PhD PROPOSAL FOR THE DOCTORAL SCHOOL
« Ecologie, Géosciences, Agronomie, ALimentation »

GENERAL INFORMATION

<table>
<thead>
<tr>
<th>Thesis title: Mechanisms of micrometric assemblies of food proteins and structural properties</th>
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<tbody>
<tr>
<td>Acronym: AMIPRO</td>
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<tr>
<td>Disciplinary field 1: Food sciences</td>
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<td>Disciplinary field 2: Food sciences</td>
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<tr>
<td>Three keywords: Proteins, Interactions, Physico-chemistry</td>
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<tr>
<td>Research unit : UMR1253, STLO</td>
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<tr>
<td>Name of the thesis director: Bouhallab Saïd</td>
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<td>Email address of the thesis director : <a href="mailto:said.bouhallab@inra.fr">said.bouhallab@inra.fr</a></td>
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<tr>
<td>Name of the thesis co-supervisor 1 (if applicable): Famelart Marie-Hélène</td>
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<tr>
<td>Email address of the thesis co-supervisor 1 (if applicable):</td>
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<tr>
<td>Name of the thesis co-supervisor 2 (if applicable): Lund Mikael</td>
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<tr>
<td>Email address of the thesis co-supervisor 2 (if applicable):</td>
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<tr>
<td>Thesis grant (funding origin and amount): INRA/Brittany Region</td>
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<tr>
<td>Contact(s) (mailing address and E-mail): 65 rue de Saint Brieuc, 35042 Rennes Cedex France. <a href="mailto:Said.bouhallab@inra.fr">Said.bouhallab@inra.fr</a></td>
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Recruitment process: Recruitment process depends on thesis funding. To select the corresponding recruitment process, please visit the EGAAL website here. This information is needed for proposal publication.

☐ Doctoral school contest  ☒ Interview  ☐ Other (indicate):

All sections must be filled. Once filled, please save the proposal form in pdf format using the following naming: Supervisor Name_Unit_Subject Acronym_EN.pdf

ED EGAAL
Direction : 65 rue de Saint-Brieuc – CS 84215 – 35042 Rennes Cedex – France
Tél : 02 23 48 52 75
Mail : ed-EGAAL@u-bretagne loire.fr
Site Web : https://ed-egaal.u-bretagne loire.fr
### SCIENTIFIC DESCRIPTION OF THE PhD PROJECT

#### Socio-economic and scientific context : (10 lines)
Spontaneous non-covalent assemblies of protein are of central importance in biology. The control of the assembly processes gives wide potential applications in various sectors, e.g. agro-food, cosmetic, pharmaceutical, etc. We focus on the interaction between oppositely charged proteins resulting in spherical micrometric assemblies such as complex coacervates or microcapsules. The formed assemblies can be used as biomaterials for encapsulation of enzymes or bioactives. The results achieved by our team showed that the interaction / assembly between proteins is very sensitive to small structural variations and / or to small changes in the electrostatic potential on their surfaces. To explain these observations, the aim of this PhD subject is to understand how molecular interactions direct the assembly process by implementing a strategy combining experimental and numerical simulation. The work will focus on two types of assemblies formed from milk proteins: spontaneous assemblages obtained by complex coacervation and microcapsules induced by dry heat treatment. Molecular and mesoscopic modelling will be conducted in collaboration with Lund University in Sweden. For this purpose, a candidate's stay in Lund for a period of a few months is therefore planned.

#### Assumptions and questions (8 lines)
- What are the initial interacting forces between two oppositely charged proteins leading to the formation of elementary bricks of heteroprotein coacervats? Their reversibility?
- What are the exact role of protein surface charge and anisotropy?
- What is the contribution of these forces to the stability and rheological properties of formed protein assemblies?
- What is the mechanism behind the formation of protein capsule during dry heat treatment?

#### The main steps of the thesis and scientific procedure (10-12 lines)
- Chemical grafting of proteins on tip and support of atomic force microscopy (AFM) (STLO controlled technology); Determination of AFM protein interaction forces as a function of ionic strength conditions and the nature of the protein grafted onto the tip.
- Study and characterization of the rheological behavior of the assemblages formed in the conditions of AFM interactions;
- Combination of data and results acquired for the understanding of the mechanical behavior of the assemblies: relations between the macro-rheology and the micro-rheology and interaction force of the constitutive bricks obtained by AFM;
- Use of results to feed / improve simulation and modeling parameters;
- Publications of the results and proposition of principles of their generalization to other types of plant or animal proteins.

#### Methodological and technical approaches considered (4-6 lines)
The approach that will be favored will involve the combination of experimental approaches and molecular and mesoscopic modeling (collaboration with University of Lund, Sweden). The proteins to use are available. An arsenal of analytical techniques and characterization are available in the laboratory:
- Tools of classical biochemical analyzes: chromatography, electrophoresis, UV-Visible, Rheology.
- Microscopy / interactions: confocal, AFM, isothermal titration
- Turbiscan® size and load characterization tools, turbidimetry
- Some "free access" molecular modeling tools.
### Scientific and technical skills required by the candidate

Motivated students with a Master degree (M2) or an engineering degree in the field of food science or soft matter physics with basic knowledge on physic-chemistry of bio-polymers/colloids. Elementary knowledge on molecular modelling will be highly appreciated. Good level of English is required.

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### THESIS SUPERVISION

<table>
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<tr>
<th>Unit name:</th>
<th>Team name:</th>
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<tr>
<td>UMR1253, STLO</td>
<td>Interactions, Structures, Functionalities</td>
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<tr>
<th>Unit director name:</th>
<th>Team director name:</th>
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<tr>
<td>Yves LE Loir</td>
<td>Saïd Bouhallab</td>
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<th>Mailing address of the team director:</th>
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<tbody>
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<td><a href="mailto:Yves.leloir@inra.fr">Yves.leloir@inra.fr</a></td>
<td><a href="mailto:Said.bouhallab@inra.fr">Said.bouhallab@inra.fr</a></td>
</tr>
</tbody>
</table>

#### Thesis director

Surname, first name: Bouhallab Saïd  
Position: Senior Scientist  
Obtained date of the HDR (Habilitation thesis to supervise research): 1997  
Employer: INRA  
Doctoral school affiliation: EGAAL  
Rate of thesis supervision in the present project (%): 70  
Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 30  
Number of current thesis supervisions/co-supervisions: 0/2

#### Thesis co-supervisor 1 (if applicable)

Surname, first name: Marie-Hélène Famelart  
Position: Senior Scientist  
Habilitation thesis to supervise research ☒ yes ☐ no  
If yes, date diploma received:  
Employer:  
Doctoral school affiliation: EGAAL  
Rate of thesis supervision in the present project (%): 30  
Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 0  
Number of current thesis supervisions/co-supervisions: 0

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1 In EGAAL Doctoral School, if only one scientist in thesis supervision = 100% of supervision rate; if 2 people involved in thesis supervision = from 50% to 70% of supervision rate for the director; if 3 people involved in thesis supervision = 40% / 30% / 30% of supervision rate distribution among supervisors.
Professional status of previous PhD students supervised by both director and co-supervisors (from 5 years)

Please provide the following information for each PhD students supervised

1. Surname, first name: G. Miranda Tavares

Date of PhD beginning and PhD defence: Oct 2012 – Oct 2015

Thesis supervision: Saïd Bouhallab

Professional status and location: Assistant Professor, Campinas University

Contract profile (post-doc, fixed-term, permanent): Fixed-term

List of publications from the thesis work:

2. Surname, first name: A.L. Chapeau

Date of PhD beginning and PhD defence: Oct 2014 – Oct 2017

Thesis supervision: Saïd Bouhallab

Professional status and location: Project manager , R&D Avril Group

Contract profile (post-doc, fixed-term, permanent): Fixed-term

List of publications from the thesis work:


3. **Surname, first name:** E. Scong

   **Date of PhD beginning and PhD defence:** Nov 2014 – Nov 2017

   **Thesis supervision:** Marie-Hélène Famelart

   **Professional status and location:** Project manager, Adria Quimper

   **Contract profile (post-doc, fixed-term, permanent):** Fiedx-term

   **List of publications from the thesis work:**


3. Schong, E., Famelart M.H., 2018, Dry heating of whey proteins leads to formation of microspheres with useful functional properties, Food Research International, 113, 210-220.


**Five main recent publications of the supervisors on thesis subject:**


4. Schong E, **Famelart MH.** Dry heating of whey proteins leads to formation of microspheres with useful functional properties. Food Research International. 2018; 113, 210-220.

## THESIS FUNDING

<table>
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<tr>
<th><strong>Origin(s) of the thesis funding:</strong></th>
<th>INRA – Brittany Region</th>
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<tr>
<td><strong>Gross monthly salary:</strong></td>
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<tr>
<td><strong>Thesis funding state:</strong></td>
<td>Acquired</td>
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<tr>
<td><strong>Funding beginning date/Funding ending date:</strong></td>
<td>October / November 2019</td>
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**Date:** Mai 17, 2019

**Name, signature of unit director:** Yves Le Loir

**Name, signature of team director:** Saïd Bouhallab

**Name, signature of thesis project director:** Saïd Bouhallab