is the most recent (2013 onwards), and it addressed reverse logistics (1.9%) and circular economy (4.2%), and the fourth cluster, design (4.5%), was quite different from all other clusters in its characteristics. The design cluster presented only one topic and the articles were published after 1998 at a very low rate. The impressive number of articles on the materials topic, on the one hand, has demonstrated the strong concern of researchers on reducing food packaging environmental harm and making it safe for human health. On the other hand, these findings may be important references for different industrial segments on new raw materials, nanotechnology, and smart packaging.

The limitation of the content analysis was the difficulty of the summarization of a large body of information from all the articles retrieved. Therefore, we have provided some Supplementary Materials and appendices to cover this restriction.

The units of context proved to be valuable to answer RQ 2, i.e., “how has the literature supported packaging professionals’ practice in the context of the circular economy and sustainable packaging?”. The objective of each phase of packaging design (briefing, planning, etc.) guided the identification of procedures, methods, and tools, including mathematical approaches and managerial and decision-making alternatives. The tools were either for planning the packaging system as a whole (frameworks for designing circular economy, reverse logistics, and supply chain processes) or procedures for designing a specific packaging device.

Likewise, the content analysis highlighted the relevant role that LCA plays in performance analysis in all stages of the packaging design or the system’s performance as a whole. It is important to mention that LCA’s relevance is also growing in the corporative background, mainly due to managers’ ever-increasing interest in environmental, social, and governance (ESG) performance strategies. The articles retrieved in this SLR, until 2020, did not mention this perspective. The low number of articles in the “design” category suggests an opportunity in this topic, especially concerning specific methods for designing sustainable circular packages.
Regarding RQ 3, “what research opportunities can emerge from analyzing current literature on sustainable packaging?”, we have identified opportunities regarding (i) the development of specific frameworks for packaging; (ii) popularization of tools; (iii) collaboration (private, public, academy) and multidisciplinary teams in packaging development; (iv) new policies; (v) boosting of the social dimension of sustainability; (vi) reinforcement of consumers’ and manufacturers’ responsibility; (vii) creation of drivers for packaging sustainability; (viii) popularization of technologies and strategies, such as eco-labeling; (ix) reinforcement of communication on environmental properties of packaging to promote sales and adequate disposal; among others.

We have observed that the search for solutions to the problems of sustainable packaging focuses on new materials, new technologies, and analytical methods for verifying the performance of packaging, among others. Fortunately, there already is a concern to treat the packaging project systemically, following the example of mathematical approaches and other applications on circular economy, supply chain, and reverse logistics. Such systemic approaches are still complex to organizations’ routines, and they should be simplified for popularization purposes soon.

Given that the categories studied present some overlap, the challenge is the proposition of approaches that integrate these categories via the combination of the best practices developed in the individual themes. Considering this set of articles, we have observed that methodological structures to guide sustainable packaging design have not evolved to the same degree as other categories analyzed. Therefore, there is an opportunity to revisit the packaging design steps to incorporate the tools and practices mentioned in the categories found in this review. Step-by-step methods are always important guides to support the practice of professionals involved with sustainable packaging, but it is also necessary to improve the education of new professionals in academic courses.

Therefore, going beyond the coding units of the SLR content analysis, we have used context units to propose a framework based on the triangulation of the packaging life cycle stages, the nine categories, and the design phases. At the same time, the framework provides an understanding of the relationship between packaging design phases, life cycle stages, and an in-depth view of the sources of information for each step of the packaging life cycle. Hence, we believe this framework is a preliminary reference for creating insights, identifying opportunities, and developing procedures for sustainable and circular packaging methodologies.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14116727/s1, S1 Classification of article by year; S2 Areas of knowledge; S3 Keywords RSL; S4 Country list; S5 Classification of articles_categories_life cycle_Design stages; S6 Tables categories for classification of the articles analyzed and S7 Packaging methods.

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Appendix A

Links of all the articles returned in SLR and links of the articles/phase of the SLR protocol.

Links of all the articles returned in the sources investigated—identification phase: https://drive.google.com/drive/folders/11YPAVP9_uTQpr5vZAxflQmNEgIsOjM?usp=sharing (accessed on 1 May 2022).

Links of articles selected—selection phase: https://drive.google.com/drive/folders/1iM9ee_n_Rn83RDhv3OCdV0lZgXroDLInM?usp=sharing (accessed on 1 May 2022).

Links of excluded articles—eligibility phase: https://drive.google.com/drive/folders/11528APjnrblQzmnr01m0pGlAkQyykT?usp=sharing (accessed on 1 May 2022).


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