

Article

Compostable Packaging Waste Management—Main Barriers, Reasons, and the Potential Directions for Development

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Abstract: The paper aims to identify the main reasons for the low level of compostable packaging waste management and to propose potential directions for development. Based on qualitative research (individual in-depth interviews and focus group discussions using the Social Innovation Lab), these are: (1) the lack of uniform and transparent regulations regarding the planning and organization of a closed-loop system for compostable packaging, (2) insufficient communication between the private and public sectors on how to increase the use of compostable packaging, (3) poorly developed infrastructure for compostable waste recycling, and (4) a lack of financial incentives to support activities for the circular economy of composting packaging at the communal level. Moreover, the portfolio of bottom-up (initiated by consumers, educational institutions, and NGOs) and bottom-down dimension (national, regional programs) proposals are presented. The diagnosis of different view perspectives of the supply chain underlines the crucial role of stakeholder cooperation improvement.

Keywords: compostable packaging market; waste management strategy; supply chain cooperation; responsible consumption; responsible production



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1. Introduction

Packaging is not only the largest source of plastic waste in the EU [1], but the plastic packaging market continues to develop dynamically [2]. In general, it is evident that waste plastics, if not disposed of properly, cause serious environmental problems such as land pollution, marine pollution, and water pollution [3]. According to the data, 40% of produced plastics are materials used for packaging, which become waste after consuming proper products [4]. Moreover, most plastic waste on a global scale comes from single-use plastics, often described as disposable plastics used mainly in packaging applications, which comprises items designed to be used only once before being discarded or recycled [5].

An alternative to conventional plastics is compostable packaging made of biodegradable polymers, belonging to the group of biodegradable packaging [6]. According to the provisions of the EN 13432:2000 standard, packaging is considered compostable if it shows the ability to decompose at least 90% within six months [7]. Compostable packaging can be used as an intermediate raw material in fertilizer as a power supply for the natural environment. Natural raw material decomposes naturally under favorable composting conditions and requires special treatment in a waste management system. However, for compostable packaging to degrade under composting conditions (i.e., specific conditions of humidity and temperature), it must meet three requirements: (a) breakdown of plastic material through the activity of microorganisms (bacteria, fungi, and algae), (b) the achievement of 100% mineralization (conversion into carbon dioxide, methane, water, inorganic compounds, or biomass under aerobic conditions), and (c) the conversion, i.e., mineralization rate, must be very high and suitable to the composting process. Therefore, some bioplastic packaging may be biodegradable but not compostable.

The growth of the bioplastic packaging (herewith compostable) market is crucial in the context of population growth. The UN forecasts that in 2050 the global population will reach the level of 9.7 billion, rising to as much as 10.9 billion in the year 2100 [8]. Consequently, this implies increased demand for consumer goods, now mainly packed in plastic packaging. Some products are irreplaceable at this point in time due to, e.g., lower barrier and mechanical properties [9], but in some sectors, including food supply chains [10,11], many products can be replaced with bio-packaging, including compostable packaging [12]. It is technologically possible to recycle to obtain new plastic packaging and articles or compost (recollect, classify, and segregate) bioplastics such as PLA [13]. One of the biggest problems surrounding compostable plastic is the problem of cross-contamination. Products are recycled in material recovery facilities, which use optical technology to view and sort waste. If compostable materials enter the recycling stream, they can contaminate the batch and make it impossible to process. Moreover, research on the packaging market in the “Global Biodegradable Packaging Market” report indicated that 45% of consumers said they want brands to offer biodegradable food packaging when it cannot be recycled [14]. There is a lack of precise data analysis concerning the current consumption of compostable packaging in Poland; it is still a niche market.

It is worth noting the perception of packaging value chains as valuable to design, considering the implementation of the circular economy [1]. The Ellen MacArthur Foundation emphasizes that the goals of the circular economy are to create waste that can be reused, to keep products and materials in the economy for as long as possible, and to regenerate natural systems by returning nutrients to the environment [15]. It should take place in parallel with consumption, production, and waste management [16]. In line with this, by moving away from the waste of natural resources in linear interconnections, bio-packaging supply chain stakeholders strive to reduce the number of primary resources introduced into circulation through the cost-effective use of those already circulating therein [17]. Compostable food packaging refers to the following postulates of the circular economy: refuse, reduce, reuse, repair, refurbish, remanufacture, re-purpose, recycle materials, recover energy, re-mine [18]. The key activities determining the closure of the packaging cycle are waste management activities, which include effective selective waste collection, increasing the quality and level of recycling, giving up single-use products, and supporting the development of eco-design [1,19].

The aim of this paper is to identify the main reasons for the low level of compostable packaging waste management and to propose potential directions for development. The following research questions were posed: (RQ1) What are the main barriers and reasons for the low level of compostable packaging waste management development in Poland? (RQ2) What are the main potential directions for compostable packaging waste management development in Poland?

Composting is considered in the scientific technical literature; however, its range of studies focus mainly on physical, chemical, and biological aspects. In the field of social sciences, in relation to supply chain management, concepts related to compostable packaging belong to a definite minority. Based on the Scopus database, using keywords “compostable” and “supply chain management”, only three results were found. This paper is based on a theoretical and mainly empirical investigation.

2. Materials and Methods

The paper presents the results of qualitative research conducted between September 2020 and October 2021 in Poland within an international project. In the first stage (September 2020–April 2021), the method of individual in-depth interviews was selected. Attention was focused on identifying challenges in applying bioplastics packaging, key barriers, activators, and supporting factors. Thirty-one interviews were conducted (November 2020–April 2021), lasting from 60 to 120 min each, transcribed, and analyzed. The researchers used semi-structured questionnaires, including a series of open-ended questions based on the topic areas to cover during a dialogue with a specific stakeholder: bioplastics packaging

manufacturers, packaging distributors, organizations involved in the packaging certification process, waste management entities, public sector units, and other supporting entities. During the next stage (July 2021–October 2021), the focus group discussion method was used. Both research methods aimed to obtain data from purposely selected individuals with high levels of expertise and experience representing various market interest groups under investigation.

The second stage of the survey was conducted using the methodology of social innovation research (the Social Innovation Lab), based on three workshop methodologies created by the Waterloo Institute for Social Innovation and Resilience, with the modification to reduce the length of the workshop from three days to one [20]. Based on four selected fundamental problems (see Table 1) with developing the bioplastic packaging market (including compostable packaging) for food in Poland, a diagnosis of the barriers of the four key issues and related reasons was elaborated with the bioplastic packaging supply chain stakeholders. More specifically, the researchers applied four substages of the research procedure: (1) defining the primary research objective and scope of the study, (2) preparing a list of questions (schedule) as guidance for each focus group discussion session, (3) inviting purposely selected stakeholder representatives in order to achieve dynamic and synergistic effects between them, and (4) conducting focus group discussions in the form of stakeholder panels.

Table 1. Four main problems in bioplastic (including compostable) packaging supply chain management [21].

1. A low share of bio-packaging (incl. compostable packaging) in the market food packaging in Poland	2. Low awareness and consumer tendency to buy food products in bio-packaging
3. Insufficient social and environmental enterprise responsibility in packaging supply chains for circular economy	4. Low level of compostable waste packaging development

Consequently, a diagnosis of reasons and barriers in the life cycle of bioplastic (including compostable) packaging was carried out in a dialogue with supply chain stakeholders. The invitation to participate in the first workshop was accepted by 22 representatives of stakeholders of bioplastic (including compostable) packaging supply chains. The participants were involved in three permanent focus groups, lasting 90 min, comprising between four and eight participants each. Among those who attended the first workshop were internal stakeholders of bioplastic packaging supply chains: suppliers of raw materials and bioplastics, packaging manufacturers, packaging distributors (including wholesalers and retailers), business customers, individual clients–consumers, and waste management entities, e.g., waste management plants and municipal waste utilization plants. On the other hand, the group of external stakeholders who are qualified to shape the conditions for developing bioplastic packaging supply chains, taking the principles of the circular economy into account, was represented at the first workshop by representatives of public administration institutions and organizations that certify plastics and packaging. The diversity of lab members is beneficial because they represent various viewpoints and increase the possibility of creating a holistic approach and innovation. The researchers played the roles of discussion facilitators and assistants, writing down participants’ opinions and reactions. They used specially designed graphic diagrams to report on the course of the discussion. The main aim of focus group discussions was the analysis of the causes of problems in and barriers to food bioplastic (including compostable) packaging supply chain management in line with the principles of the circular economy. Data collected during the workshop were analyzed, and finally, the main results were reported.

Both methods—individual in-depth interviews and focus group discussions—were applied within the online environment, using calls, chat, and discussion panels due to the need for remote communication during the COVID-19 pandemic.

3. Results

The qualitative data allowed us to identify the four main problems in bioplastic (including compostable) packaging supply chain management according to the principles of the circular economy, presented in Table 1.

Moreover, it was recognized that these problems could be attributed to specific barriers that hinder the development of this market in the food sector in Poland. This article presents the conclusions of an analysis of barriers and their reasons at the low-barrier level of economic development in terms of compostable waste packaging.

Barrier 1: Lack of uniform and transparent regulations regarding the planning and organization of a closed-loop system for compostable packaging.

Limited awareness of implementing the closed-loop economy in food supply chains and the lack of a systemic approach to creating regulation in the circular economy led to difficulty in crafting suitable legal provisions. Consequently, the existing rules are selective and appear in the content of specific legal acts not directly related to the closed cycle of compostable packaging. European regulations have been very slowly implemented into national law (including the plastic directive and the waste package). Moreover, there have been inconsistencies and changeability in legal regulations, which have often been modified. The implementation of such laws in Poland and the harmonization of said law to European law are subject to long delays resulting from the bureaucratic legislative process. The inconsistencies result in difficulties in interpreting legal provisions in both the private and public sectors, where an insufficient level of communication has been noticed. There is a significant gap between the private and the public sectors, represented by law-making bodies, experts in composting packaging, enterprises, and local waste management entities, in planning and implementing regulations in the circular economy. Such a barrier is only deepened by the insufficiently qualified staff in the field of the circular economy, the lack of efficiency of communication tools, and the different expectations of both parties. Public entities introduce legal instruments for compostable packaging waste management, taking the functioning of the entire economic system into account, but often without regard for bottom-up initiatives and ideas generated by representatives of the private sector. Furthermore, lobbying activities are often pressed on conventional packaging market representatives. The private actors expect clear rules to enable them to take advantage of the compostable potential of packaging waste to close its economic cycle. The results of consultations on the design of individual provisions are unsatisfactory and, consequently, difficult to implement in practice—time pressure on internal stakeholders' composting packaging supply chains as a result of the implementation of emerging regulations has been noticeable.

Barrier 2: Insufficient communication between the private and public sectors on how to increase the use of compostable packaging.

The lack of effective communication is visible in the discrepancies appearing in the definitions and terms used in regulations compared to those used in the economic approach, which leads to many ambiguities and, consequently, inhibits the effective development of compostable packaging waste management. On the national level, waste management has been treated as one of many problems but not as a priority, e.g., adaptation to climate change and the development of blue–green infrastructure in cities or activities strengthening the resilience of the economy as a result of the crisis caused by the COVID-19 pandemic, etc. Nowadays, offices do not see a problem with compostable waste packaging if the waste is compostable, i.e., environmentally friendly. Hence, this topic is not a problem. Moreover, expert comments on the legislative process of practitioners operating in the composting packaging market have often been omitted by public entities.

According to the results of the survey, the public sector pays inadequate attention to the needs of stakeholders in the bio-packaging supply chain and utilizes the resource capabilities inefficiently. There are, for example, no homogenous marking signs on the packages that allow their proper segregation after use, resulting in a lower stream of uncontaminated bio-waste going to the composting plant. In addition, there has been a

notable lack of a nationwide cooperation platform. Dialogue has been crucial because private and public sector goals have been in conflict when it comes to developing the compostable packaging market. The composting packaging market, which determines cooperation between companies, is in the early stages of development. There is a reluctance to share knowledge and limited readiness to competition in this regard. Market participants treat access to information as an element of its know-how.

Barrier 3: Poorly developed infrastructure for compostable waste recycling.

Consumer awareness and behavior are vital in developing the bioplastic (including compostable) packaging sector. The preferences and purchasing decisions of domestic farms determine the course of action in waste packaging management. Unfortunately, the involvement of Polish society in circular waste management is low due to, among others, a dislike of and resistance to changes in waste management, a low level of social capital, and the limited culture of waste segregation. The knowledge deficit has been remarkable, and consumers' low level of awareness about excessive packaging contributes to the natural environment contamination. Moreover, the difficulties of distinguishing compostable packaging waste have been indicated by conventional consumers and waste management organizations. On the packaging itself, there is a lack of visible and understandable information on the compostability of packaging in home composters, as well as the possibilities of "educating consumers through packaging". The communication is also disturbed by the greenwashing effect on the compostable food packaging market, which makes it difficult for consumers to properly segregate waste.

Knowledge of the correct segregation of waste acquired, e.g., at school, cannot be fully utilized due to the limited infrastructure for sorting waste, especially in multi-family buildings. In addition, there is a lack of individual responsibility for failure or improper use of waste segregation with high anonymity (e.g., in multi-family buildings, on housing estates) and few or no consequences for non-compliant household waste segregation. In effect, this compostable packaging goes to the improper garbage fraction, preventing the effective process of raw material recovery. There is no control of the quality of compostable waste provided by consumers and no enforcement of requirements by public administration concerning separate collection because waste is sent to composting plants and often contaminates other garbage fractions. As a result, implementing the correct composting process is complicated.

It is, however, worth emphasizing that when it comes to the intensification of exploitation, it is not just the consumers themselves or the organizations representing them that impact composting packaging but also other public and private sector entities. The poorly developed infrastructure supporting consumers' selective packaging collection is also due to the reactive attitude of municipalities and local authorities. Resources and financial support for municipalities are often limited when it comes to organizing separate waste collection. The decision to invest in specific infrastructure solutions is determined by the uncertainty occurring in the sector due to frequent changes in the implemented legal and technological solutions. Local government units exhibit noticeable opportunistic behaviors in composting packaging, and selected municipalities give their express consent to place compostable packaging in compostable waste containers.

Composting entities accept waste according to a strictly defined catalog, which often does not include packaging waste. The phenomenon also implies an insufficient level of knowledge among composting entities about the properties of composting packaging and the possibility of composting. Consequently, the potential of the compostable waste management system has not been sufficiently exploited.

In the compostable waste management system, the number, capacity, and spatial availability of composting plants are noticeably limited, which affects the cost of transporting waste. Moreover, the number of installations for energy recovery from biodegradable waste is negligible. Enterprises are reluctant to engage in infrastructure development due to the risk of a lack of profitability, frequent changes in legal regulations, and the risk of non-continuation of operations in the event of failure to win another tender. Obtaining permits

for investments in infrastructure is associated with lengthy procedures, often associated with protests by local communities against the location of this type of investment.

Barrier 4: No financial incentives to support activities for the circular economy of compostable packaging at the communal level.

The lack of interest indicated here results from the limited awareness of consumers and composting entities regarding the potential of composting waste in the circular economy system. The lack of investment outlays on composting infrastructure is due to the low level of interest in its use. The interest of public administration in composting waste in the economic system is insufficient, limiting the financial outlays of local government on implementing tasks in this area. On the other hand, local governments do not include the circular economy of compostable packaging in their investment priorities. Especially in economically weaker communes, there is a lack of financial resources for introducing changes; in the case of waste management rules established by regulations, the new laws in force in all communes may require financial support at the state level. The lack of funds also highlights the challenges inherent in developing infrastructure, e.g., industrial composting plants or programs co-financing the growth of home composting plants. Short-term contracts for waste management services at the municipality and city level, which are not conducive to medium- and long-term private sector investments in suitable infrastructure, increase the investment risk.

4. Discussion

Responsible packaging management can significantly reduce food waste in the food supply chain [22]. The involvement and participation of all waste management stakeholders, such as, e.g., waste generators, waste processors, formal and informal agencies, non-governmental organizations, and financing institutions, are crucial to successful sustainable waste management [23]. The supply chain actors should then create potential and implement solutions to compostable packaging barriers and their reasons identified in the research.

The research results indicate that, in response to market, technological, financial, administrative, legal, and social challenges, implementing a waste management system requires a focus on the implementation of many critical strategic activities to increase the competitiveness of companies, as well as educational, systemic, and legislative activities. To remove barriers no. 1–4, it is crucial to develop and launch a strategic waste management system development program in the compostable packaging industry in a circular economy using the latest technologies, including material, chemical, and organic recycling and processing various waste materials, including compostable waste [24]. Appropriately managed composting is a sustainable waste management option with multiple benefits, including reducing greenhouse gas production and improving soil quality when used as a soil amendment [25]. However, composting may lead to the above-mentioned environmental issues when improperly managed and performed, especially plants in open spaces [26–28]. To achieve an efficient system of compostable waste packaging, market entities should surely strengthen cooperation with national and international industry organizations, clusters, research institutions, companies, and between representatives of private sector and public sector entities. More specifically, a win-win strategy should be implemented. The research results point out that stakeholder cooperation should be characterized by two-way communication and with mutual needs, expectations, and opportunities taken into consideration. Public support for recycling policy is essential [29].

Certainly, removing barriers no. 1 and 2 needs the adjustment of national law to the upcoming regulations, the implementation of administrative rules in the field of circular economy, expanded producer responsibility, recycling, reduction of plastic consumption, and waste segregation, including rules for compostable waste [30]. To create a mature approach to compostable packaging waste management, it is worth standardizing compostable waste in terms of its use as secondary raw materials—minimizing the use of primary raw materials and creating tools to control the final product from recycle. This

would develop certified quality assessment services. Waste material recycling and environmental risk control require quality-based compost classifications [25]. Investments in composting plants would promote enterprise responsibility and compostable packaging waste management development, which is linked to barriers no. 3 and 4.

According to the research results, the quality of the waste management system is determined both by the resources of internal stakeholders (e.g., engineering knowledge, financial resources allocated to designing eco-solutions) and the resources of external stakeholders (e.g., opportunities and competencies in the area of developing legal regulations) of compostable packaging supply chains. The recommendations require coordination between designers, manufacturers, marketers, and government policymakers to achieve positive changes in individuals' behavior [31]. Increasing the transfer of knowledge between stakeholders in compostable packaging supply chains could take place via a dedicated digital platform, which would provide a space for exchanging experiences, developing a network of contacts, and cooperation between individual entities in the compostable packaging value chain [32]. This platform would support the establishment of associations and partnerships between individual market participants and commercial information on the demand and supply of biological or secondary raw materials and the prices thereof.

One of the most critical potential directions for compostable packaging waste management development is designing packaging according to the principles of sustainable development, assuming cooperation throughout the value chain—from selecting the raw material, its sources of origin and eco-design, to technological processes of modification/functionalization and processing of the raw material, to a finished product with the assumed performance parameters, corresponding to various needs in the food sector [33,34]. It could remove barriers no. 2 and 3 identified in the research.

Moreover, to remove barrier no. 2, some proposals are interesting. It is worth developing educational initiatives to increase social awareness of proper compostable waste management, the use of waste, and rational nutritional management [35]. Results indicate that consumer awareness is crucial in compostable packaging supply chains, from making purchasing decisions to purchasing, using home composting plants, and adequate waste segregation. The critical decision variables that influence product purchasing decisions are positive beliefs about the impact of compostable packaging on the environment, a pro-ecological attitude, and product availability. One of the tasks of compostable packaging is to provide consumers with as much information as possible so as to make purchasing decisions and to promote lifestyle changes that lead to responsible consumption [36], which is one of the goals of sustainable development [8]. The role and market potential of retail chains in terms of influencing both suppliers and customers are essential. It is also vital to reduce ambiguities regarding compostable labels, which reduces skeptical attitudes toward purchasing a compostable product. Another possibility for improvement is the implementation of effective packaging labeling systems in terms of segregation, recycling, and the possibility of multiple uses—a system of labeling the way of handling packaging which is uniform and readable for consumers [37].

5. Conclusions

The main barriers and reasons for the low level of compostable packaging waste management were identified, and then potential directions for waste management development were proposed. Based on the empirical results, the main barriers for the low level of compostable packaging waste management development in Poland are: the lack of uniform and transparent regulations regarding the planning and organization of a closed-loop system for compostable packaging, insufficient communication between the private and public sectors on how to increase the use of compostable packaging, poorly developed infrastructure for compostable waste recycling, and a lack of financial incentives to support activities for the circular economy of composting packaging at the communal level. Referring to barriers and reasons identified, the main possible directions for compostable packaging waste management development in Poland were proposed.

The literature and research findings allow for the formulation of some interesting conclusions which could lead to practical implications.

Firstly, the awareness of ecological issues and sustainable practices certainly has an impact on compostable waste management level development. Hence, the implementation and development of training, information, and consumer education programs are one of the potential directions. However, raising the level of compostable packaging waste management not only depends on the actions of final consumers but also of different supply chain actors and their efficient cooperation. It is necessary, then, to work individually and systemically in compostable packaging supply chains. The actions undertaken across the regulatory sphere and supply chain from the government (e.g., waste management international, national, and regional regulations) to factories (e.g., increase of supply of compostable packaging, eco-labeling, greenwashing practices elimination) and retailers (e.g., compostable private label, educational initiatives) could impact consumer behavioral changes.

Secondly, operations could have a bottom-up (initiated by consumers, educational institutions, and NGOs) and bottom-down dimension (e.g., a regional or even national waste management system program). The latest technologies in recycling and processing compostable waste should be used. The possibilities of inventing new ones would be assured by subventions and close cooperation between public and private sectors and between companies.

Further, it is essential to implement the packaging eco-design to reinforce the effective labeling system in terms of segregation and recycling. These include improving information on the source of the packaging material, how the packaging waste is processed, and how to dispose of the packaging. These changes, however, will not be sufficient unless facilities for local compostable waste collection and processing are improved. To achieve this, the policies that focus on improving the current compostable waste infrastructure, e.g., potentially adapting existing food waste management streams to accommodate compostable plastics, are required.

This research has its limitation. While the above-mentioned findings are valuable, they only include a single national perspective. However, the comparison of parallel research studies from different countries is a matter for a future research paper by the author.

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