PhD Thesis (funded) - Call for Applications

Transformation and transfers of matters during the baking and staling of BREAD, understanding mechanisms in GLUTEN-FREE recipes (TETAPAIN)

Offered by the OPAALE Research Unit, IRSTEA

Irstea, the National Research Institute of Science and Technology for Environment and Agriculture is a Public Scientific and Technical Research Establishment (EPST) working on agri-environmental challenges in the areas of water, natural hazards, land management and environmental technologies.
Strongly multidisciplinary, the Institute's research activities deliver practical applications and support for public policies. We can boast strong partnerships with French and European Universities and research organisations along with businesses and public-service providers. Our work is carried out across nine Regional Centres and is divided into three broad Departments (Water, Land Use and Environmental Technologies). Working within the Environmental Technologies Department in Rennes, the Optimisation of Processes in Agriculture, Agri-Food and the Environment (OPAALE) Research Unit is pleased to offer this thesis opportunity.
The four research teams that make up the OPAALE Research Unit provide original and innovative practical solutions for agribusiness and agriculture. In particular, they set out to optimise technologies for the transformation of resources (food, vegetable, waste) and the development of high-quality food products, bio-resources and energy (bio gas) that minimise environmental impacts, moving towards sustainable development in the agricultural and food sectors. The successful candidate will work within the MRIFood team (IRMFood), whose main aim is to study the structures and improve the quality of agricultural and agribusiness products and help the industry to adopt sustainable processes. The team is developing particular metrological expertise in the use of dynamic NMR imagery and spectroscopy to investigate products in the course of transformation. The team is certified to ISO9001 and forms part the offer provided by the Imaging and Structural and Metabolic Spectroscopy Platform (PRISM), which carries the coveted IBISA label.

Project description (purpose, issues and objectives)

This thesis will focus on the quality of a core element of the French diet, bread. As the chief source of starches in France, its production generates an annual income of around 11 billion euros (INSEE figures). 22% of this income is generated by artisan bakers, while industrial bread production has taken over the greater part of the market and continues to expand, making up the **third-largest sector of France's top industry – agrifood**.

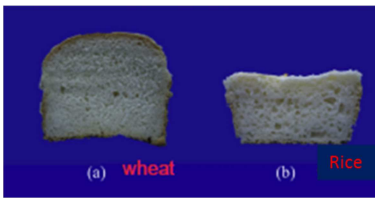

Fig 1. Gluten-free bread without additives is very dense

An aerated texture in bread makes it both palatable and digestible. This product is also affected by consumer trends, with an increased demand for food on the go (+3-4% pa in the sandwich market) and health foods such as gluten-free products (30-40% market increase pa for more than five consecutive years). **Gluten-free products attract sufferers from celiac disease** (~1% of the population) but, also, the estimated 21% of consumers interested in healthy eating who notice a significant increase in their 'physical well-being' when they reduce their consumption of gluten-based products. The gluten-free bread currently available nevertheless remains:

- unsatisfactory from an **organoleptic perspective**: products fail to expand and have a very dense crumb (Fig 1) that stales rapidly
- of debatable value from a **nutritional perspective:** for an equivalent mass they contain fewer minerals (being made with refined ingredients) and higher levels of saturated fats, known to act as a temporary stabiliser for the gas/water interfaces
- unable to meet the growing demand for **clean labels** and natural products (their multiple ingredients include hydrocolloid additives and emulsifiers, which, again, act as stabilisers for the gas/water interfaces).

Such disadvantages can nevertheless be overcome, as a small number of studies have shown, demonstrating that it is possible to manufacture a well-aerated gluten-free loaf using additive-free flours. The functional properties of these ingredients, however, have not as yet been elucidated.

The scientific issue is, then, to link the biochemical and mechanical mechanisms that control the expansion of this type of bread as it bakes and its subsequent preservation during storage. Focus will be on the starchy phase and on the distribution of water within the gluten-starch matrix.

From an **agronomical and environmental perspective**, the production of gluten-free bread calls for the cultivation of gluten-free crops. Several such crops (see http://www.sorghum-id.com for example) require fewer nitrate applications and less water than do high-gluten cereals, whose production relies on high nitrogen and water inputs. In the longer term, therefore, the diversification of cereal types consumed can be expected to contribute to a **more diversified agriculture that better respects the environment.** This outcome has a high probability, not least in France where the cultivation of sorghum wheat is increasing.

Starch is the main component of flour (70% dry base) and is in the shape of granules varying between 3 and 100 µm in size, depending on the botanical source. Variations in its capacity to absorb water and to swell also depend on its botanical source. It has been demonstrated that **starch plays a central role in the development of the risen structure** of bread during baking, but there has been **little response** within the research community, despite **strongly indicative results**. As early as 1951, Rotsch asserted that gluten is not essential to the gas cell structure, that its only function is to bind the starch granules to each other and that this can be performed by other molecules. This has been confirmed in very recent work by the degree of expansion and the fineness of the crumb obtained using gluten-free formulae derived from certain starches. However, **the fundamental properties in such starches that produce the aerated structure are still to be identified.**

In this thesis, the successful candidate will, it is hoped, identify the properties that bring about the different functionalities of starch and will use these findings to test different botanical sources of starch. In order to establish the best variety, the key criteria for organoleptic quality in this food product will be taken into account, but it is also hoped to include the properties of the starches during retrogradation as a factor. **The objective of the thesis is to monitor these mechanisms as they occur during baking, cooling and storage, and to link them to crumb textures for bread doughs prepared using starch from different gluten-free varieties.**

The experimental approach will be based on quantitative measures at low field NMR. The originality of these measures will reside on the dynamic approach, in real-time during baking and the use of mixtures of flour at low water content. We will focus on two-dimensional D - T2 and T1 - T2 methods developed at the laboratory. A part of the thesis will be also devoted to assessment of the interest of measures using NMR coupled to rheology (Rheo-NMR). In addition, various traditional methods of characterization of cereal products will be used (DSC, DRX, RVA, Swelling factor).

Supervision: Corinne Rondeau-Mouro HDR, Tiphaine Lucas HDR
Team partner: David Grenier

Working Environment:

The thesis forms part of two joint projects currently in preparation. The first has been submitted as part of the general 2019 ANR funding round (in partnership with INRA, CIRAD, LESAFFRE and EUROSORGHO) and the outcome will be known in July 2019. The other has been submitted to the COFECUB call for projects (with UNICAMP, USP and EMBRAPA in Brazil) and the outcome will be known very soon. If these bids are successful, the doctoral student will work alongside Irstea's project partners and will also benefit from their expert knowledge, particularly that relating to starches from different botanical sources (CIRAD Montpellier, UNICAMP) and gluten (INRA Montpellier).

The supervision provided at IRSTEA 's Rennes Centre offers a broad multidisciplinary spectrum of expertise, from **analytical** chemistry to the **functionality** of materials that contribute to the development of the gas-cell structure in bread during the baking **process.** C Rondeau-Mouro specializes in NMR, particularly for bio-polymers including starch and its transformations. T Lucas is an expert in process engineering, specializing in the baking process of bread doughs. D Grenier is an expert in mechanical structures and measurements and on the baking process. This combination of skills in a single laboratory is unique in France. The team publishes in the top quartile of publications in its field and, where possible, in the top five journals.

Last, it should be noted that the host research team is equipped with its own full range of bread manufacturing devices. In addition, it has access to NMR high and low field spectrometers (0.2 T, 0.47 T and 11.7 T) and has developed (with the École Centrale de Nantes) innovative signal-processing methods (EMILIO-FID©) not used by other teams in the field. The applicant will benefit from the professional support of an NMR technician and a physical measurements engineer.

Qualifications, knowledge and skills:

Applicants must have fully completed a Masters by research (or equivalent) in Engineering Sciences, Analytical Chemistry, Physicochemistry, or Biochemistry

They must have a good knowledge of analytical methods and physical measurements, preferably in NMR and/or MRI.

Knowledge in the fields of Food Sciences and Biochemistry and in signal processing are desirable. The candidate must also have the following skills:

- Excellent understanding of experimental approaches
- Proven ability in the writing of reports, presentations and, if possible, scientific articles
- Very good command of English

Thesis Starting Date: October 2019

Remuneration: € 1874.41 gross/month

Contact

Applications (CV, Covering Letter setting out reasons for applying accompanied by one or, ideally, two supporting letter(s)) should be submitted **17, April 2019** to:

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Please note that the final application (end of April) must include an in-depth analysis of the research topic based on the relevant scientific articles available in the literature and setting out feasible lines of investigation.