PhD Programme: Food Science
Title of the research project: Application of Moderate Electric Fields (MEF) and artificial intelligence tools to guide food-grade fermentation of fermentable plant-based food systems: effects on functional metabolites and structural properties
Supervisor: Fabrizio Sarghini
Co-supervisor: Angela De Vivo
Reference Scientific-Disciplinary Sector: AGR/09 – Agricultural Mechanics
Objectives, methodologies of the research project, and interdisciplinary collaborations
The project is structured around three integrated scientific objectives, developed through a coherent methodological framework. The first objective consists in defining a representative set of model matrices, selected not simply as application cases, but as substrate classes characterized by different fermentation behaviors. These include protein-rich systems derived from legumes, cereal or pseudocereal systems, and mixed protein-starch systems. The second objective concerns the identification of the operating window of Moderate Electric Fields (MEF) during fermentation, in relation to the main process parameters. The third objective aims to reconstruct the causal relationships between process inputs, microbiological response, biochemical outputs, and the final properties of the matrix, in order to clarify how electrical modulation can translate into measurable techno-functional effects. Alongside these three objectives, the project includes a cross-cutting methodological axis based on AI/ML, aimed at the integrated management of experimental data, the predictive modeling of microbiological, biochemical, and techno-functional responses, and the identification of robust and transferable operating conditions. To this end, the project will involve bench-scale fermentations in temperature-controlled systems, with MEF applied during selected phases of the process.
Elements of innovation and/or originality of the project
The project presents three main elements of innovation and originality, complemented by a cross-cutting component based on artificial intelligence. The first concerns the positioning of MEF within the fermentation process: they are not considered merely as a preliminary treatment, but as a true process variable applied during fermentation. The second element of originality lies in the integration, within a single experimental design, of levels of analysis that are still treated in a fragmented way in the literature: microbiological response, formation of functional metabolites, and development of the final properties of the matrix. A further element of originality is represented by the use of AI as a tool for data integration and process decision support. Rather than simply describing the effects of MEF on individual endpoints, the project envisages the development of models capable of linking electrical parameters, microbial kinetics, functional metabolites, and structural properties, thereby enabling the identification of non-linear relationships and optimal operating conditions. This approach will make it possible to move from a sequential experimental logic to a predictive, interpretable design logic that can potentially be updated with new data. The third element of innovation concerns the transferable nature of the project. It is not conceived as the development of a single product, but rather as the generation of principles applicable to a family of fermentable plant-based food systems.
Availability of funds Bioplast agreement – €120k Remaining PRIN 2017 funds – €34k -Remaining PRIN 2022 funds – €40k
Availability of facilities
The project activities will be carried out at the affiliated laboratory and, according to specific experimental needs, at national and international partner laboratories involved in the scientific collaborations.
Collaborations with foreign institutions Collaborations are planned with Prof. Ferruh Erdogdu, Ph.D., Professor of Food Engineering at the Department of Food Engineering of Ankara University, Ankara, Turkey, and with Prof. James Lyng, Head of the Food and Nutrition Section at the School of Agriculture and Food Science, University College Dublin (UCD), Dublin, Ireland.
Collaborations with external institutions outside UNINAA collaboration is planned with Prof. Francesco Marra, Full Professor of Chemical and Food Engineering at the Department of Industrial Engineering of the University of Salerno, Fisciano, Italy.