

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

Project title: Active bio-packaging produced from residues of agro-food industries and their application in oil-based food products

1.1. Project goals:

The main goals of the project are:

- Application of residues from agro-food industries for developing biodegradable and innovative films for packaging oil-based food products.
- Addition of natural antioxidants and other functional agents to make the packaging system active.
- Characteristic of chemical composition, mechanical, optical, morphological, antioxidant and antibacterial properties and cytotoxicity of the active films.
- Analysis of oil-based food products packed in an innovative active food packaging materials.

1.2. Outline: The quality of food products depends on their nutritional, organoleptic and microbiological properties, which are subject to dynamic changes in foods during storage and distribution. These changes are mainly due to interactions between food products and their surrounding environment or to migration between different food components. Therefore, food packaging plays its primary role in the protection of the food products from the influence of the external environment. Among them innovative materials are designed to embed components able both to release active substances into the packaged food and to absorb undesirable compounds from the surrounding environment. Active, biodegradable films represent an interesting alternative to conventional paper, metal, glass and plastic materials for food packaging. Although, plastic materials have been widely used in the food packaging area because they are easily available at relatively low cost, present good mechanical and gases permeability properties, and light weight. However, plastic materials are classified as non-renewable and non-biodegradable, having serious environmental drawbacks, and their use conducting to a large environmental pollution. For this reason, biodegradable, reusable, environmentally friendly and active materials have become an increasingly considered as sustainable alternatives to traditional polymeric food packaging due to growing consumer awareness. Many compounds such as biopolymers, fibers, nanoparticles, bioactive compounds, and inorganic substances from residues of agro-food industries can be used for packaging materials. In general, biopolymers are the basic material for packaging, since they form the matrix or network (continuous structure), while other mentioned constituents are rather considered as additives (plasticizers, active agents, cross-linking agents, etc.) or fillers (fibers) in the manufacture of packaging materials. On the other hand, recovering substances from by-products and agro-food residues that can be incorporated in food materials, promote the “zero waste” movement.

With increasing attention to environmental and food safety issues, in the course of the project the production and characterization of different type of active packaging based

on compounds obtained from byproducts and agro-food wastes are planned. In order to test the actual capability of innovative films and coatings to improve the shelf life and quality of food products rich in fat prone to oxidation, model and real food systems will be used.

1.3. Work plan:

- Preparation of new active and intelligent packaging incorporating agents from by-products of agro-food industries.
- Implementation of a new methodology for extraction of bioactive compounds from by-products as potential additives for packaging materials.
- Characterization of the obtained films by spectroscopic, thermal, imaging, chromatographic methods.
- Determination of physicochemical, mechanical, optical, antibacterial properties and cytotoxicity of the prepared films.
- Optimization of storage conditions for adequate shelf-life of oil-based food products packaged in a novel, active packaging materials.
- Investigation of influence of new packaging on quality of stored food products.
- Application of statistical and chemometric tools to data analysis and optimize the parameters of films' synthesis, storage conditions of food products in new packaging materials etc.

1.4. Literature:

1. Bianchi F., Fornari F., Riboni N., Spadini C., Cabassi C.S., Iannarelli M., Carraro C., Mazzeo P.P., Bacchi A., Orlandini S., Furlanetto S., Careri M. Development of novel cocrystal-based active food packaging by a Quality by Design approach. *Food Chem.* 2021, 347, 129051.
2. Gaspar M.C., Leocádio J., Mendes C.V.T., Cardeira M., Fernández N., Matias A., Carvalho M.G.V.S., Braga M.E.M. Biodegradable film production from agroforestry and fishery residues with active compounds. *Food Packaging Shelf Life* 2021, 28 , 100661.
3. Sharma S., Barkauskaite S., Jaiswal A.K., Jaiswal S. Essential oils as additives in active food packaging. *Food Chem.* 2021, 343, 128403.
4. Mesgari M., Aalami A.H., Sahebkar A. Antimicrobial activities of chitosan/titanium dioxide composites as a biological nanolayer for food preservation: A review. *Int. J. Biol. Macromol.* 2021, 176, 530–539.
5. Debeaufort F. Active biopackaging produced from by-products and waste from food and marine industries. *FEBS Open Bio* 2021, 11, 984–998.

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

- Basic knowledge in the field of analytical, food and polymer chemistry.
- Basic knowledge in the instrumental techniques used for films characterization and food analysis.
- The ability to interpret and describe experimental results and draw conclusions.

- Knowledge of speaking and writing English.
- Commitment to scientific work, permanent self-education and ability to cooperate in a team.

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

- The ability to practical skills, such as
 - (1) methodology for preparation of new active packaging materials and their characterization by using modern instrumental techniques,
 - (2) application of new techniques and instrumentations for determination of food quality;
- The ability to write scientific publications, scientific projects (grant applications) and presentation of results at international conferences, workshops and tutorials;
- Preparation for hard work, formulation and solving the scientific problems related to trends in food science and technology.