

THESIS OFFER

MICROBIAL COMMUNITY ASSEMBLY AND METABOLIC DIVERSITY IN A MATRIX ENRICHED WITH LEGUMES

The French National Institute for Agriculture, Food, and Environment (INRAE) is a public research establishment bringing together a working community of 12,000 people, with 268 research, service and experimental units, located in 18 centres throughout France. INRAE is one of the world leaders in agricultural and food sciences, plant and animal sciences. Its research aims to develop solutions for multi-performance agriculture, high-quality food and sustainable management of resources and ecosystems.

YOUR MISSION AND ACTIVITIES

→ Fermented foods are an important part of our diet. These foods contain a wide range of microorganisms that can improve the preservation of foods, produce typicality and a wide range of tastes, and also increase the nutritional value of these foods. This thesis is part of the European DOMINO project - *Harnessing the microbial potential of fermented foods for healthy and sustainable food systems* (DOI [101060218](https://doi.org/10.1016/2018)). This project, coordinated by INRAE, brings together 18 partners from 10 European countries.

One of the major challenges of the project is to help steer the design of plant-based fermented products to meet the combined needs of society's food transition, the urgent need to ensure the sustainability of the food system and to create the effervescence of a profitable economic market for small European businesses. One of the solutions is to promote the consumption of plant-based fermented foods. DOMINO will carry out six case studies on plant-based fermented foods as part of its citizen science programme. The case study on the fermentation of legumes is the subject of this thesis.

Because they are rich in protein, legumes are a choice alternative to animal proteins, but they suffer from defects associated with vegetable proteins (e.g. sensory defects, anti-nutritional factors). Fermentation can provide an effective solution for reducing these sensory defects and creating new sensory worlds.

The main challenge here is to put **in place a synthetic ecology approach that will enable us to study the mechanisms by which microbial communities capable of fermenting it are assembled, while at the same time improving its organoleptic properties.**

The **research questions** that the doctoral student will have to deal with are :

→ What are the micro-organisms whose metabolic capacities (e.g. degradation, biosynthesis) can be used/associated for the fermentation of legumes in order to obtain new products such as vegetable cheese?

→ Which metabolic pathways are responsible for the production of aromas and the reduction of off-flavours?

→H What types of microbial interactions are involved in the expression of these metabolic pathways of interest?

Within the SayFood research unit, this thesis is part of the CoMiAl (Food Microbial Communities) team, which aims to gain a better understanding of the structure and functions of these microbial communities. To achieve this, it will draw on skills in the fields of genomic analysis (bacteria and fungi), genetic modification (yeasts), microbial ecology and physiology, and the characterisation of micro-organism/surface and micro-organism/micro-organism interactions. It also addresses the societal challenges of "New protein sources" and "Fermented foods", to which the unit hopes to contribute. In addition, it will share common problems with two other teams in the unit: IHAC (Human-Food Interactions for Design) and GéPro (Product Engineering), which are also involved in the DOMINO project. As such, it is perfectly at the heart of the unit's scientific concerns and has a strong structuring character.

→H In order to achieve the **expected objectives**, the thesis will follow the following sequence:

Phase 1: Participation in living labs to better define the expectations/needs of consumers/stakeholders with regard to new fermented foods.

Phase 2: Definition of a model matrix enriched with legume proteins

Objectives: Definition of a typical matrix to study the rules of assembly of microbial communities.

Phase 3: Design of synthetic microbial communities adapted to the fermentation of a matrix enriched with plant proteins

Objectives: Selection/design by synthetic ecology of microbial communities (prokaryotes and eukaryotes) adapted to the matrix enriched with plant proteins. Selection of a collection of bacteria and fungi capable of colonising the matrix and generating, during fermentation, interesting functionalities at the sensory level (olfactory and visual).

Phase 4: Functional and sensory characterisation of fermented products

Aims: To characterise the matrix fermented by the various microorganisms selected in Phase 3. A subset of consortia will be analysed in order to i) identify and quantify the perceptions of these fermented products enriched with plant proteins (aroma, flavour and texture), ii) understand the origin of any defects by characterising the products using analytical techniques (volatile and non-volatile fractions), iii) study the potential for implantation and functional expression of the microbial consortia in the matrices.

The products favoured for this synthetic ecology approach are vegetable fermented products such as legume-based cheese.

The PhD student will mainly be required to use microbiology, molecular biology and food fermentation techniques, but may also be trained in more advanced omics approaches (metagenomics/metatranscriptomics/metabolomics) and bioanalysis methods (bioinformatics/biostatistics). He/she will interact with various project partners, as well as with other PhD students involved in the DOMINO project.

→H The **expected results** of this thesis are :

→H To provide knowledge about the potential of each ecosystem to establish itself, its metabolic plasticity and its functional redundancy depending on the nature of the matrix.

→H To better define the assembly rules of microbial communities and microbial interactions within the matrix.

→H Propose some principles for setting up synthetic communities for the fermentation of legume-enriched products.

→ To be able to propose mock-ups of fermented legume-based products to manufacturers for pilot trials.

→ You will be working in the [SayFood UMR](#) (Paris-Saclay Food and Bioproduct Engineering Research unit), which aims to contribute to product-process innovation that takes into account the constraints of upstream production, consumer needs and expectations, and environmental issues.

→ You will be supervised by Pascal Bonnarme (INRAE Research director in microbial biochemistry of fermented foods), Vincent Hervé (INRAE Researcher in microbial ecology and bioinformatics) and Eric Dugat-Bony (INRAE Researcher in microbial ecology and food microbiology). You will also interact with other scientists at UMR SayFood, and in particular with the other PhD students recruited as part of the DOMINO project, who will be working on the 5 other fermented products studied.

→ Special working conditions: travel within Europe is required for DOMINO project meetings.

THE PROFILE WE ARE LOOKING FOR

→ Recommended training: You have an engineering degree or Master degree in microbiology/microbial ecology/microbial biochemistry with an interest in food science.

→ Essential skills and knowledge :

- You have already used microorganisms/microbial consortia, if possible in food matrices.
- You have a good knowledge of microbial ecology, microbial biochemistry, genomics and omics analysis.
- Experience in bioinformatics and/or biostatistics
- You are fluent in reading, writing and speaking French and English.
- You read, write and speak scientific English

→ Skills and knowledge required :

- You have a good knowledge of the food industry
- Experience in food science and/or sensory characterisation would be a plus.

→ Skills required :

- You are motivated to work in an interdisciplinary team
- You are motivated to carry out studies rooted in the reality on the ground
- You have excellent interpersonal skills
- You are recognised for the quality of your written and oral presentations
- You are autonomous, organised and respect deadlines

→ Experience: Young graduates accepted

YOUR QUALITY OF LIFE AT INRAE

By joining INRAE, you can benefit from the following depending on the type of contract:

→ up to 30 days holiday + 15 TOIL days per year (for full-time employees)

→ [support for parenthood](#) childcare, leisure services ;

→ skills development systems: [training](#), [career guidance](#) ;

→ [social support](#): advice and listening, social assistance and loans;

→ [holiday and leisure services](#) holiday vouchers, accommodation at preferential rates ;

→ sports and cultural activities; catering.

⇒ Reception arrangements

- ⇒ Unit: **UMR SayFood**
- ⇒ Postcode + town: **91 120 Palaiseau**
- ⇒ Type of contract: **Doctoral contract**
- ⇒ Contract duration: **3 years**
- ⇒ Starting date: **November-December 2023**
- ⇒ Salary: €2,105.44 gross per month; annual increase on 1^{er} January of around €100 gross per month.

⇒ How to apply

Send a cover letter, a CV of maximum two pages as well as the names and e-mail addresses of two referees by e-mail to Pascal Bonnarme, Vincent Hervé and Eric Dugat-Bony.

⇒ **By e-mail:** pascal.bonnarme@inrae.fr;
vincent.herve@inrae.fr; eric.dugat-bony@inrae.fr

Deadline for applications: **29 September 2023**

Interviews are scheduled for **18-20 October 2023** for candidates whose applications have been selected.