

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

Project title:

### DEVELOPMENT AND CHARACTERISATION OF INNOVATIVE FORMULATIONS INCORPORATING NATURAL ANTIMICROBIAL AGENTS FOR FOOD PACKAGING APPLICATIONS

#### 1.1 Project goals

The objectives of the project are to design biodegradable insert formulations for the packaging of highly perishable food products, enabling the controlled release of natural antimicrobial agents.

#### 1.2 Outline

The current state of knowledge indicates that the modern food industry is seeking packaging solutions based on innovative and biodegradable materials. For minimally processed foods, the challenge lies in developing packaging that enhances safety without compromising sensory quality. Among biodegradable and biocompatible packaging components, chitosan deserves particular attention. When used in packaging, it provides good barrier properties and extends the shelf life of fruits, vegetables, meat, and bakery products. A promising solution to improve food safety, while ensuring cost-effectiveness for market implementation, may involve the incorporation of antibacterial active inserts into conventional packaging. To date, few such solutions have been described that rely on systems releasing compounds inhibiting microbial growth during food storage. This project proposes the development of active packaging inserts enriched with plant-derived antimicrobial agents (e.g., essential oils, antioxidant mixtures). These inserts would act within the packaging system—surface, headspace, and product—helping to inhibit microbial and fungal growth, delay food aging processes, and reduce lipid oxidation. By integrating food chemistry, biopolymers, and innovative food technology, the project aims to deliver practical, safe, and cost-effective solutions for the food industry.

#### 1.3 Work plan

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

**TASK 1** Development of methods for extracting active compounds from plants.

**TASK 2** Development of biocompatible insert formulations for minimally processed food

packaging.

Task 3 Enrichment of the developed packaging insert formulations with active plant-derived antimicrobial inhibitors.

TASK 4 Testing of the physico-chemical and biological properties of the developed packaging insert formulations.

TASK 5 Evaluation of the effectiveness of the developed inserts for selected food categories.

TASK 6 Assessment of consumer acceptance of food stored in packaging containing active inserts.

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

1. Upadhyay, P.; Zubair, M.; Roopesh, M.S.; Ullah, A. An Overview of Advanced Antimicrobial Food Packaging: Emphasizing Antimicrobial Agents and Polymer-Based Films. *Polymers* 2024, 16, 2007. <https://doi.org/10.3390/polym16142007>
2. Fadiji, T.; Rashvand, M.; Daramola, M.O.; Iwarere, S.A. A Review on Antimicrobial Packaging for Extending the Shelf Life of Food. *Processes* 2023, 11, 590. <https://doi.org/10.3390/pr11020590>
3. Bahmid, N.A.; Dekker, M.; Fogliano, V.; Heising, J.; Development of a moisture-activated antimicrobial film containing ground mustard seeds and its application on meat in active packaging system. *Food Packaging and Shelf Life* 2021, 30. <https://doi.org/10.1016/j.fpsl.2021.100753>
4. Bahmid, N.A.; Heising, J.; Fogliano, V.; Dekker, M. Packaging Design Using Mustard Seeds as a Natural Antimicrobial: A Study on Inhibition of *Pseudomonas fragi* in Liquid Medium. *Foods* 2020, 9, 789. <https://doi.org/10.3390/foods9060789>
5. Jastrzębska A., Kmiecik A., Gralak Z., Brzuzy K., Krzemiński M., Gorczyca D., Szłyk E., A new approach for analysing biogenic amines in meat samples: Microwave-assisted derivatisation using 2-chloro-3-nitropyridine, *Food Chemistry* 2024, 436, 137686. <https://doi.org/10.1016/j.foodchem.2023.137686>
6. Jastrzębska A., Kmiecik A., Brzuzy K., Gralak Z., Krzemiński M. P., Szłyk E., Determination of selected biogenic amines in fermented vegetable juices, *Food Control* 2023, 154, 109980. <https://doi.org/10.1016/j.foodcont.2023.109980>

1.5. Required initial knowledge and skills of the PhD candidate

- basic knowledge on analytical and organic chemistry,
- basic skills in laboratory work,
- analytical thinking,
- eager to learn.

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

- learning advanced instrumental techniques,
- learning techniques of laboratory work,
- learning food chemistry research techniques,
- development of analytical thinking,
- personal development as a young scientist.