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

Project title:

Active and intelligent biodegradable polysaccharide-based films for food packaging

1.1. Project goals:

The main goals of this project are:

- to use polysaccharides, natural compounds, and substances sensitive to pH changes to obtain antibacterial and pH-sensitive packaging materials,
- characteristics of the produced films in terms of antibacterial and antifungal activity,
- physicochemical characteristics, spectroscopic, morphological, mechanical, and thermal studies of the prepared films,
- determination of the films effect on packaged products (cheese, fruits, vegetables).

1.2. Outline

Food packaging films produced from biopolymers, e.g., polysaccharides, are alternatives for synthetic packaging that constitute about one-third of all plastic products. The used-up plastics lie in landfills, posing a threat to the natural environment and humans. That is why there is a need to reduce plastic waste by replacing it with biodegradable materials. Eco-friendly packaging can be produced from polysaccharides or proteins. Adding active compounds to the packaging film can result in functionalizing this material, which becomes an active and intelligent film. Packaging aims to maintain the product's freshness and protect it against spoilage and mechanical damage. Active packaging ensures prolonging shelf-life of foodstuffs, whereas intelligent packaging monitors food quality. The development of functional packaging is essential for reducing food waste and ensuring product quality. The topic is still vital.

This project aims to obtain suitable packaging for dairy products, especially cheese. The presence of active substances will reduce the multiplication of microorganisms, while pH-sensitive substances will indicate spoilage. Food colorants can act as indicators of pH changes and antibacterial agents. Moreover, the development and usage of active packaging for other perishable foods, such as fruits and vegetables, is included in this project.

1.3. Work plan:

- Preparation of polysaccharide films with natural origin compounds such as essential oils, plant extracts, or selected substances to acquire active films with antimicrobial properties.
- Incorporation of pH sensitive compounds to the film.
- Characterization of the prepared films regarding antibacterial, antifungal, and antioxidant activity.
- Examination of mechanical, optical, morphological, and thermal properties, water vapor transmission rate, moisture content, and biodegradation.
- Comparison of the food quality in new packaging, classic packaging and without packaging. The products for studies are mainly cheese, fruits, and vegetables.

1.4. Literature *(max. 10 listed, as a suggestion for a PhD candidate)*

1. Active edible furcellaran/whey protein films with yerba mate and white tea extracts: Preparation, characterization and its application to fresh soft rennet-curd cheese, A.Pluta-Kubica, E. Jamróz, A. Kawecka, L. Juszczak, P. Krzyściak, *International Journal of Biological Macromolecules* 155 (2020) 1307–1316.
2. Preparation and antibacterial performance of bacterial nanocellulose sachet containing *Zataria multiflora* essential oil loaded halloysite nanotubes on *Escherichia coli* O157:H7 in cheese, H. Shafiei, S. Saei-Dehkordi, Mehran Moradi, R. Molaei, *LWT - Food Science and Technology* 194 (2024) 115812.

3. Active and intelligent food packaging. Review paper. Part 2, H. Makała, *Packaging Review* 1 (2023) 6-12.
4. The Development of a Novel Sodium Alginate-Based Edible Active Hydrogel Coating and Its Application on Traditional Greek Spreadable Cheese, A. E. Giannakas, K. Zaharioudakis, E. Kollia, A. Kopsacheili, L. Avdylaj, S. Georgopoulos, A. Leontiou, V. K. Karabagias, G. Kehayias, E. Ragkava, Ch. Proestos, C. E. Salmas, *Gels* 9 (2023) 807.
5. Use of Alginates as Food Packaging Materials, M. G. Kontominas, *Foods* 9 (2020) 1440.

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

Knowledge about general chemistry, polymer chemistry, biopolymers, speaking and writing English.

1..6. Expected development of the PhD candidate's knowledge and skills:

Improvement in the preparation of posters, oral presentations, writing publications, and applications for grants. Moreover, acquiring the skill in operating research apparatuses and equipment, planning and conducting experiments.