Post-doctoral position

Understanding and modeling browning reactions to predict the storage stability of dairy powders

Context and objective

Many food products are processed into powders because this dry form extends their shelf life while facilitating storage and transport through reduced water content and volume. The dairy sector is no exception, with 12 million tons of dairy powders produced annually worldwide, allowing their storage for 1 to 3 years. Despite this extended shelf life, several chemical and physical phenomena can occur in the dry state and during storage, namely browning reactions, and caking. All these phenomena, collectively referred to as aging, can deteriorate product quality (organoleptic, nutritional, microbiological, functional - particularly rehydration capacity) [1]. It is therefore essential to understand the mechanisms behind these changes to predict the shelf life of powders, especially in a context of global trade and climate change where these products are often exposed to temperatures of 60°C or higher for several weeks [2].

The mechanisms of browning reactions in dairy powders are not fully understood. Many studies are conducted on simplified liquid model systems [3], [4], [5], which do not account for the spatio-temporal heterogeneity of temperature and concentration within a solid matrix, followed by phase changes. The results are therefore not transferable to powders [6], [7]. The existing literature on dairy powders highlights the influence of various parameters (composition, water activity, temperature, *etc.*) but is insufficient and sometimes contradictory in elucidating the mechanisms of browning reactions. This is particularly due to several levels of reaction complexity: i) several types of reactions can occur simultaneously from the same reducing sugar or protein; ii) the simultaneous presence of multiple precursors (reducing sugars, amino groups) whose type, quantity, and availability vary depending on powder composition [8], [9] et iii) difficulty in measuring quantitatively relevant reaction markers.

Thus, the objective of this post-doctoral position is to better understand the reaction mechanisms of browning in model dairy powders during storage, through the identification of the involved reaction scheme and kinetic modeling.

Missions

The recruited person will be responsible for:

i) Definition of model powder compositions and identification of reaction markers

- selection of precursors and construction of reaction schemes based on literature;
- development/optimization of analytical methods to quantify reaction markers.

ii) Study of reaction dynamics during storage:

- production of model powders at pilot scale and storage under controlled conditions;
- monitoring of reaction markers and kinetic modeling.

Required profile

Education: PhD in Chemistry, Chemical Engineering or Food Science.

Skills:

- Mastery of analytical techniques (LC, GC, spectroscopy)
- Experience in kinetic modeling (Python, Matlab, R)
- Knowledge of chemistry and physico-chemistry of food matrices.

Desired qualities:

- Scientific curiosity and ability to take the initiatives
- Autonomy, rigor, and strong organizational and teamwork skills.
- Proficiency in English (writing articles, conference presentations).

Work environment

The recruited person will carry out their activities within the Process-Structure-Functionality (PSF) team of the Joint Research Unit Science and Technology of Milk and Eggs (UMR STLO) (https://eng-stlo.rennes.hub.inrae.fr/). This work is part of the "Predicting the browning of dairy powders by kinetic modeling of Maillard reaction and caramelization during drying and storage (MARACAS)" project, funded by the French National Research Agency (ANR) under the Generic Call for Projects (AAPG) 2025.

STLO aims to generate knowledge about milk and egg and their transformation into ingredients or finished products for human consumption. By leveraging expertise in biochemistry, physico-chemistry, process engineering, physics, technology, and microbiology, its goal is to contribute to safe, healthy, and nutritious food that respects the environment and meets the needs of specific populations.

STLO is equipped with state-of-the-art facilities to support its multidisciplinary research activities. The dairy platform offers pilot scale equipment with advanced instrumentation capabilities. The unit also has high-performance tools for chemical, physical, and microbiological analyses, specifically adapted for dairy products. The recruited person will fully benefit from these resources to successfully carry out the required tasks, under the supervision of two permanent members (Jeehyun Lee and Thomas Croguennec) from STLO.

Employment conditions

Contract: 18-month fixed-term contract (post-doctoral position)

Salary: From €3,000 gross per month (depending on experience)

Location: 65 rue de Saint-Brieuc, 35000 Rennes, France

Start Date: From January 1st 2026

Application process

Submit applications to jeehyun.lee@institut-agro.fr by September 30 2025

- Detailed CV (including publications)
- Cover letter
- Contact information for two academic references.

[1] Phosanam, A., Chandrapala, J., Zisu, B., & Adhikari, B. (2021). Storage stability of powdered dairy ingredients: a review. Drying Technology, 39(11), 1529-1553.

[2] Leinberger, D., (2006). Ocean container temperature and humidity study. Dimensions., 6.

[3] Buera, M. D. P., Chirife, J., Resnik, S. L., & Wetzler, G. (1987). Nonenzymatic Browning in Liquid Model Systems of High Water Activity: Kinetics of Color Changes due to Maillard's Reaction Between Different Single Sugars and Glycine and Comparison with Caramelization Browning. Journal of Food Science, 52(4), 1063–1067. https://doi.org/10.1111/j.1365-2621.1987.tb14276.x

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[6] Martins, S. I. F. S., Jongen, W. M. F., & van Boekel, M. A. J. S. (2000). A review of Maillard reaction in food and implications to kinetic modelling. Trends in Food Science & Technology, 11(9–10), 364–373. https://doi.org/10.1016/S0924-2244(01)00022-X

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[8] Norwood, E. A., Pezennec, S., Burgain, J., Briard-Bion, V., Schuck, P., Croguennec, T., Jeantet, R., & Le Floch-Fouéré, C. (2017). Crucial role of remaining lactose in whey protein isolate powders during storage. Journal of Food Engineering, 195, 206–216. https://doi.org/10.1016/j.jfoodeng.2016.10.010

[9] Paul, A., Gaiani, C., Cvetkovska, L., Paris, C., Alexander, M., Ray, C., Francius, G., El-Kirat-Chatel, S., & Burgain, J. (2022). Deciphering the impact of whey protein powder storage on protein state and powder stability. Journal of Food Engineering, 326, 111050. https://doi.org/10.1016/j.jfoodeng.2022.111050