BIO-BASED AND BIODEGRADABLE POLYMERS FOR FOOD CONTACT: A CHEMICAL APPROACH TO INVESTIGATE THEIR SAFETY

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INTRODUCTION

Plastic packaging are present in our daily lives because they make it more convenient by facilitating the distribution and delivery of products to the marketplace. However, plastics have some disadvantages, such as their use generates large amounts of waste because of their non-degradable nature causing an adverse impact for human health and the environment [1]. The replacement of conventional plastics by sustainable materials is a priority of the European Union [2].

Bio-based polymers derived from renewable biological resources and biodegradable polymers that will easily disintegrate and biodegrade in the environment, are being developed and promoted as an alternative to conventional petroleum-based non-biodegradable plastics to be utilized in food packaging. Some of the most common bio-based and biodegradable polymers are those based on polylactic acid (PLA), polyhydroxyalkanoates (PHA), polybutylene succinate (PBS), and so on. However, these materials generally do not perform as well as conventional plastics and require additional chemicals such as plasticizers, antioxidants, light and UV stabilizers, release agents, crosslinking agents, etc. Alternatively, the polymers are blended together or copolymerized to obtain materials with improved properties [3]. Therefore, these polymers, like other food contact materials, can release low molecular weight components to food and pose a health risk to consumers. The chemical safety of these sustainable materials has been scarcely studied.

In the framework of MIGRABIOQUANT project, funded by the Spanish National Research Agency, an analytical methodology to identify potential migrants in bio-based and/or biodegradable materials is being developed.

OBJECTIVE

How safe are bio-based and/or biodegradable plastics for food contact applications?
Do they contain unexpected hazardous chemicals?

RISK ASSESSMENT

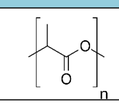
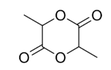
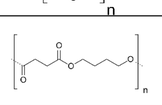
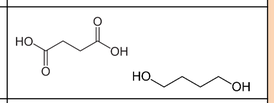
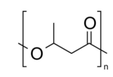
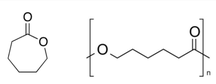
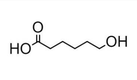
This project intends to provide a better scientific knowledge for the safety assessment of bio-based and/or biodegradable plastic materials for food contact, establishing an analytical methodology for the study of their chemical composition, the evaluation of migration and the estimation of the exposure to migrating chemicals through the diet, including intentionally added substances (IAS) and non-intentionally added substances (NIAS).

METHODOLOGY

Task 1: Planning and searching information

- Bibliographic review and update of knowledge on the chemical composition of bio-based and/or biodegradable plastics used for applications in contact with food.
- Extensive literature review on the analytical methods used for the determination of chemical components of bio-based and/or biodegradable plastics.
- Preparation of a homemade database with all possible substances present in each type of polymer, including their physical and chemical properties.

Table 1: Polymer and monomer structure of common biodegradable polymers [4].

Biodegradable polymer	Polymer structure	Monomer structure
Polylactic acid (PLA)		
Polybutylene succinate (PBS)		
Polyhydroxy butyrate (PHB)		
Polycaprolactone (PCL)		

Task 2: Sampling and polymer identification

- Selection of food packaging materials, including biodegradable bio-based, biodegradable petrochemical and non-biodegradable bio-based plastics. Both materials already marketed and those new polymer with potential for applications in contact with food.
- Identification of the type of polymer using FTIR and IR spectral libraries.

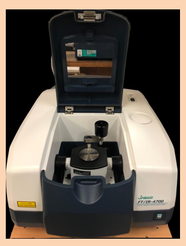


Figure 1: Fourier-transform infrared spectroscopy (FTIR)

Task 3: Development of targeted and non-targeted analytical methods for IAS and NIAS

- Selection of the most appropiate extraction method, analytical technique and detection system for identification and quantification (GC-MS for volatile and semi-volatile migrants and LC-MS or LC-MS/MS for non-volatile migrants).
- Optimization of chromatographic conditions and the instrumental parameters.
- Study of linearity, sensitivity, and repeatability when the analytical standards is available.
- Comparation with commercial spectra libraries and homemade database in the case of unknowns.
- Estimation of toxicity using Toxtree software for those compounds identified for which there are no toxicological evaluation data.

Figure 2: Gas chromatography coupled to mass spectrometry (GC-MS) with purge and trap (P&T) technique

Task 4: Migration of chemical compounds and exposure assessment

- Selection of foods and beverages of different nature (aqueous, fatty, acid, dry, etc.), that may be marketed and packed with bio-bases and/or biodegradable plastics.
- Optimization of the extraction procedure for analytes from food matrices (SPE, SPME, ASE, QuEChERS, etc.) with recovery assays.
- Determination of migrating substances in foodstuffs following the methodologies described.
- Exposure assessment though diet combining migration levels obtained in foods with consumption data obtained from national food consumption surveys.

Figure 3: High performance liquid chromatography combined diode array and fluorescence detection (HPLC-DAD-FLD)

Figure 4: High performance liquid chromatography combined with tandem mass spectroscopy (LC-MS/MS)

Task 5: Publication of results

At the end of each task:

- ✓ Scientific articles derived from the results obtained will be prepared and submitted in high impact international journals within the thematic area.
- ✓ Communications at international conferences and congresses

Task 6: Outreach and dissemination

- A scientific seminar to share with different food safety laboratories the main project advances.
- A specialized training workshop on chemical safety of bio-based and/or biodegradable materials used in food contact materials for doctoral students from different universities.
- A public session organized in cooperation with regional Food Cluster to present the main project results to the food industry.

CONCLUSION

The proposed research is of interest from the point of view of Food Safety and risk managers at national, European and international level, in order to establish possible restrictions on the migration of substances from these materials and carry out a risk assessment since data on exposure to chemicals transferred from these sustainable food contact materials are very limited. Also, from the analytical point of view, since there are few analytical protocols for the determination of NIAS. As well as of interest to companies that manufacture bio-based plastics intended for contact with food and need to perform migration tests to optimize their formulations.

Acknowledgement:

The study was financially supported by the Ministerio de Ciencia e Innovación, Agencia Estatal de Investigación and by Fondo Europeo de Desarrollo Regional (FEDER). Ref. No. PID2021-124729NB-I00 "MIGRABIOQUANT" (MCIN/AEI/ 10.13039/501100011033/FEDER, UE), and BACFood4Expo project (PID2020-114569RJ-I00) funded by Spanish Ministry of Science and Innovation under the competitive State R&D Program Oriented to the Challenges of the Society, "R&D Projects 2020" - Modalities "Research Challenges and Knowledge Generation". L. Barbosa-Pereira is grateful to the Spanish Ministry of Science and Innovation for her "Ramón y Cajal" Grant (Agreement No. RYC2021-033505-I).

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