

MGR JAKUB BRZEZIŃSKI / ORCID: 0000-0001-5353-8777

UNIVERSITY OF LODZ, FACULTY OF MANAGEMENT, DEPARTMENT OF LOGISTICS

DR HAB. BARBARA OCICKA, PROF. SGH / ORCID: 0000-0003-4898-9594

SGH WARSAW SCHOOL OF ECONOMICS, COLLEGIUM OF BUSINESS ADMINISTRATION,

INSTITUTE OF CORPORATE FINANCE AND INVESTMENT, RISK MANAGEMENT UNIT

DR ANETA PLUTA-ZAREMBA / ORCID: 0000-0002-8869-9017

SGH WARSAW SCHOOL OF ECONOMICS, COLLEGIUM OF BUSINESS ADMINISTRATION, DEPARTMENT OF LOGISTICS

DR JOLANTA TUREK / ORCID: 0000-0002-4553-2815

SGH WARSAW SCHOOL OF ECONOMICS, COLLEGIUM OF BUSINESS ADMINISTRATION,

INSTITUTE OF CORPORATE FINANCE AND INVESTMENT, RISK MANAGEMENT UNIT

DR BEATA WIETESKA-ROSIAK / ORCID: 0000-0003-0353-2558

UNIVERSITY OF LODZ, FACULTY OF ECONOMICS AND SOCIOLOGY, DEPARTMENT OF INVESTMENT AND REAL ESTATE

POTENTIAL SOLUTIONS DEDICATED TO THE BIO-PACKAGING MARKET DEVELOPMENT IN POLAND – THE SIMBIO PROJECT RESEARCH FINDINGS

POTENCJALNE ROZWIĄZANIA DEDYKOWANE ROZWOJOWI RYNKU BIOOPAKOWAŃ W POLSCE
– WNIOSKI Z PRAC BADAWCZO-ROZWOJOWYCH W PROJEKCIE SIMBIO

ABSTRACT: The paper presents results and conclusions from the qualitative identification and assessment of potential solutions to the main problems, barriers and causes for hindering the development of the food bio-packaging supply chains. It also provides a spectrum of solutions by presenting selected social innovations from other countries. In this way, it inspires and expands the interest in transferring innovative solutions to Poland. The paper provides a well-defined scope for continuing research and development work on the rapid prototyping of potential solutions in the SIMBIO project. It opens up opportunities for the development of social innovations of different nature: product, process, technological and organizational. It also proves that an open approach to innovation development and implementation in bio-packaging supply chains is a key to identifying solutions that meet the market stakeholders' needs. The concept of research has application values, as it integrates stakeholders from private and public sectors in the pursuit of creating and implementing innovations. **JEL:** D22, Q35, Q01. **Acknowledgment:** This paper is an output of the science project "New Frontiers in Social Innovation Research: Social Innovation Management for Bioplastics", no. T-AP SI/SIMBIO/1/2020, financed by the National Centre for Research and Development (NCBR) in Poland, within the Trans-Atlantic Platform: Social Innovation Call programme.

Key words: bio-packaging, packaging, supply chain, circular economy, social innovation

STRESZCZENIE: W artykule przedstawiono wyniki i wnioski z jakościowej identyfikacji i oceny potencjalnych rozwiązań głównych problemów, barier oraz przyczyn utrudniających rozwój rynku bioopakowań do żywności w Polsce. Wskazano również szereg rozwiązań w formie innowacji społecznych zidentyfikowanych w innych krajach jako benchmark kierunków rozwoju innowacji na polskim rynku. Opracowanie stanowi opis prac badawczo-rozwojowych poprzedzających prototypowanie potencjalnych rozwiązań w projekcie SIMBIO. Otwiera możliwości rozwoju innowacji społecznych o różnym charakterze: produktowym, procesowym, technologicznym i organizacyjnym. Dowodzi również, że otwarte podejście do opracowywania i wdrażania innowacji w łańcuchach dostaw bioopakowań jest kluczowe dla identyfikacji rozwiązań odpowiadających potrzebom interesariuszy rynku. Wyniki badań mają wartość aplikacyjną, gdyż integrują one interesariuszy z sektorów prywatnego i publicznego w dążeniu do tworzenia i wdrażania innowacji.

Słowa kluczowe: bioopakowania, opakowania, łańcuch dostaw, GOZ, innowacje społeczne

INTRODUCTION: THE SCOPE OF THE SIMBIO PROJECT

The project *New Frontiers in Social Innovation Research: Social Innovation Management for BIOPlastics* (SIMBIO) has been implemented in Poland by the consortium of the SGH Warsaw School of Economics and the University of Lodz. The project is provided under a grant from the National Center for Research and Development and granted as a result of a competition procedure in the Trans-Atlantic Platform: Social Innovation Call. SIMBIO is an international project of global nature and scope. The Polish researchers team cooperates closely with scientists from foreign academic centers such as Coventry University from Great Britain, Federal University of São Carlos from Brazil and Simon Fraser University from Canada. The project is scheduled in Poland from 01/09/2020 to 31/08/2022. SIMBIO is a unique platform for stakeholders cooperation aiming at the development of the bio-packaging market and its applications in the food sector. The project's main goal is to develop social innovations to meet environmental and social challenges in the use of bio-packaging in food supply chains, taking into account product entire life cycle and the principles of the circular economy.

RESEARCH METHODOLOGY

The scope of the project covers four stages (Figure 1). The first stage of the SIMBIO project 'Defining challenges' was aimed at identifying key activators, drivers and barriers to the application and co-creation of packaging eco-innovations. It was also focused on bio-packaging supply chain management as well as the life cycle management of packaging produced

from bio-based and biodegradable polymers. To meet all these goals, extensive dialogue with the key stakeholders of food bio-packaging supply chains in Poland was carefully designed and conducted.

The second phase of the SIMBIO project 'Understanding problems' was focused on in-depth analysis and understanding of the main problems and barriers to the development of supply chains of food bio-packaging (including compostable packaging) in Poland.

The third stage of the project, implemented in the period from 01/07/2021 to 31/03/2022, was aimed at identifying potential solutions to meet the problems in managing the supply chains of bio-packaging (including compostable packaging) in accordance with the principles of circular economy in Poland. The starting point for the implementation of the third stage was a list of four problems and barriers to the development of the bio-packaging market in Poland and their causes. The list was prepared on the basis of information and data collected during the second stage of the project. Work began with identifying which of them are the most important from stakeholders perspective. For this purpose, a survey questionnaire was created and then sent to all participants of the SIMBIO project with a request to complete it, in accordance with the experience, observed challenges and market needs. Based on the survey results, the most important barriers and their causes for the development of the bio-packaging market, which were the main subject of discussion during the second workshop in the project, were identified. In parallel, other research tools were developed in the form of research questions

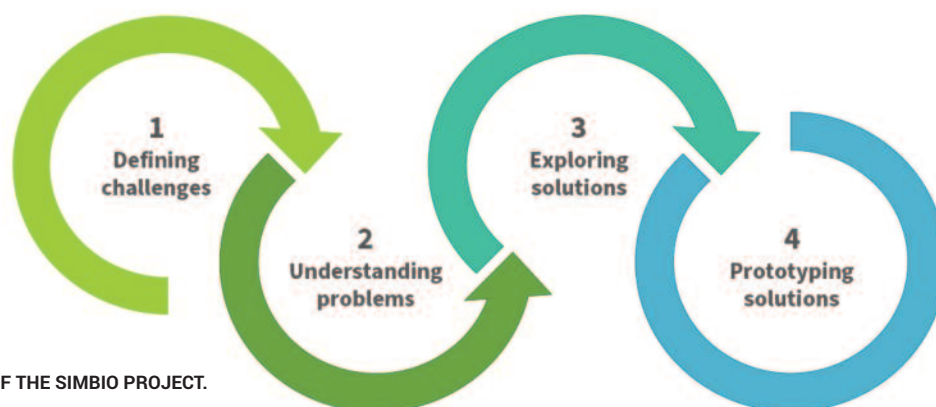


FIG. 1. FOUR STAGES OF THE SIMBIO PROJECT.

SOURCE: OWN ELABORATION.

and templates for collecting potential solutions, designed during the laboratory of cooperation on social innovations. In the next step stakeholders' representatives of the bio-packaging market were invited to participate in discussion panels organized during the 2 *Social Innovation Lab* workshop. The online panels were held on 28/01/2022 and 18/02/2022. An extended discussion was conducted in dialogue with 21 stakeholder representatives to identify concepts and innovations that are viable solutions enabling the management of supply chains of compostable packaging in accordance with the circular economy principles. Thanks to the assessment of new solutions, stakeholders selected social innovations with the greatest potential for rapid prototyping in the next stage of the SIMBIO project. As part of the third project's stage, team members conducted analyzes of the global market in search of innovative solutions used in the bio-packaging market. The stage ended with the preparation of the report and dissemination of the research results.

RESEARCH RESULTS:

SIMBIO PROJECT KEY FINDINGS

The main problems of the Polish bio-packaging market identified during the study are presented in Figure 2.

The key barrier to the first problem i.e., the insignificant share of bio-packaging, including compostable packaging, in the food packaging market in Poland, is the high price of bio-packaging in relation to the price of packaging made of plastics (table 1). The two main reasons for this barrier are (1) high prices of raw materials (3.5 times higher than the prices of conventional plastic raw materials), low availability of imported and domestic raw materials to produce bio-packaging, and high logistics costs related to the import of raw materials; (2) low demand for bio-packaging (resulting from low environmental awareness of consumers and difficulties in identifying such packaging). During the discussion, a set of solutions aimed at eliminating the two main causes of this barrier was developed. The most urgent solution identified during the panel was an increase in the number of production plants (producing bioplastics) in Poland and an improvement in their cooperation with research and development organizations. On the supply side, in the long run, this could have an impact on reducing the price

of bioplastics by increasing the availability of domestic biopolymers for the production of packaging and reducing logistics costs related to the partial abandonment of their import. The solution could also lead to an increase in the production scale of bio-packaging but is found difficult to implement. The second solution proposed during the panel was to improve cooperation between supply chain stakeholders, including cooperation between manufacturers. It is worth emphasizing that, the respondents perceive this solution as difficult to achieve due to the reluctance to share information, know-how and low propensity to cooperation in a highly competitive, niche, early stage of market development.

The decisive barrier to the second problem, which is the low awareness and willingness of consumers to buy food products in bio-packaging, is the insufficient level of consumer knowledge about bio-packaging (including compostable ones) in a circular economy. The key causes of the barrier are the following two (1) the lack of consumer awareness of the importance of the packaging problem, accompanied by the lack of education (e.g. in schools, social media), information campaigns on bio-packaging (including compostable packaging), and the shortage of mobile applications supporting the dissemination of knowledge and waste segregation; (2) the lack of clear information on the packaging about its compostability. An urgent and important solution indicated by the participants is the inclusion of uniform information on the packaging on its compostability. Clear and visually legible information can perform two functions. On the one hand, it supports the consumer in choosing compostable packaging. On the other hand, it provides the consumer with information on how to manage the packaging when it becomes a waste. The labeling should take into account the possibilities and competencies of all consumers. The supporting activity is broadly understood education of children and youth, as well as adults and the elderly. For this purpose, innovative teaching methods can be applied, such as lectures with experiments, educational games, mobile applications, educational films, or additional waste management classes. It is important to undertake the education of all stakeholders in order to achieve the best



FIG. 2. THE MAIN PROBLEMS OF THE BIO-PACKAGING MARKET IDENTIFIED IN THE SIMBIO PROJECT.

SOURCE: OWN ELABORATION.

possible results regarding appropriate waste management, including compostable packaging.

The third problem is an insufficient social and environmental enterprise responsibility in packaging supply chains for a circular economy. It is determined by one main barrier described as insufficient cooperation between enterprises for the circular economy in the field of, inter alia, design and development of bio-packaging, including compostable food packaging. In fact, there is one fundamental reason inducing the above-mentioned barrier - a lack of cooperation between enterprises in the field of acquiring and sharing knowledge about bio-packaging and circular economy; a lack of joint R&D initiatives for bio-packaging resulting in difficulties in achieving economies of scale; lack of joint efforts to simplify and harmonize bio-packaging specifications; insufficient cooperation towards a single European standard; lack of interdisciplinary cooperation within enterprises. Workshop participants indicated three urgent solutions aimed at minimizing the above-mentioned limitations. The first one is designing a strategy for the empowerment of investments and entrepreneurship in the biopackaging market (including compostable packaging). The creation and implementation of a strategy defining goals, directions and pro-development assumptions would provide

stable conditions for the progress of both entrepreneurship and innovation, as well as the cooperation in the supply chains of bio-packaging in accordance with the principles of the circular economy. Developing a strategy would be the basis for creating management instruments and tools, e.g. road maps and decision trees, for market participants who wish to develop their activities in the desired strategic directions. The second solution is the identification of leaders with the potential to initiate and foster the cooperation and with the ability to integrate stakeholders within the supply chain. This solution is aimed at using the leading position of selected links in the food packaging supply chains, the involvement of which can act as a catalyst for changes in the relationships of the bio-packaging market participants. Stakeholder representatives indicated large retail chains as potential leaders due to the scale of their operations, and their ability to influence many food and packaging producers, as well as their bargaining power in trade relations, that can effectively stimulate the development of the bio-packaging market offer, including compostable packaging, in the circular economy. The stakeholders' representatives also considered building an education system in the field of social and environmental responsibility, taking into account the principles of circular economy, not only end products but also their packaging, to be a very urgent, third, solution to implement.



CLEAR AND VISUALLY LEGIBLE INFORMATION CAN PERFORM TWO FUNCTIONS. ON THE ONE HAND, IT SUPPORTS THE CONSUMER IN CHOOSING COMPOSTABLE PACKAGING. ON THE OTHER HAND, IT PROVIDES THE CONSUMER WITH INFORMATION ON HOW TO MANAGE THE PACKAGING WHEN IT BECOMES A WASTE.

The fourth problem is the low level of development of compostable packaging waste management. The key barrier shaping this problem is the lack of uniform and transparent regulations regarding the planning and organization of closed-loop compostable packaging. It results from (1) legal regulations that are inadequate and insufficient for the market, often also inconsistent, and above all (especially in recent years) changing many times, and (2) the limited awareness of the implementation of the circular economy principles. One of the two most urgent solutions indicated by the stakeholders is the creation of a strategy for the development of the compostable packaging market (along with operational documents) as an important element of the bioeconomy development. The strategy would define the legal, financial and economic conditions in relation to the education, regulation and innovation pillars. The second urgent solution is the creation of an industry organisation for bioplastics (obtained from bio-based renewable raw materials) processors (and/or producers of compostable packaging). The organisation would play an important role in integrating internal and external stakeholders in the bio-packaging supply chains and leading regulatory lobbying activities. It would be a platform for dialogue and knowledge exchange, extensive consumer education, as well as joint initiatives, including research and development projects.

DISCUSSION: POTENTIAL SOLUTIONS FOR DEVELOPING THE BIO-PACKAGING MARKET

The in-depth discussion with the stakeholder representatives revealed the multitude and diversity of potential solutions in the perspective of the strategic direction of the bio-based and biodegradable packaging market development in Poland. A strategic perspective is a foundation for designing solutions dedicated to particular problems, barriers and causes in private and public spheres. The nature of solutions and the expected importance of their impact determine the need for their co-creation by different stakeholders cooperating in various forms, e.g.: platforms or industry organisations. Considering the clear need for collaborative social innovation development in the strategic perspective to solve the most serious problems and barriers in Poland, we would like to suggest good practices observed on foreign markets based on the two key pillars, which are strategy and multi-stakeholder collaboration.

As a first example of the solution coming from foreign markets and worth following, we would like to present the strategic approach to the development of bioeconomy sectors in the United Kingdom. The UK has three complementary national development policy strategies, i.e.: *Growing the Bioeconomy*, *Improving lives and strengthening our economy: A national bioeconomy strategy to 2030*, an environmental plan *A Green Future: Our 25 Year Plan to Improve the Environment* and a strategy for bio-based packaging *Our Waste: Our Resources. A Strategy for England*. The bioeconomy development strategy articulates a collaborative approach between government, industry and the scientific community, particularly in biology and biotechnology, to transform the UK economy into a sustainable bioeconomy that does not depend on non-renewable resources. The strategy outlines a vision that by 2030, the UK will be a global leader in the development, production, use and export of bio-based solutions, encouraging investment and business, supporting innovation and economic growth [3]. In the same context, but more precisely focused on the compostable packaging market, it is worth pointing out the *National Compostable Packaging Strategy* in Australia. The strategy stresses the need to educate households on the proper segregation of compostable packaging and to educate

TABLE 1. MAIN SOLUTIONS TO PROBLEMS, BARRIERS AND THEIR CAUSES.

SOURCE: OWN ELABORATION.

Problems I-IV	Main barriers	Causes of the barriers	Main solutions
Problem I: Insignificant share of bio-packaging, including compostable packaging, in the food packaging market in Poland	The high price for bio-packaging in relation to the price of packaging made of plastics.	High prices of raw materials (3.5 times higher than the prices of conventional plastic raw materials), low availability of imported and domestic raw materials to produce bio-packaging and high logistics costs related to the import of raw materials. Low demand for bio-packaging (resulting from low environmental awareness of consumers and difficulties in identifying such packaging).	<ul style="list-style-type: none"> An increase in the number of production plants (producing bioplastics) in Poland and an improvement in their cooperation with research and development organisations. An improvement of cooperation between supply chain stakeholders.
Problem II: The low awareness and willingness of consumers to buy food products in bio-packaging.	The insufficient level of consumer knowledge about bio-packaging (including compostable ones) in a circular economy.	The lack of consumer awareness of the importance of the packaging problem, the lack of education (e. g. in schools, social media), information campaigns on bio-packaging (including compostable packaging), and the shortage of mobile applications supporting the dissemination of knowledge and waste segregation. The lack of clear information on the packaging about its compostability. The participants of the discussion panel jointly proposed potential solutions to eliminate the key causes of the barrier.	<ul style="list-style-type: none"> Simple and visually clear information on the packaging about its compostability as a source of education for the consumer (1) at the time of purchase (2) on how to manage packaging that is already a waste. Incorporating information on compostable packaging into existing waste management applications or creating new mobile applications. Education with the use of innovative teaching methods and additional educational classes on waste management (including packaging).
Problem III: Insufficient social and environmental enterprise responsibility in packaging supply chains for a circular economy	Insufficient cooperation between enterprises for the circular economy in the field of, inter alia, design and development of bio-packaging, including compostable food packaging	Lack of cooperation between enterprises in the field of acquiring and gathering knowledge about bio-packaging and circular economy; no joint R&D works for bio-packaging, no economies of scale; lack of joint efforts to simplify and harmonize bio-packaging specifications; insufficient cooperation towards a single European standard; lack of interdisciplinary cooperation within enterprises.	<ul style="list-style-type: none"> Development of a national strategy for the empowerment of investments and entrepreneurship in the bio-packaging market (including the compostable packaging sector), including financial and regulatory stimuli. Use of the position and potential of selected internal stakeholders of food supply chains (especially retail chains) as leaders catalysing changes / driving changes on the packaging market. Education in the field of social and environmental responsibility provided by various and targeted at various stakeholders.
Problem IV: The low level of development of compostable packaging waste management	The lack of uniform and transparent regulations regarding the planning and organization of closed-loop compostable packaging	The legal regulations that are inadequate and insufficient for the market, often also inconsistent, and above all (especially in recent years) changing legal regulations The limited awareness of the implementation of the circular economy idea.	<ul style="list-style-type: none"> Creation of a development strategy for the compostable packaging market with operational documents. Establishing an association of bioplastics processors (and / or producers of compostable packaging) obtained from biodegradable renewable raw materials

consumers about the differences between biodegradable and compostable packaging. It is proposed to include information on desirable segregation of waste, including compostable packaging, in educational programs at the local level, as well as educational activities carried out by waste recipients in their operations. A good practice could be to educate children and youth indirectly, i.e.: through the choice of food bio-packaging used for school purposes. The development and implementation of similar strategies in Poland is possible but requires the commitment and involvement of external and internal stakeholders of bio-packaging supply chains representing both public and private spheres.

Stakeholders unite around various initiatives and collaborate to transform packaging supply chains. On the global stage, there are several examples that can be given to illustrate the scope of their collaboration. *The Plastics Pact Network* [2] is a global initiative where companies share responsibility for transforming their supply chain management in light of sustainable development requirements. On the one hand, it is worth noting the broad spectrum of the network's activities aimed at fulfilling the circular economy principles. On the other hand, it is worth noting the relatively limited attention has been given so far by its members to larger-scale research, development and implementation activities related to the use of compostable packaging. The global reach of the *Plastics Pact Network*, which influences and shapes the development trends of supply chains, provides an opportunity to see the leading role of companies (network members) in the growth of corporate social and environmental responsibility. This opportunity has also been opened in Poland by companies cooperating in the *Polish Plastics Pact*, striving for "a unique, multi-stakeholder partnership to implement systemic changes towards a closed-loop" [6]. The next interesting initiative to strengthen the bio-packaging market is the Austrian supply chain platform *Plattform Verpackung mit Zukunft*, which integrates all groups of actors in the packaging supply chain, including bio-packaging: from raw material suppliers and producers to recyclers. Its overarching goal is to rationally manage packaging and seek the best solutions (for companies, consumers and the environment) based on the cooperation of all stakeholders [7].

An interesting initiative to support entrepreneurship in the compostable sector is the UK *Synthetic Biology for Growth Programme*. It consists of the creation of 6 centers of excellence in the UK and a GBP 10 million equity fund (*Rainbow Seed Fund*). Support is provided to start-ups in the field of synthetic biology, including the development of new biodegradable materials [4]. Another example is the cooperation of waste treatment plants within the Swiss Association of Waste Management Plant Operators (*L'association suisse des exploitants d'installations de traitement des déchets, ASED*). Approx. 6% of the affiliated organizations are involved in waste composting. The entity is committed to sustainable, responsible, ecological and professional waste management. It supports R&D initiatives for the development of the market for compostable waste [1]. Another example is the Italian composting association (*Consorzio Italiano Compostatori*) which deals with issues related to composting and biogas production and has introduced, among others, an optional label to ensure compost quality (*CIC Quality Compost Label*) or the *Circular Economy Network* operating in Italy [2]. In Poland, there is a lack of stakeholder collaboration focused on bio-packaging waste management, in particular for closing the life cycle through organic recycling (composting). A necessary condition for its initiation and application is to increase the scale of the compostable packaging market and the emergence of the need to coordinate activities in waste management in line with the circular economy principles.

CONCLUSIONS:

SIGNIFICANCE OF SOCIAL INNOVATIONS FOR THE POLISH BIO-PACKAGING MARKET

The SIMBIO research project is a unique study involving groups of key external and internal stakeholders of bio-packaging supply chains in the research process. The initially designed potential solutions are dedicated to specific problems, barriers and their causes of the Polish bio-packaging market. First, the research results revealed that collaborative innovation development is crucial to bio-packaging supply chain management in line with the circular economy principles. There is sufficient potential in Poland, to co-create social innovations

of different nature: product, process, technological and organizational. Second, the social innovation implementation also requires in-depth cooperation of stakeholders. Their collaboration is very important for the systemic transformation of the Polish bio-packaging market towards circularity. Third, collaborative social innovations in our country can be developed in a strategic perspective using good practices from foreign markets. However, they should be adjusted to the needs of domestic stakeholders and the possibilities of the Polish market. The SIMBIO research team takes into consideration the specificity of the domestic market while prototyping selected social innovations in the fourth stage of the project. The following three priority solutions were developed:

- (1) national strategy of the compostable market development,
- (2) industry organization and
- (3) digital B2B multi-sided platform.

Each of the solutions is subject to rapid prototyping in cooperation with the stakeholders of bio-packaging supply chains. The development process is limited to prototyping main assumptions of innovations, without implementation projects.

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