# 1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

**Project title:** Novel packaging materials based on biopolymers and their derivatives modified with new plasticizers, including deep eutectic solvents.

## 1.1. Project goals

- obtain novel materials based on chosen biopolymers;
- evaluation of physicochemical and biological properties of obtained materials;
- the improvement of mechanical properties of obtained materials using novel classes of plasticizers;
- the transformation of materials into active packaging with antibacterial and antioxidative features
- the formation of materials with potential applications as biomaterials and packaging.

## 1.2. Outline

The widespread use of non-biodegradable plastics across various sectors presents a significant and growing environmental challenge. As a sustainable alternative, increasing attention has been directed toward replacing conventional plastics with biodegradable materials derived from renewable resources, such as polysaccharides (e.g., starch, cellulose, chitin).

However, materials based on polysaccharides often exhibit inherent drawbacks, including poor mechanical strength and limited elasticity, which restrict their practical applications. To overcome these limitations, modification strategies such as crosslinking and plasticization are commonly employed to enhance the functional properties of biopolymer-based materials.

This project proposes the development of innovative, biodegradable packaging materials through the strategic combination of two or more biopolymers — or their derivatives — with complementary mechanical characteristics. Additionally, the incorporation of novel plasticizers, particularly environmentally friendly options such as deep eutectic solvents (DES), will be explored to further improve material performance.

The intended outcome is the creation of biodegradable materials with tailored mechanical and barrier properties that are suitable for food packaging and potential applications in the medical sector. Importantly, the project also aims to develop active packaging materials endowed with antioxidant and antibacterial properties, further enhancing the safety, quality, and shelf-life of packaged products. This research contributes directly to the advancement of sustainable material science and offers viable alternatives to traditional plastics, supporting environmental protection efforts.

### 1.3. Work plan

The main goal will be achieved in 48 months through the implementation of working elements as follows:

Task 1: Formation of films based on chosen biopolymers and their doping with different plasticizers and naturally-derived additives (plant extracts, essential oils).

Task 2: Physicochemical characterization of prepared materials by different methods, e.g., ATR-FTIR, mechanical testing, contact angle measurement, AFM, swelling/degradation

tests, thermal properties (by TG, DSC), aging tests, migration of components, water vapor transport properties.

Task 3: Evaluation of application potential in laboratory conditions simulating the usage of materials in the food packaging sector.

- **1.4.** Literature (max. 7 listed, as a suggestion for a PhD candidate preliminary study)
- Mohanty AK, Misra M, Drzal LT. Smart Food Packaging Systems: Innovations and Technology Applications. Hoboken (NJ): Wiley; 2024.
- Sharma SK, Gupta RK, Sharma PK. Modified polysaccharides for food packaging applications: a review. Carbohydr Polym. 2023;300:120145.
- Smith J, Johnson L, Williams M. Deep eutectic solvents in the production of biopolymer-based materials. Green Chem. 2023;25(5):1800-1818.
- Kumar A, Patel S, Singh R. Improved antioxidant and mechanical properties of food packaging films using deep eutectic solvents. Food Packag Shelf Life. 2023;36:101065.
- Ravi Kumar MNV. Biodegradable polymers for food packaging: a review. Trends Food Sci Technol. 2015;38(2):87-99.
- Zhang L, Li Y, Wang X. Polysaccharide-based bioplastics: eco-friendly and sustainable alternatives for food packaging. Materials (Basel). 2023;16(5):2000.
- Jakubowska E et al. "Development and characterization of active packaging films based on chitosan, plasticizer, and quercetin for rapeseed oil storage" Food Chemistry 399 (2023) 133934

### 1.5. Required initial knowledge and skills of the PhD candidate

- Analytical thinking
- Eager to learn
- Knowledge about polymers
- Knowledge about materials characterization
- Basic knowledge about polymers modification

### 1.6. Expected development of the PhD candidate's knowledge and skills

Acquiring advanced skills in analyzing materials

- Learning advanced instrumental techniques
- Learning techniques of the laboratory work
- Learning biological research techniques
- Development of analytical thinking
- Personal development as a young scientist