

## Plastic packaging management and the transition to the circular economy model: Brazil as a case study

### Gestão de embalagens plásticas e a transição para o modelo de economia circular: o Brasil como estudo de caso

Carolini Ferreira Gomes <sup>1</sup>, Isabela da Silva Pedro Rochinha <sup>1</sup>; Daiane Cecchin <sup>1</sup>; Afonso Rangel Garcez de Azevedo <sup>2</sup>; Dirlane de Fátima do Carmo <sup>1\*</sup>

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#### RESUMO

O presente trabalho teve como objetivo analisar a gestão de embalagens plásticas no contexto de transição para o modelo de economia circular. Foi realizada pesquisa bibliográfica e documental, no período de 2006 a 2021, onde se verificou a contribuição atual das embalagens plásticas para o modelo linear, além da avaliação das dificuldades e necessidades deste setor para aplicação da logística reversa e retorno ao ciclo de vida. Verificou-se que há uma grande quantidade de resíduos plásticos sendo produzidos e descartados de forma inadequada; o baixo valor agregado, a ineficiência na padronização das embalagens e suas condições pós-consumo são fatores que dificultam o fechamento do seu ciclo de vida; a existência de compromissos de empresas e países para aplicar a economia circular, bem como a aplicação de seus conceitos no Brasil e o papel de cada setor da sociedade, foram entendidos para uma aplicação eficiente da economia circular para embalagens plásticas.

**Palavras-chave:** Lógica reversa; Ciclo da vida; Material reciclado; Gestão de resíduos

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#### ABSTRACT

The present work aimed to analyze plastic packaging management in the context of transition to the circular economy model. Bibliographic and documentary research was carried out, with a period of 2006-2021, where the current contribution of plastic packaging to the linear model, in addition to the difficulties and needs of this sector for the application of reverse logistics and return to life cycle was evaluated. It was verified that there is a large amount of plastic waste being produced and inadequately disposed of; the low added value, the inefficiency in the standardization of packaging, and its post-consumption conditions are factors that make it difficult to close its life cycle; the existence of commitments from companies and countries to apply the circular economy, as well as the application of its concepts in Brazil and the role of each sector of society, was understood for an efficient application of the circular economy for plastic packaging.

**Keywords:** Reverse Logistics; Life Cycle; Recycled Material; Waste Management

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<sup>1</sup> Universidade Federal Fluminense

<sup>3</sup> Universidade Estadual do Norte Fluminense Darcy Ribeiro

\*E-mail: [dirlanefc@id.uff.br](mailto:dirlanefc@id.uff.br)

## INTRODUCTION

To produce, to buy, to consume, and to discard: these are the main verbs that can characterize a linear production system. Mainly adopted with the emergence of industries, the linear model presents itself in the daily life of humanity, stimulating the extraction of raw materials, production, consumption, and disposal of materials.

However, with population growth, waste management has been a constant subject of discussion. One of the points is the prioritization of land use, since landfills and dumping grounds, the main destinations of waste, use this resource at the same time that the demand for physical space for housing, businesses, and industries grows. As a way of privileging the use of natural resources for activities with greater economic and social value, alternative technologies have been sought for the disposal of waste and disposal only of the tailings. In addition, incorrectly disposed waste generates environmental pollution, also affecting the health of living beings. The perception of natural resources finitude has also gained an agenda and brought a sense of urgency in the reformulation of the current model (FOSTER et al., 2016). Despite having been adopted as the only possible production model for many years, the linear system is, in reality, a human invention, in contrast to a system that, in practice, is even older: the cyclical model of production. Nature exercises this model masterfully, as its ecosystems work by transforming matter into a cyclical flow.

In this way, the circular economy assumes the role of mimicking this natural action applied to the productive and economic system in which the world is inserted. With it, the extraction of raw material loses space for the reuse and recycling of materials, since the disposal is minimized to its maximum (FOSTER et al., 2016; GHISELLINI et al., 2016; ELLEN MACARTHUR FOUNDATION, 2020a). Given the above, appears a need to transition production processes to the circular economy to meet the lifestyle of a large part of the world's population and reduce negative pressures on the environment.

Plastic is one of the standout materials when it comes to sustainability. Due to its characteristics, it meets the demand of many industries and sectors very well, at a low financial cost. However, generally, it has its origin in non-renewable sources, has a complex recycling process, and, in large part, has a short life cycle (ABIPLAST 2019a).

For the packaging sector, which is known for having a very low consumption time, 39.6% of the production value forecast for the year 2020 would come from plastic packaging (ABRE, 2021). This type of consumption favors the increase of waste and

worsens its management, being, therefore, one of the main targets of circular economy supporters. The study "The Circular Economy Solution for Plastic Pollution", carried out by the Ellen MacArthur Foundation in 2020 (ELLEN MACARTHUR FOUNDATION, 2020b), states that this production model would be able to reduce the volume of plastic that reach the oceans by 80%, without disfavor the economy, as it would bring different sources of income and new markets and technologies.

Given the shown scenario, it is important to identify how the management of plastic packaging presents itself owing to the transition to this cyclical production model. In this way, the aim was to analyze the management of plastic packaging in the context of transition to the circular economy model. To achieve this purpose, it is important to evaluate the current contribution of plastic packaging to the linear model, as well as the difficulties and needs of the packaging sector for the application of reverse logistics and return to the life cycle, in addition to identifying efforts to solve the problem of plastic packaging and verify the actions that can be taken to implement the circular economy in the sector.

## **MATERIAL AND METHODS**

### **Data Survey**

Data were obtained through bibliographic and documentary research. The first one aims to verify the existing literature, contributing to the exploratory nature, as it aimed at understanding the problem more deeply, aiming to improve ideas or discover intuitions (Gil 2002). On the other hand, it was necessary to carry out documentary research to verify the problem addressed through statistical data, obtained through the main organizations and agencies responsible for the production, consumption, and disposal of plastic packaging waste, in addition to plastic or packaging in general. Furthermore, knowledge of laws, decrees, and studies became relevant for contextualization and analysis, being characteristic of this type of research.

For the bibliographic research, scientific articles from national and international literature were considered in a time frame from 2006 to 2021, using the following platforms: SciELO, ScienceDirect, ResearchGate, GeAS, and UNIFACTS. To this end, the following keywords were used: circular economy, sustainability, plastic packaging, recyclables, and life cycle. In addition, the book "Economia circular: um modelo que dá

impulso à economia, gera empregos e protege o meio ambiente" by Ohde et al. (2018), was also considered.

The documentary research had data made available by the following institutions: Ellen MacArthur Foundation, Associação Brasileira da Indústria do Plástico - ABIPLAST, Associação Brasileira de Embalagem - ABRE, Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais - ABRELPE, World Fund for Nature - WWF, Sistema Nacional de Informações sobre a Gestão dos Resíduos Sólidos - SINIR, United Nations Environment Programme - UNEP, Sistema Nacional de Informações sobre Saneamento – SNIS and Federal, State and Municipal Legislative Powers. These data have a temporal variation of ten years, from 2010 to 2020.

### **Data and Results Analysis**

Considering that most of the data are presented statistically, but that there is a need to incorporate a relatively new concept together with its theoretical attributions, a qualitative and quantitative approach was carried out for data analysis and obtaining results. The sources used were secondary, following the provisions of the previous topic. To facilitate the understanding and visualization of the results obtained, the data were arranged in a table with the application of the tool known as SWOT matrix. This tool consists of the application of a technique that relates strengths, weaknesses, opportunities, and threats, whose initials form the aforementioned acronym. With a more qualitative character, the tool assumes the function of exposing strengths and points that need improvement (GÜREL & TAT, 2017).

## **RESULTS AND DISCUSSION**

### **Plastic packaging and the Linear Economy**

The convenience of plastic packaging is undeniable. They are practical, hygienic, weightless, and have low cost. In the food sector, in addition to conserving products and facilitating their transport, packaging contributes to various forms of consumption. For example, it is currently common to carry out a form of consumption known as "on the go", that is, along the journey; therefore, it is necessary to easily dispose of the container, often plastic, that contains the food. There is also the option of delivery, fast food, among others, which use the facility offered by plastic packaging. In addition, it is already common to notice, in supermarkets, the plastic packaging even in fruits, replacing the

paper of their natural peels, offering a food ready for consumption. If, on the one hand, this type of offer is beneficial for people with motor difficulties, on the other hand, it represents an unnecessary use for a large part of the population, which purchases this option only for convenience.

Food consumption, however, is only a fraction of society's growing demand for plastics. Consumption patterns have already exceeded the planet's regenerative biocapacity since the 1970s and have been increasing even more with population growth and economic development (WWF 2020).

Considering the linear economy and Brazil as a case study, the growing generation of waste becomes worrying, which can be observed by data from ABRELPE, where in Brazil, in 2010, about 348 kg.year<sup>-1</sup> was produced, in 2019, the number increased to 379 kg.year<sup>-1</sup>, which indicates that the production of waste in the country increased by 31 kg.year<sup>-1</sup>.hab<sup>-1</sup> in a period of only nine years (ABRELPE, 2020).

This value can indicate two main trends: the increase in consumption and the shorter life of products. Currently, the market constantly offers new products, new versions, customizations, and limited editions, and it is still powered by globalization and the ability to have infinite options with a simple click through the internet. It is noteworthy that utility is of great value; however, one of the negative consequences of online shopping, for example, is the increase in the use of necessary packaging that is transformed into waste soon after reaching the consumer's destination. Added to this, there is an increase in the emission of carbon dioxide due to more individualized transport for making deliveries, especially for large distances due to globalization.

Considering plastic packaging, the linear economy demonstrates an accelerated growth, given the data from the "Estudo ABRE Macroeconômico da embalagem e cadeia de consume" (ABRE,2021) which presented a production projection specifically for plastic packaging of 36.79 billion reais for the year 2020 in Brazil. On the world stage, this product represents 50% of existing plastic waste (UNEP, 2018), which can be explained by the fact that they generally have a shorter shelf life and are not biodegradable. The destination of these packages, as well as of all waste, greatly influences their impact on the environment: it can be negative, with disposal in unprepared places, reaching rivers, water tables, and oceans or contributing to soil contamination; or positive from reuse and recycling. In a more critical analysis, landfills, for example, are also correct destinations for waste, according to the "Política Nacional

de Resíduos Sólidos" (PNRS), which do not have a positive impact, but rather avoid the negative (BRASIL 2010a, 2010b). In the Brazilian reality, dump grounds and controlled landfills, however, correspond to 24.9% of waste disposal on the ground (SNIS, 2019) and only 1.28% of plastic is recycled (WWF 2019).

The recycling process for plastics is complex and must be analyzed from the manufacture of the product, in the initial stage, since, according to the booklet *Reciclagem de Materiais Plásticos Pós Consumo* (ABIPLAST, 2019b), the choice of resins, colors, translucency, presence of aluminum or the fact of having something written on them can influence the recyclability of the packaging. In addition, post-consumer conditions, such as dirt and the presence of contaminants in packaging, are also relevant factors for the recyclability of the material, which highlights the importance of recycling responsibility also for the consumer, who often does not recognize their role.

Despite the complexity, recycling technologies exist, have been improved, and could already generate more expressive numbers for recycling in Brazil (LANDIM et al., 2016; SANTOS & YOSHIDA, 2011). The major obstacle to this development is associated with the need for greater stimuli and, mainly, the attribution of greater market value to the remanufactured products from this post-consumption production chain (ABIPLAST, 2019a). In addition to the advantage of reducing the volume of waste, remanufacturing often reduces production costs and greenhouse gases emission (FOSTER et al., 2016; WWF, 2019). Besides that, encouraging this activity can generate even more jobs. However, the linear economy does not encourage this type of reuse and ends up corroborating the low recycling rate in Brazil.

In addition to the worrying destination, plastics also have reservations due to their main raw material: oil (UNEP, 2018). As it is a non-renewable source, oil has limitations in its production and cannot be extracted indefinitely (GEYER et al., 2017). Once again, the characteristic flow of the linear economy, therefore, cannot be sustainable. Due to the demand caused by this perception and in an attempt to solve this problem, the green plastic market, plastics from renewable raw materials, has grown over the years, but it is still not so significant.

That said, the problem can be verified on all fronts of the linear economy for plastic packaging: the extraction of non-renewable raw material, the large production of materials with a low life cycle, the unconscious consumption, and the incorrect final destination. The linear economy no longer finds a scenario to remain as the main model

adopted for long-term production, especially with the increase in recurrent world demand. The study "A Solução da Economia Circular para a Poluição por Plásticos" (MACARTHUR FOUNDATION, 2020b) is assertive in stating that only with the adoption of the circular economy, as a set of interconnected activities, planned and executed by all sectors, can significant changes occur for the projections of pollution by plastics until the year 2040.

### **Application of Reverse Logistics and Life Cycle Change**

For the implementation of the circular economy, a fundamental component is to enable the return of the product to the life cycle after consumption. Reverse logistics, an instrument of the PNRS in Brazil, is responsible for facilitating this consumer-distributor/producer flows, being, therefore, extremely important for the viability of the circular production model (BRASIL, 2010a, 2010b).

The mechanisms for applying Reverse Logistics for packaging have been established through the application of decentralized federal legislation and specific ones, as in the State of Rio de Janeiro with State Law No. 8.151/2018 (RIO DE JANEIRO, 2018) and the State do Mato Grosso do Sul with State Decree No. 15.340/2019 (MATO GROSSO DO SUL, 2019). An excellent example of reverse logistics at the federal level is the pesticides that were regulated by Federal Decree No. 4074/2002 (BRASIL, 2002), which has guaranteed high rates of recovery of this material after consumption. The result was stimulated both by the toxic nature of pesticide packaging, with society bringing pressure, and by the effort of the productive sector to organize itself to implement reverse logistics. This successful implementation becomes a precedent for the expansion to other types and could be studied to be replicated for other packages. It should be noted, however, that for another packaging, the mechanism for applying reverse logistics, at the federal level, was outlined in the Sector Agreement for the "Acordo Setorial para Implementação de Logística Reversa de Embalagens em Geral". The latter has been "between phases" since 2019, which may weaken the results obtained in Phase 1 (SINIR, 2021).

The main element of the actions to be implemented for the application of the aforementioned legislation and the sectorial agreement are the manufacturers, importers, suppliers or distributors of packaging, since they are the ones who own or are intermediaries to those who have the means of production for reinsertion into the

productive cycle. However, despite the implementation of mechanisms by companies being a key factor for the success of this instrument, consumers also lack attention.

As mentioned by Azevedo (2015), shared responsibility can lead to a feeling of not attributing responsibility to any of the agents. Furthermore, the example of Germany demonstrates that the definition of the role of companies is really important, however, the consumer is also aware of their responsibility (RIBEIRO & CARMO, 2018). Thus, as important as establishing the means to carry out the reverse flow, it is effectively using this new option once the packaging is under the responsibility of consumers. In this sense, there are other ways to stimulate, at the same time, also the participation of the consumer market. Not only to make you aware of the existence of the reverse flow and informed about the process, but also to promote incentives to those who use it. In Europe, for example, it is possible to observe vending machines that receive post-consumer packaging and remunerate or offer vouchers in exchange (KOKOULIN et al., 2018). This type of action gives value to the material and makes the idea of separation even at home more advantageous. In Brazil, post-consumer material is still considered worthless by a large part of the population and companies, which makes the application of reverse logistics difficult.

This role of stimulus must come from companies, which occurs in the State of Rio de Janeiro through State Law nº 8.151/2018 (RIO DE JANEIRO, 2018), even as a way of putting into practice the investments that need to be made. Furthermore, once the mechanism is working effectively, it can generate savings in the company itself by reducing the need to obtain raw materials. On the other hand, and even more relevantly, this stimulus must also come from the Public Power, either through awareness campaigns and events, or through the establishment of incentives, such as the deduction of taxes, or the establishment of sanctions, such as the consumer taxation by volume of waste, as in Germany. The fact is that conscientious and adept consumers, cooperatives and companies are needed for the cycle to continue.

In the industrial sector, there is the example of the initiative of the Federação das Indústrias do Estado do Rio de Janeiro - FIRJAN, which launched, in 2020, the platform "Conecta Recursos", in which it is possible to advertise raw materials, waste, machinery and even infrastructure, spaces and logistics. In this way, what is waste or is idle or underused by a company can be passed on or shared with other companies that need these resources. The program is open to the entire country, not limited to the State of Rio de



Janeiro, and offers the space negotiation completely free of charge; however, registration is limited to legal entities. The initiative began with the “Bolsa de Resíduos” program, also from FIRJAN, which offered space for negotiation limited to company waste, allowing for reinsertion into the production cycle by another company that could use them as raw material (FIRJAN, 2021).

Another initiative that has gained prominence in the implementation of PNRS instrument is the Reverse Logistics Credits (BRASIL, 2010a, 2010b). Such credits work similarly to carbon credits and correspond to certifications issued by cooperatives that carry out re-verse logistics. Companies that are legally obligated or that intend to carry out reverse logistics can acquire these credits as proof that the service was performed, without the need to adapt their own logistics and production flow to fulfill them. In this way, the role of cooperatives in reverse logistics gains even more strength and is still beneficial for the reduction of informal employment in the sector. An example of a company offering Reverse Logistics Credits is Polen (POLEN, 2021).

Despite the initiatives being positive, it is still necessary to invest in their dissemination, in order to increase adherence and encourage its continuity. The “Bolsa de Resíduos” program, for example, underwent reformulations until it reached the current “Conecta Recursos” precisely because there was not such a significant adhesion initially (FIRJAN, 2021).

Reverse logistics, however, is just one aspect that must be addressed to change the captive behavior to the linear economy. The instrument will not reach its final objective if, when carried out, the generated waste does not allow reuse, recycling or some type of reuse due to the processes suffered during its production. In this case, the end-of-life of the product would remain the same as what the consumer could provide: the final disposal. Therefore, actions must be taken throughout the products life cycle, to ensure that production is optimized, reducing waste of energy, water, workforce and raw materials, and that the object of reverse logistics effectively finds a new place in the productive cycle. This implies, for example, the correct and broad classification of plastic materials used in packaging, through the application of the Brazilian regulation (NBR) of the Associação Brasileira de Normas Técnicas - ABNT, NBR 13.230:2008 (ABNT, 2021), preferably through its regulation, facilitating the identification and separation of post-consumer products by recycling cooperatives. Despite having been in existence for thirteen years, the regulation is still not used significantly, being one of the biggest

difficulties that co-operatives face when carrying out the separation of post-consumer material. In addition, preference must be given to the use of pure resins, without mixtures and additives, in transparent products whenever possible. Large companies such as Unilever, Braskem and Coca Cola, for example, already assume this type of concern with the use of pure and recyclable resins (LANDIM et al., 2016; SANTOS & YOSHIDA 2011), but it is necessary that more companies adopt this alternative. In this way, the material that is the object of reverse logistics can be better used.

To put these recommendations into practice, it is often necessary to rethink the entire product still in its production process, adopting sustainable practices in the life cycle and applying the concept of clean production. However, the creation of new designs, which take into account all stages of the product life cycle in a more optimal way, often needs to be accompanied by innovation. In this case, consumers have limited power of action. They can and have created demand for more sustainable products, but they still need to stick to what is available on the market and their purchasing power. It is the strong brands that tend to be pioneers in this sense, as they hold market share and have the financial resources to explore new technologies through investment in research and development. Public authorities, however, have an important role to play in providing conditions for smaller companies to also take advantage of this opportunity. The market exists and has been growing with the encouragement of companies' socio-environmental responsibility area, making it necessary to create a more competitive scenario.

In the case of plastic packaging, the small added value also makes it difficult to overcome the economic argument of the linear economy. The plastic packaging industry is the one that employs the most in the packaging sector in Brazil, according to the study “Estudo ABRE Macroeconômico da embalagem e cadeia de consumo” (ABRE, 2021), demonstrating its great economic power. However, it is important to consider other aspects, since after consumption; the material is almost totally devalued. However, the environmental awareness of a portion of the population has led consumers to also relate the environmental value associated with the product, generating social pressure that encourages the much needed revaluation in the sector. Even so, as previously mentioned, this pressure has limited power of action, requiring the intervention of the public power, seeking to assess impacts that were possibly not accounted for and encourage a change in the behavior of companies in the sector.

Regarding employment opportunities in the transition from plastic packaging to a circular economy, they may be encompassed by innovation, with new forms of production and services, or by the cyclical production process itself. This is because, considering the workforce throughout the life cycle of the products, it is in production that the largest share of vacancies is found, 75% according to Ohde et al. (2018). With the circular economy, the beginning and end of life stages must lose workforce, being redirected to the productive process of industries, which need more manpower. Therefore, the tendency is for employment opportunities to grow from the application of the closed life cycle. However, it will be necessary to readjust the professionals who were previously allocated in the phase of extraction of raw material or disposal of waste. Companies themselves can absorb this workforce and qualify their workers, in order to reassure them in the midst of the transition to the circular economy.

In view of the points raised, Table 1 presents a SWOT analysis summarizing the Brazilian situation in relation to the difficulties and needs for the application of reverse logistics and closing the life cycle in the packaging sector. In this analysis, the matrix is divided into four quadrants represented by the letters of its name, which mean, respectively: Strengths, Weaknesses, Opportunities and Threats. Therefore, the aspects punctuated in the Strengths and Opportunities quadrants are already existing incentives or actions that can be used in favor of reverse logistics and closing the life cycle. And, on the other hand, Weaknesses and Threats represent aspects that need improvement or that make it difficult to apply reverse logistics and closing the cycle. These must be recognized to be solved, circumvented or avoided (GÜREL & TAT 2017). For the implementation of the circular economy, a fundamental component is to enable the return of the product to the life cycle after consumption. Reverse logistics, an instrument of the PNRS in Brazil, is responsible for facilitating this consumer-distributor/producer flows, being, therefore, extremely important for the viability of the circular production model (BRASIL, 2010a, 2010b).

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The main element of the actions to be implemented for the application of the aforementioned legislation and the sectorial agreement are the manufacturers, importers, suppliers, or distributors of packaging since they are the ones who own or are intermediaries to those who have the means of production for reinsertion into the production cycle. However, despite the implementation of mechanisms by companies being a key factor for the success of this instrument, consumers also lack attention.

As mentioned by Azevedo (2015), shared responsibility can lead to a feeling of not attributing responsibility to any of the agents. Furthermore, the example of Germany demonstrates that the definition of the role of companies is really important, however, the consumer is also aware of their responsibility (RIBEIRO & CARMO, 2018). Thus, as important as establishing the means to carry out the reverse flow, it is effectively using this new option once the packaging is under the responsibility of consumers. In this sense, there are other ways to stimulate, at the same time, also the participation of the consumer market. Not only to make you aware of the existence of the reverse flow and informed about the process but also to promote incentives to those who use it. In Europe, for example, it is possible to observe vending machines that receive post-consumer packaging and remunerate or offer vouchers in exchange (KOKOULIN et al., 2018). This type of action gives value to the material and makes the idea of separation even at home more advantageous. In Brazil, post-consumer material is still considered worthless by a large part of the population and companies, which makes the application of reverse logistics difficult.

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In the industrial sector, there is the example of the initiative of the Federação das Indústrias do Estado do Rio de Janeiro - FIRJAN, which launched, in 2020, the platform "Conecta Recursos", in which it is possible to advertise raw materials, waste, machinery and even infrastructure, spaces, and logistics. In this way, the waste, or the idle, or underused by a company can be passed on or shared with other companies that need these resources. The program is open to the entire country, not limited to the State of Rio de Janeiro, and offers the space negotiation completely free of charge; however, registration is limited to legal entities. The initiative began with the "Bolsa de Resíduos" program, also from FIRJAN, which offered space for negotiation limited to company waste, allowing for reinsertion into the production cycle by another company that could use them as raw material (FIRJAN, 2021).

Another initiative that has gained prominence in the implementation of PNRS instrument is the Reverse Logistics Credits (BRASIL, 2010a, 2010b). Such credits work similarly to carbon credits and correspond to certifications issued by cooperatives that carry out reverse logistics. Companies that are legally obligated or that intend to carry out reverse logistics can acquire these credits as proof that the service was performed, without the need to adapt their logistics and production flow to fulfill them. In this way, the role of cooperatives in reverse logistics gains even more strength and is still beneficial for the reduction of informal employment in the sector. An example of a company offering Reverse Logistics Credits is Polen (POLEN, 2021).

Despite the initiatives being positive, it is still necessary to invest in their dissemination, to increase adherence and encourage its continuity. The "Bolsa de Resíduos" program, for example, underwent reformulations until it reached the current "Conecta Recursos" precisely because there was not such a significant adhesion initially (FIRJAN, 2021).

Reverse logistics, however, is just one aspect that must be addressed to change the captive behavior to the linear economy. The instrument will not reach its final objective if, when carried out, the generated waste does not allow reuse, recycling, or some type of reuse due to the processes suffered during its production. In this case, the end-of-life of the product would remain the same as what the consumer could provide: the final disposal. Therefore, actions must be taken throughout the product's life cycle, to ensure that production is optimized, reducing waste of energy, water, workforce, and raw materials and that the object of reverse logistics effectively finds a new place in the productive cycle. This implies, for example, the correct and broad classification of plastic materials used in packaging, through the application of the Brazilian regulation (NBR) of the Associação Brasileira de Normas Técnicas - ABNT, NBR 13.230:2008 (ABNT, 2021), preferably through its regulation, facilitating the identification and separation of post-consumer products by recycling cooperatives. Despite having been in existence for thirteen years, the regulation is still not used significantly, being one of the biggest difficulties that co-operatives face when carrying out the separation of post-consumer material. In addition, preference must be given to the use of pure resins, without mixtures and additives, in transparent products whenever possible. Large companies such as Unilever, Braskem, and Coca-Cola, for example, already assume this type of concern with the use of pure and recyclable resins (LANDIM et al., 2016; SANTOS & YOSHIDA 2011), but more companies must adopt this alternative. In this way, the material that is the object of reverse logistics can be better used.

To put these recommendations into practice, it is often necessary to rethink the entire product still in its production process, adopting sustainable practices in the life cycle and applying the concept of clean production. However, the creation of new designs, which take into account all stages of the product life cycle in a more optimal way, often needs to be accompanied by innovation. In this case, consumers have limited power of action. They can and have created a demand for more sustainable products, but they still need to stick to what is available on the market and their purchasing power. It is the strong brands that tend to be pioneers in this sense, as they hold market share and have the financial resources to explore new technologies through investment in research and development. Public authorities, however, have an important role to play in providing conditions for smaller companies to also take advantage of this opportunity. The market

exists and has been growing with the encouragement of companies' socio-environmental responsibility area, making it necessary to create a more competitive scenario.

In the case of plastic packaging, the small added value also makes it difficult to overcome the economic argument of the linear economy. The plastic packaging industry is the one that employs the most in the packaging sector in Brazil, according to the study "Estudo ABRE Macroeconômico da embalagem e cadeia de consumo" (ABRE, 2021), demonstrating its great economic power. However, it is important to consider other aspects, since, after consumption; the material is almost totally devalued. However, the environmental awareness of a portion of the population has led consumers to also relate the environmental value associated with the product, generating social pressure that encourages the much-needed revaluation in the sector. Even so, as previously mentioned, this pressure has limited power of action, requiring the intervention of the public power, seeking to assess impacts that were possibly not accounted for, and encourage a change in the behavior of companies in the sector.

Regarding employment opportunities in the transition from plastic packaging to a circular economy, they may be encompassed by innovation, with new forms of production and services, or by the cyclical production process itself. This is because, considering the workforce throughout the life cycle of the products, it is in production that the largest share of vacancies is found, 75% according to Ohde et al. (2018). With the circular economy, the beginning and end of life stages must lose the workforce, being redirected to the productive process of industries, which need more manpower. Therefore, the tendency is for employment opportunities to grow from the application of the closed life cycle. However, it will be necessary to readjust the professionals who were previously allocated in the phase of extraction of raw material or disposal of waste. Companies themselves can absorb this workforce and qualify their workers, to reassure them during the transition to the circular economy.

Given the points raised, Table 1 presents a SWOT analysis summarizing the Brazilian situation concerning the difficulties and needs for the application of reverse logistics and closing the life cycle in the packaging sector. In this analysis, the matrix is divided into four quadrants represented by the letters of its name, which mean, respectively: Strengths, Weaknesses, Opportunities, and Threats. Therefore, the aspects punctuated in the Strengths and Opportunities quadrants are already existing incentives or actions that can be used in favor of reverse logistics and closing the life cycle. And, on

the other hand, Weaknesses and Threats represent aspects that need improvement or that make it difficult to apply reverse logistics and close the cycle. These must be recognized to be solved, circumvented, or avoided (GÜREL & TAT, 2017).

**Table 1** – SWOT Matrix analysis of the application of reverse logistics and life cycle closure in the packaging sector in Brazil

| <b>Strengths</b>  | <b>Weaknesses</b>   |
|---|---|
| 1. Great coverage of the garbage collection service;<br>2. Support of national legislation for implementation, with Reverse Logistics already regulated in Brazil;<br>3. Lower volume of waste for final disposal;<br>4. Reduction of waste with a possible increase in the company's profit;<br>5. Existing consumer market.         | 1. Low added value to plastic packaging;<br>2. Need to change the mode of production;<br>3. Need to reallocate a portion of the workforce at the beginning and end of the products' life;<br>4. Need for investment in Research and Development with medium and long-term returns;<br>5. Little knowledge of end consumers about the life cycle and reverse logistics;<br>6. Selective collection is left in the background by the garbage collection system. |
| <b>Opportunities</b>  | <b>Threats</b>  |
| 1. Sector Agreement for the application of Reverse Logistics for packaging;<br>2. Technological development;<br>3. High market demand for more ecologically responsible products;<br>4. World trend;<br>5. Advancement of mechanisms for the company's social and environmental responsibility;<br>6. Increase in the supply of jobs. | 1. Offer the most economically advantageous raw material;<br>2. Lack of adherence by consumers;<br>3. Disagreement between the parties involved, mainly producers and distributors;<br>4. Lack of communication between companies, cooperatives, stakeholders, and public authorities;<br>5. Incorrect or non-application of NBR 13.230:2008 on the identification and symbology of recyclable plastics of recyclable plastics.                               |

### Current Efforts

Given the negative impacts caused by the current production model, the management of plastic packaging has been put on the agenda together with solutions to make them environmentally sustainable. Although the Circular Economy is not regulated in Brazil, some of its concepts regarding the life cycle and solid waste management are addressed by the PNRS (2010) (BRASIL, 2010a, 2010b). This is the case of reverse logistics already mentioned in the previous topics.

The "Acordo Setorial para Implantação do Sistema de Logística Reversa de Embalagens em Geral", signed in 2015 in the country, has already had its first phase concluded with positive results and goals achieved. According to SINIR, until 2019, the agreement was found "between phases", despite the instrument's implementation plan not having stopped. There are no new updates for 2021 (SINIR, 2021).

The recyclable material collectors' cooperatives were one of the main investment points for the companies participating in the agreement, with the increase in the capacity



of existing cooperatives and the creation of new cooperatives. In addition to their role in reverse logistics and the environment, they have great social importance as they can generate jobs and improve the working conditions of informal recyclable material collectors. Furthermore, in the first phase of the agreement, the signatory companies also invested in voluntary delivery points for the participation of consumers, in awareness campaigns for them, in the improvement of communication between the industrial and commercial sectors, and the promotion of the recyclables market. Although the goals of the first phase have been achieved, it is still necessary to expand these actions so that they are internalized in society (SINIR, 2021).

State and municipal governments have also taken small measures to raise environmental awareness about plastic waste. This is the case of laws prohibiting non-biodegradable plastic materials, such as bags, straws, and disposables. These actions encourage the search for more sustainable materials to replace them. There is, then, a trend in today's society: the social pressures coming from the population and from organizations concerned with the environment grow to the point of being heard by the government, which acts in favor of solutions based on the regulation of laws and decrees, which, in turn, drive companies to adapt to the new rules, leading to market innovation and offering new products. There are times, however, when companies serve their consumers directly and invest in this type of innovation without government intervention, which usually leads them to a pioneering position.

Companies such as Braskem, Coca Cola, Nespresso, among others, have already publicly committed to making the transition to the circular economy model (BRASKEN, 2021; COCA-COLA, 2021; NESPRESSO, 2021). The returnable bottle is a great example of an industrial-scale product that touched on closed life cycle concepts. Adopting this refill format, brought savings to both the company and the consumer, in addition to reducing end-of-life disposal through non-generation. The pet bottle would be another successful example that ended up promoting recycling and generating job opportunities through cooperatives. In the case of Nespresso, a major disadvantage of its products was the fact that each capsule represented a wet residue composed of aluminum. However, the companies implemented the reverse logistics system, offering points of voluntary delivery, at home and even the return of capsules via mail, through moisture-resistant paper packaging, and started to recycle them to manufacture new capsules and branded products. Several companies have verified positive results in the implementation

of circular economy points, whether by attracting consumers to assume their socio-environmental responsibility, by financial savings, or by optimizing their processes (NESPRESSO, 2021).

On the world stage, the circular economy takes different formats and is implemented in a heterogeneous way. The divergence in the Chinese and European approaches, for example, was studied by McDowall et al. (2017), as mentioned above. Each one proceeded with the implementation of the model according to local needs, directing it to the solution of problems, namely: reduction of pollution and search for resources to feed accelerated development in China; and limited land use and waste management need in Europe. Even on the European continent itself, member states have adopted different priorities and, despite the existence of the circular economy implementation plan for the continent since 2015, each country has drawn up its plan. In Australia, the document "Circular Economy Roadmap: Pathways for unlocking future growth opportunities for plastics, glass, papers, and tyres" was launched in 2021, focusing on the circular economy on more specific points that need more attention (AUSTRALIAN GOVERNMENT, 2021). In general, the concern with plastic waste is a point of convergence worldwide.

In addition, it appears that government action is incisive in countries with a high recycling rate of plastic packaging. Lithuania, for example, has adopted a system of taxes on the purchase of packaging and refunding them to consumers who return the packaging to the reverse logistics system. Norway, another European country that is a reference in recycling, also adopts this same system. On the other hand, civil society initiatives can also stimulate government actions. The Ellen MacArthur Foundation itself presented the "Plastics Pact" initiative, which includes the development of solutions to the plastic problem in several countries, such as the United Kingdom, Portugal, the United States, and Canada, in partnership with the governments and companies of these countries (ELLEN MACARTHUR FOUNDATION, 2021).

Finally, as for social pressures, they are not defined only by consumers, but also by teaching and research institutions, non-governmental organizations, among others. The work of organizations such as the aforementioned Ellen MacArthur Foundation and the World Wide Fund for Nature - WWF, for example, offers benchmark studies and projections concerning the circular economy and waste management. In addition, these studies are important for disseminating knowledge of the impacts of the current

production model and the benefits of the transition (ELLEN MACARTHUR FOUNDATION, 2021; WWF 2021).

There are several fronts of action for the circular economy, adapting to the reality of each location. It is noted, once again, that Brazil does not have a regulation for the circular economy itself, relying on initiatives isolated from its concepts. It is a fact that there is no pre-defined universal flowchart with the steps to be followed for the correct implementation of the circular economy; however, it is recommended that there is an action plan that involves the different fronts addressed so that better work can be done together, enhancing their effects. According to a study by the Ellen MacArthur Foundation (2020), isolated actions can improve some indices, but they should not bring the necessary changes to alter the reality of the country (ELLEN MACARTHUR FOUNDATION, 2020b). Therefore, planning is paramount.

### **Enabling the application of the Circular Economy**

There is no single correct methodology for applying the circular economy. It is composed of a set of concepts that can be applied individually, but only with the simultaneous application and interaction between them, can the circular economy, as well as its benefits, be truly experienced. Therefore, each of the actors involved has a range of actions that can contribute to the viability of the circular economy in the plastic packaging sector.

As already discussed, the role of public authorities is essential to encourage changes at scale. The government can not only establish specific legislation but also regulate it, define public policies, goals, and objectives to be achieved by the nation. Brazil lacks an implementation plan like the European continent (UNEP, 2018). It is necessary to expand the regulation regarding unnecessary plastics, that is, plastics that can be easily replaced by other materials, such as cardboard packaging for the transport of solid products, and with a very short lifetime, as was the case of non-biodegradable plastic bags.

In addition, the government can create incentives and stimuli to the economy to favor the conscious use of plastic packaging. For example, promoting actions that lead to the valorization of recycled packaging or that value more rigorously the environmental damage caused by the extraction of raw materials and their final destination. As in Germany, taxation of consumers by volume destined for final destination can increase the

level of awareness of this actor (UNEP, 2018). This type of action is necessary mainly in the absence of a well-defined and widespread environmental education for the population, but it does not exempt the need to promote environmental education through partnership programs between the government, schools, and institutions, since it is fundamental for the development of environmental awareness. Even public purchases could already give preference to more sustainable options as an example of conduct for companies. Finally, the government needs to assume the role of interlocutor between companies, cooperatives, and the population, allowing the producer, consumer, and other associated sectors to interact effectively.

Society, on the other hand, can help in the transition to the circular economy of plastic packaging through the initiative to debate, bringing to the attention of companies and authorities the desire to exercise a conscious consumption, which in turn, must be disseminated by the population itself. Therefore, it is not enough for companies to provide more sustainable options for plastic packaging; they must be the consumer's choice and, for that, it is necessary to promote the benefits of this option in all social classes. In this moment of transition, the market has made available both options for renewable sources, recyclable materials, and correct application of NBR 13.230:2008 (ABNT, 2021), as well as traditional options, without concern for standardization or the origin of the raw material, with the mixing of materials, among other factors that prevent recycling.

In many cases, the economic factor is no longer a force for choosing traditional options, since many sustainable products are already on the market with great economic competitiveness. The substitution of non-recyclable plastic for recyclable ones, for example, usually does not make a big difference to the final value of the packaging. In this way, consumer choice is an essential point for establishing the trend.

Educational institutions play a fundamental role in opinion formation and, therefore, must be engaged in this debate about the circular economy and the dissemination of the concept, in addition to the promotion of environmental education mentioned above. In addition, they can carry out research and academic work that end up providing data that support concrete actions, together with other institutions and civil society organizations.

As for companies, the main way to implement the circular economy is through innovation. This innovation can occur in the product itself, through the application of intelligent design, for example, which would be characterized as innovation at the origin

addressed in the study carried out by the Ellen MacArthur Foundation, *Inovação na origem* (2020a). In this case, the design must be rethought to enable the repair and maintenance of the product, the separation of parts with different materials to enable recycling and reuse, the adoption of refills that dematerialize part of the product and increase its lifespan, choice of more sustainable and recyclable raw materials, without mixing resins for plastics, for example, among other possibilities. According to ABIPLAST (2019), to enable the recycling of plastic packaging in the best possible way, it would be interesting to opt for the use of lids that do not require sealing and are made of polypropylene (PP) and polyethylene (PE), as well as the use of these resins for the manufacture of plastic labels.

In the packaging production process, the implementation of clean production include, for example, the use of a closed cycle for the cooling water of the machines, reducing water consumption, in addition to other adaptations that contribute to the reduction of entropy and waste production. Plastic waste from the production process of processed plastics can be used as raw material for packaging this material (Landim et al. 2016). Transport from factories to distributors and consumers also needs to be considered, as they contribute to the emission of greenhouse gases. A good logistics would be to be close to the consumer center and align the supply of new packaging with its post-consumption transport, optimizing the transport stage and avoiding unnecessary trips. The positioning of delivery points in supermarkets, for example, could facilitate this flow.

Regarding the product, the option of changing the plastic raw material to other materials can bring more expressive results for the reduction of plastic waste and has become increasingly viable with the advancement of technology. It is known that one of the great advantages of plastic is its ability to pack products with greater humidity, something that was not recommended to do with paper packaging, as it does not maintain its structure when subjected to high humidity, or glass packaging, which could make it the product more expensive and make transport difficult. However, today it is possible to find paper products, light, biodegradable and 100% recyclable, resistant to moisture (SANTOS & YOSHIDA, 2011). This is the case, for example, of the bag intended for the reverse logistics of Nespresso capsules (NESPRESSO, 2021). Another great example is the carton package which, despite still having a certain percentage of polyethylene, is mainly based on cardboard and is capable of packaging liquid products, such as milk (SANTOS and YOSHIDA, 2011). Given the above, technological advances have shown

that the conveniences found in plastic are not exclusive to it and that through innovation it is possible to opt for raw materials from renewable and more environmentally responsible sources.

Changing the entire production process to apply sustainable practices in the life cycle, making reverse logistics viable, and effectively closing the cycle of a product, among other things, is a complex task that demands time and investment in education, research, and development. In this way, the sooner companies begin the transition, the better it will be to adapt to the future reality.

## CONCLUSIONS

Throughout the present work, it was possible to verify that in Brazil, the environmental problem in which plastic packaging is inserted, as well as the need for a change not only in the production model but also in the current consumption patterns, so that the damage caused by the linear model can begin to be reversed, without the need to hold back socio-economic development.

The study presented in the literature from 2006 to 2021 demonstrates that the circular economy approach, despite not being so recent, has gained strength today, given the dissatisfaction and consequences of the production and incorrect disposal of waste, in addition to the perception of the finitude of natural resources. It was also possible to perceive the dichotomy of plastic products, especially plastic packaging, since, on the one hand, they present themselves as major contributors to these negative consequences, on the other hand, they have advantages and benefits such as resistance, low cost, low weight, sanitary characteristics, among others.

There is a considerable contribution of plastic packaging in a linear economy, demonstrating the need to transition to a model that reduces the pressure on the environment. In this regard, there was a large amount of plastic waste produced and discarded, the inadequate final disposal still expressive, and the lack of incentive in the linear economy for the reuse and recycling of products, and the finitude of the main raw material of the plastics materials.

It was also possible to perceive the difficulties and needs of the plastic packaging sector for the application of constant concepts in the cyclical model, namely, reverse logistics and adaptation for the closing of the life cycle. Among them, the low value-added to the plastic material, the mentality of waste as something without value for the

Brazilian population, the inefficiency in the application of the regulation of standardization of recyclable plastic packaging, the post-consumption conditions of the packaging, the choice of pure resins that make recycling possible, the lack of incentives from the government and the need for investments by companies with medium and long-term financial returns.

There are some current efforts to implement the circular economy and improve packaging management, such as commitments made by companies and countries to transition to the circular economy, incentives for reverse logistics and recycling, or sanctions and fees for practices that make them difficult. In Brazil, efforts are focused on the application of concepts with the implementation of the National Policy on Solid Waste, the Sectorial Agreement for the Implementation of Reverse Logistics for Packaging in General, and decentralized legislation, in addition to individual initiatives such as Conecta Recurso, by FIRJAN, and Reverse Logistics Credits.

Considering the possibilities and actions necessary for the application of the circular economy, each sector of society has an essential role: the government can contribute through specific legislation, public policies, goals, and objectives to be achieved, in addition to the application of taxes on waste; the consumer, on the other hand, needs to make a conscious choice and be engaged, with the important function of making use of reverse logistics channels after consumption; companies, on the other hand, need to continue to invest in these reverse logistics channels and rethink the design of their products, with the choice of renewable or at least recyclable raw materials, plastic material without mixing, adoption of refills that dematerialize part of the product and increase their lifespan, among others.

Although the discussions and knowledge acquired by this work have been relevant, there must be a greater depth on the subject. Whether due to the variety of plastic packaging production processes, the different existing materials, or the different post-consumer possibilities of packaging. Many features can be explored in future works within the same theme. More broadly, the circular economy itself presents a multitude of approaches that are relevant to different industries and their particularities, and can thus be studied in a "case" structure, to serve as a model for companies to adhere to the sectors covered. In addition, it is also interesting that financial studies are produced for different proposals to change the production process or raw materials to replace plastic, to assess the feasibility of the proposals, and bring more security to the sectors involved.

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