BIO-PLASTICS EUROPE POLICY BRIEF: BIO-BASED AND BIODEGRADABLE MATERIALS

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About BIO-PLASTICS EUROPE

BIO-PLASTICS EUROPE is a research and innovation project, funded by the European Commission Horizon 2020 Framework Programme under Grant Agreement N° 860407. The project aims to deliver sustainable strategies and solutions for bio-based plastics to support the EU-Plastic Strategy and a circular economy, by considering biodegradability features. Therefore, the project also intends to offer support to public interventions. By considering the complex and dynamic processes of societal transformation, which have been triggered by a new awareness of the use of bio-based plastics, the project seizes upon opportunities that emerge from a grounded and participatory research and innovation process.

The vision is to develop and implement sustainability-based solutions for bio-based biodegradable plastic production, by turning knowledge into practice through technical, policy and business-model innovations. This includes innovative product design, health and safety standards, end-of-life solutions and life cycle assessment of the environmental and economic impacts of bio-based plastic products. Furthermore, the project is developing business models for efficient reuse and recycling, ensuring the safety of recycled materials for the environment and within society.

One way to accomplish this vision is to explore and gather insights regarding the frameworks, mechanisms and business models required for the social and business expectations of bio-based and biodegradable plastics. To ensure that the BIO-PLASTICS EUROPE journey is successful, it is vital to integrate the viewpoints of different experts, actors, and stakeholders from across value chain. This initiative contributed to achieving the goal and support the definition of policy recommendations.

1. Scope of the document

This policy brief document aims to provide efficient feedback into policymaking in research, innovation and technology, in particular in the EU Plastics strategy.

Policy and Governance suggestions are derived from the results obtained during the implementation of activities within the EU Horizon 2020 funded project "BIO-PLASTICS EUROPE". This project commenced in October 2019 and ended in January 2024. The project consisted of nine Work Packages, out of which, one Work Package primarily contributed to relevant EU policies, such as understanding of the fate of biodegradable plastics in the environment.

The project focused on **bio-based and biodegradable plastics**, a kind of material that is (partly) produced from renewable organic material derived from plants or animals (e.g., corn, sugarcane, cellulose, shrimp shells) and that is biodegradable.

2. Summary of BIO-PLASTICS EUROPE activities related to policy recommendations

Within this project, a mapping exercise over the policy landscape has been conducted with the aim of obtaining an understanding of possible gaps. Additionally, a macro-analysis has been conducted in terms of establishing a base to further expand policy suggestions upon.

Laboratory and field tests have been conducted on materials for specific applications, with the aim to test performance features, and to improve biodegradability, as well as to assess ecotoxicity. Furthermore, a map analysis was conducted to establish an understanding of when it is suitable or BIO-PLASTICS EUROPE, to use biodegradable and compostable plastics. Finally, thanks to stakeholder consultation, replicable strategies were identified to overcome the obstacles hindering the deployment of the entire bio-plastics system.

2.1 Overview of applications in scope

Within the scope of this project, five compounds for several applications have been assessed. These applications have different intended end-of-life scenarios, all of which have been considered.

The following applications have been assessed:

- Agricultural mulch film and marine geomaterial
- Rigid and soft packaging
- Multiple use cutlery
- Toys
- Fishing baits and fish crates

Figure 1. Overview of applications in scope. Source: BIO-PLASTICS EUROPE, 2023b

2.2 Laboratory and field tests

Both laboratory and field tests have been conducted across two rounds of tests. The first round consisted of an extensive screening of material features, while in the second round a specific selection of tests was carried out based on the focused properties to investigate.

Results obtained from the first round were used by material producers to refine formulations and development targets. This resulted in the production of a second generation of five innovative bio-based plastics with different above-mentioned applications. A detailed list of target applications, directly linked with requested material properties, was produced. This was used to plan a more targeted second round of testing activities which aimed to evaluate the capability of the improved bio-based compounds to be suitable for the envisaged target applications.

The tests included proper evaluation of material properties for end-user application, degradability under controlled and natural environmental conditions, biodegradability in aerobic and anaerobic conditions, the mechanical recyclability

and ecotoxicity assessment. The results can be used as a support to investigate the suitability of the bio-based plastics for the envisaged intended use.

2.3 Policy and stakeholder engagement activities

To obtain an overall picture of the current situation related to bio-based and biodegradable plastics, a PESTEL[1] analysis was conducted. Based upon the results of the PESTEL analysis, a desk study and stakeholder consultations through interviews were conducted with the aim to assess the suitability of biodegradability in conjunction with the specific applications. The stakeholders involved were mainly producers, European association members, waste managers, researchers, and policy makers. The desk research and stakeholder engagement activities showed that both policy gaps as well as the most promising applications are mainly related to three key product types:

1) Packaging
2) Mulch Film
3) Recreational Fishing baits/lures and fishing crates.

Moreover, the best replicable strategies to support the deployment of the entire system for bio-biobased plastics from a circular economy perspective were identified. Aspects related to improved education and communication to end-users/consumers in terms of choosing bio-based, biodegradable, and compostable plastic products were also highlighted to be of great importance.

Since the identification of strategies cannot be based solely on theoretical frameworks, a stakeholder consultation process was integrated into the methodology. An inclusive approach was followed, involving various stakeholder with diverse knowledge and experience.

[1] It examines the Political, Economic, Social, Technological, Environmental, and Legal factors in the external environment.

3 Key critical issues

As part of the selection process of replicable strategies, it was essential to identify the most critical issues that may hinder the deployment of the whole bio-plastics system: 9 key critical issues were identified Figure 2 shows that these 9 key critical issues span over 5 different areas: Political and Legal, Economical, Technological, Environmental and Social.

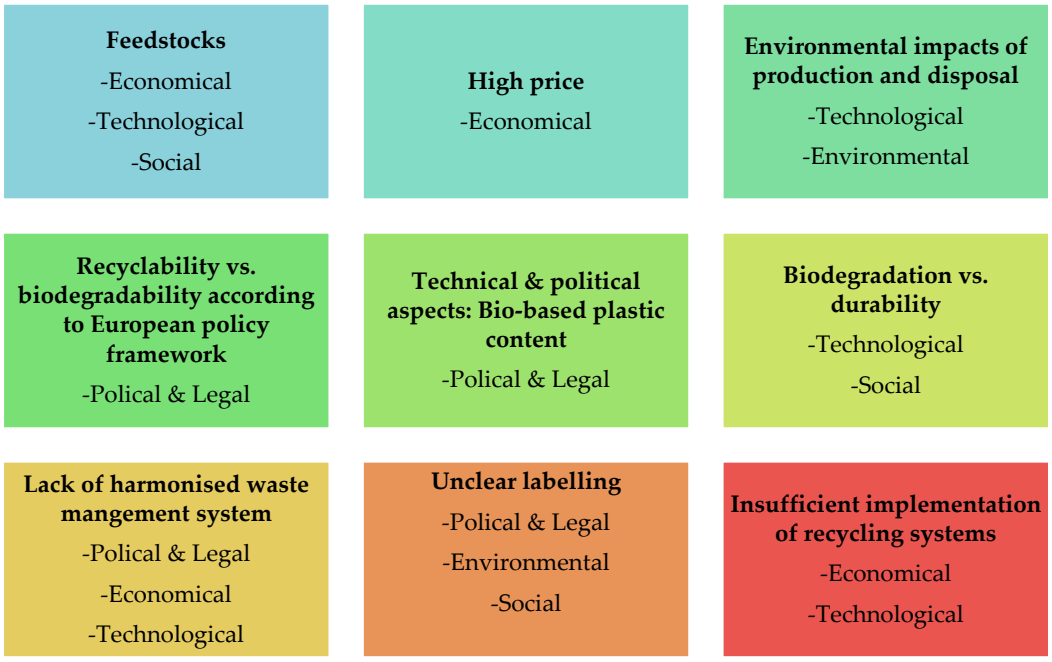

Figure 2. Summary of 9 key critical issues. Source: BIO-PLASTICS EUROPE, 2023c

3.1 Feedstocks

Today, bio-based and biodegradable plastics originate mainly from food crops. This creates competition for agricultural land relating to food products. Thus, it makes producers highly dependent on world market prices for these crops. Finding alternatives for the use of second and third generation feedstocks[2] are currently at a research and development level. Avoiding the use of food crops, it is recommended to provide support for research on the use of second- and third generation of feedstocks. These technical aspects are not fully developed yet.

[2] Second generation feedstocks: lignocellulosic gained from non-food crops or as by-products from the cultivation of food crops. Third generation feedstocks: feedstock extracted from a range of substrates like whey, industrial and municipal waste or algae.

3.2 High price

The EU Bioeconomy strategy is part of European Union's Green deal. It contains an action plan that relates to develop substitutes for fossil-based materials that are bio-based, recyclable, and marine European Commission, 2020). Today, however, production costs for conventional plastics are much lower than bio-based and biodegradable plastics. Due to fluctuation of market prices for raw materials and associated high costs of plastics, pricing policies for raw materials have been identified as one of the key issues to further investigate. The results from this project can provide valuable input to the EU Bioeconomy strategy by providing knowledge on how bio-based plastics behave in the environment.

3.3 Environmental impacts of production and disposal

Production of bio-based plastics can reduce the use of fossil resources, but it requires extensive use of fertilizers and pesticides that in turn, may cause negative effects such as soil acidification and eutrophication of water courses.

Further, disposal from bio-based and biodegradable plastics may just as conventional, fossil-based plastics release harmful accompanying additives, metabolite compounds and microplastics that are taken up by organisms in the environment. Little is known about the ecotoxicity of biobased and biodegradable plastics and microplastics. Ecotoxicity tests were conducted within this project, which yielded adequate results in some cases but identified adverse effects in some cases. This highlights the importance to investigate the ecotoxicity of new materials thoroughly and carefully before they are introduced to the market with an overall aim to eliminate risks of hazardous impacts on organisms living in areas affected by plastic or microplastic pollution. To address this, we recommend targeting more dedicated research in this field.

3.4 Recyclability vs biodegradability according to EU policy framework

The European policy framework on bio-based, biodegradable, and compostable plastics was launched during November 2022 (European Commission, 2022a). The framework aims to harmonise sourcing, labelling and use of bio-based biodegradable plastics, thus reduce the overall environmental impact of plastic products. The framework is promoting recyclable plastics, rather than biodegradable plastics.

We recommend policymakers to consider the results from the BIO-PLASTICS EUROPE project, in terms of broader issues related to bio-based, biodegradable and traditional plastics, for instance when the Single-use plastic Directive (SUP) (European Parliament, 2019a) will be assessed in the near future.

3.5 Bio-based plastic content: technical and political aspects

This is an important aspect in terms of avoiding greenwashing and misleading Another recommendation is to implement a policy which provides obligations for producers to disclose the exact amount of bio-based materials in their product. This is an important aspect in terms of avoiding greenwashing and misleading consumers. The research results from this project can provide essential input to the development of the European Strategy for Plastics in a Circular Economy (European Commission, 2022b).

The EU plastic packaging and packing waste directive (European Parliament, 1994) presents every fourth year an impact report, the latest one originates from 2022. The plastic packaging and packing waste directive has been proposed to be amended (European Parliament, 2022). It contains stricter requirements in terms of clarification of biodegradability and compostability aspects. We recommend policymakers to focus on establishing a regulatory framework for plastics with biodegradable properties.

3.6 Biodegradation vs. durability

An important identified technical challenge is related to the deployment of bio-based and biodegradable plastics in terms of finding a good balance between material performance and sustainability aspects. For instance, considering environmental impact and waste management. Durability is one of the main characteristics of conventional plastic; good shelf-life and durability are necessary features to guarantee the quality of the final product.

The EU policy framework on biobased, biodegradable, and compostable plastics (European Commission, 2022a) does not contain any legally binding agreements which apply for biobased, biodegradable, and compostable plastics. Hence, there is a lack of sustainability criteria which can be applied to bio-based plastics. Currently, there is no general standard for marine biodegradation.

The chemical legislation, Fertilising Products Regulation (European Parliament, 2019b) has been found as relevant for the research results related to mulch films. By July 2024, there will be a biodegradability review within this legislation. We recommend policymakers to examine the possibilities of incorporating biodegradability criteria of mulch films into component material category 9 in Part II of Annex II.

3.7 Lack of harmonized waste management system

The current different waste management infrastructures that are being used across the European Union create confusion regarding the disposal of bio-based and biodegradable plastics. Several countries lack separation possibilities through the collection systems, sorting facilities for recovery of bio-based and biodegradable fractions and possibilities for industrial composting. To address this policy gap, we recommend to further improve the harmonization of these systems across Europe, as it can support the collection, sorting and recycling of the materials.

3.8 Unclear labelling

The current European recycling codes do not provide an adequate product labelling of bio-based and biodegradable plastics products. Based upon the results of this research we highly recommend policymakers to implement a legislation for clear product labelling which indicates the type of material, and the correct end-of-life disposal. This is necessary to help consumers to clearly distinguish bio-based and biodegradable materials from each other, as well as from fossil-based materials. The proposed EU legislation on the packaging and packaging waste directive, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, includes a component related to harmonized labelling of products and waste receptables (European Parliament, 2022). If the proposed amended legislation becomes implemented, it could contribute to resolving the critical issue of unclear labelling, thus facilitating consumers sorting of plastics.

3.9 Insufficient implementation of recycling systems

Previous studies have shown that mechanical recycling is one of the best alternatives for bio-based and biodegradable materials such as PLA[3], allowing the possibility of reusing materials. Tests carried out in Bioplastics Europe project also demonstrated the recyclability potential of PLA-based material. However, this type of recycling is rarely used. Bio-based and biodegradable plastics are sensitive to structural and thermal degradation resulting in decreased performance of recycled products. Thus, a conventional plastic recycling plant is not a feasible option for this type of plastics. To address this implementation gap, we highly recommend policymakers to further examine how a recycling system for bio-based and biodegradable plastics could be implemented across the European Union, given its relatively small market size.

4 Main outcomes from the BIO-PLASTICS EUROPE project

4.1 Findings obtained from laboratory and field tests

FINDING 1: The test design implemented in the project has demonstrated the great importance of following a circular process and a continuous exchange of information between producers and researchers. This enables refinement of the material formulation and improvement of the bio-based and biodegradable compounds to make them suitable for the intended applications.

FINDING 2: As previously mentioned, one of the main issues relates to finding a good balance between material performance and the environmental impact: a good shelf-life and durability are necessary features to guarantee the quality of the final product.

FINDING 3: The second round of field and laboratory tests have demonstrated the improvement of the modified material in respect to durability and resistance to degradation during the usage. However, some challenges remain, especially regarding degradation under natural conditions and ecotoxicity in certain cases.

FINDING 4: Bio-based and biodegradable materials tested in this project degrade slowly in natural settings. The materials exposed to sea water showed minimal or no degradation over a 12-month period. This highlights the importance of

[3] PLA is an acronym for Polylactic Acid.

preventing even biodegradable plastics from becoming marine litter and a source of pollution.

FINDING 5: Biodegradation in controlled composting conditions exhibits significant variability and depends on several factors such as nature of the material, additives used, and the final product use. Another important factor is the size of the material. Smaller particles degrade in the environment faster than larger ones. Efficient compostability of materials requires precise regulation of humidify, pH and temperature controlling the right composting environment.

FINDING 6: Another key result is that PLA-based, PBS[4]-based as well as PHBV[5]-based materials can trigger ecotoxic effects. These effects include reduced growth in marine algae and mortality. In addition, possible endocrine effects on the reproductive ability of limnic invertebrate plankton as well as inhibited shoot and root growth of plants can occur. The field and laboratory test also indicated a decreased reproductive ability in earthworms. The severity of these effects varies, thus occasionally only observed at high concentrations. In some cases, these toxic effects were linked to specific additives. Therefore, it is crucial to impose a strict control of additives used, along with further research into their leaching behavior and toxicity.

4.2 Findings obtained jointly with BIO-PLASTICS EUROPE project's stakeholders

FINDING 1: Suitability of biodegradability in different applications

Findings based on the desk review and stakeholder consultations conducted in BIOPLASTICS EUROPE project indicated for which application bio-based and biodegradable materials are suitable. Table 1 illustrates which applications have been identified to have a clear added value, if biodegradable material is used, and which applications do not have a clear added value.

[4] PSB is an acronym for Polybutylene succinate.
[5] PHBV is an acronym for 3-hydroxybutyrate-co-3-hydroxyvalerate.

Table 1: Short summary of suitability assessment

Application	Added value of biodegradable material use
Mulch film	Yes. During the use phase, may reduce associated labour and resource costs by avoiding removal from the field
Rigid packaging for cosmetics	Not clear. The application does not contain food or organic waste, cosmetic residues could harm the composting process.
Rigid and Soft packaging for food stuff	Yes, in cases where the food stuff being contained leaves an organic residue, could be collected with organic waste fraction destined for organic recycling.
Cutlery	Yes, multiple-use compostable cutlery can be collected with food waste for organic recycling.
Beach toys	Not clear. Beach toys should not be abandoned in aquatic environments, even though biodegradable materials have less impact on the environment.
Fishing gear	Yes, biodegradable plastic can reduce the environmental impact of lost fishing gear as the material degrades faster compared to conventional plastic.
Fishing crates	Not clear. They can be recycled in current recycling infrastructure, the reusable products would be more suitable to be produced from bio-based and/or conventional plastics to ensure durability.
Aquatic geomembrane	Yes. It can be left in the aquatic environment to degrade, eliminating the need to remove it.

Source: BIO-PLASTICS EUROPE, 2023b

FINDING 2: The process to identify the replicable strategies for the deployment of the whole bio-plastic system included activities of stakeholder engagement involving people from different sectors across the entire value chain. This was a good opportunity to find proper and concrete strategies and to overcome critical issues and threats.

The following main replicable strategies have been identified:

- Implementing policies that encourage the use of bio-plastic materials for suitable applications, reducing fossil resources and environmental impacts.

- Prioritizing research and development of target applications to overcome technical issues and high price.
- Promoting normative harmonization at national and European level, that can enhance consumer confidence, support proper waste management, and foster market growth.
- Prioritizing the development of clear guidelines and standards for bio-plastic material to avoid producer and consumer confusion.
- Investing in waste management technologies (as bio-based plastic recycling and composting), to overcome the lack of infrastructures for bio-plastic waste management and create efficient disposal systems.
- Establishing of technical working groups involving municipality, producers, marketing experts, and waste managers to facilitate the sharing of knowledge, resources, and dialogue.
- Increasing the consumer awareness also implementing training activities at various levels.
- Using simple tools to make clearer the communication about bio-based and biodegradable plastic materials and their end-of-life scenarios.

5. Policy recommendations

The outcome of this project is of great importance for policymakers, as it contributes with evidence on understanding of the fate of biodegradable plastics in the environment.

One of the main building blocks of the EU Green Deal is the EU Circular Economy Action Plan (European Commission, 2023). The research results from the BIO-PLASTICS EUROPE project can provide valuable input to the policy framework on use of bio-based, biodegradable and compostable plastics.

Multiple current EU policies and evidence reports are related to the key findings from the BIO-PLASTICS EUROPE project. The most relevant policies and reports have been identified and are discussed in this policy brief. For instance, the Fertilising Products Regulation, the EU plastic packaging and packing waste directive, the Bioeconomy strategy and the EU Circular Economy Action Plan.

In terms of broader issues that relate to traditional plastics, the Single-use plastic Directive (SUP) (European Parliament, 2019a) is pertinent for the research results from the BIO-PLASTICS EUROPE project. The overall aim is to promote a circular economy transition that includes innovative and sustainable business models, products, and materials. This directive will be evaluated and reviewed during July 2027. It will include an assessment of scientific and technical progress relating to imposing criteria or standards from biodegradability in the marine environment.

We recommend policymakers to include the results from the BIO-PLASTICS EUROPE project, as it can provide valuable input to the development of a clear regulatory framework for bio-based plastics that includes biodegradable properties.

The recommendations are:

- Importance of enhanced education and communication to end-users/consumers on benefits of choosing bio-based, biodegradable and compostable plastic products and how to better dispose them.

- Promote further research on the entire bio-based material value-chain system, from production to disposal, with the aim to overcome both technical and economic issues that are still in place.

- Relevant and sensitive toxicity and ecotoxicity tests, for human as well as environmental risk assessment, should be included for bio-based and biodegradable materials. Particularly, for any additives and combinations of additives which are used in the production of both bio-based and biodegradable plastics.

- An overall recommendation targeting the plastic industry companies in terms of their work on improving materials, is that they should include specific tests. For instance, degradation tests, and also rapid degradation test of the material. Investigate how the material properties change both during degradation in waste plants, as well as in the environment.

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