Plant-based and cheese-like

Creating functional plant proteins for cheese curd (PlantCurd)

There is an ever-increasing focus on producing food in a more sustainable fashion, and milk-based products have been identified as a focus area due to their contribution to greenhouse gas emissions. Substituting animal with plant-based proteins in foods is desired for both sustainability and health. Seed storage proteins of legumes, oilseeds, and cereals offer a large potential as protein sources for the future, however, obtaining the required functionality is challenging, as they are complex, and vastly different to milk proteins.

Generally, proteins for food have two main complementary functions: i) Biofunctionality related to the nutritional and physiological properties of the proteins (i.e., amino acid content and composition and digestibility), and ii) techno-functionality related to physico-chemical properties of proteins affecting solubility, viscosity, foaming, emulsifying, and gelling ability.

The challenge with plant-based "cheese"

Most of the plant-based "cheese" products today have a huge quality and taste trade-off compared to conventional dairy cheeses *(please note that cheese is a legally protected name, so inverted commas are used here).* Current plant-based dairy-cheese alternatives appeal to consumer segments such as vegans and flexitarians focusing on animal welfare, sustainability, and health. However, nutritionally the products are very poor when compared to dairy cheese, because they contain a minimum of protein – in most cases only 2-4%, which is substantially lower than traditional cheese.

Cheese is not as easy to mimic as other dairy alternatives (e.g., plant-based "yoghurts"), and thus requires a more technically advanced approach than what is currently applied. Today's plant-based "cheeses" are produced by blending and homogenising the ingredients (water, oil, starch, aroma, and colour) followed by heat treatment. This calls for a more advanced approach in order to produce plant-based "cheeses" which are of high sensory, functional and nutritional quality.

The project

In this project we aim to produce plant-based and mixed plant-and-dairy-based curds with





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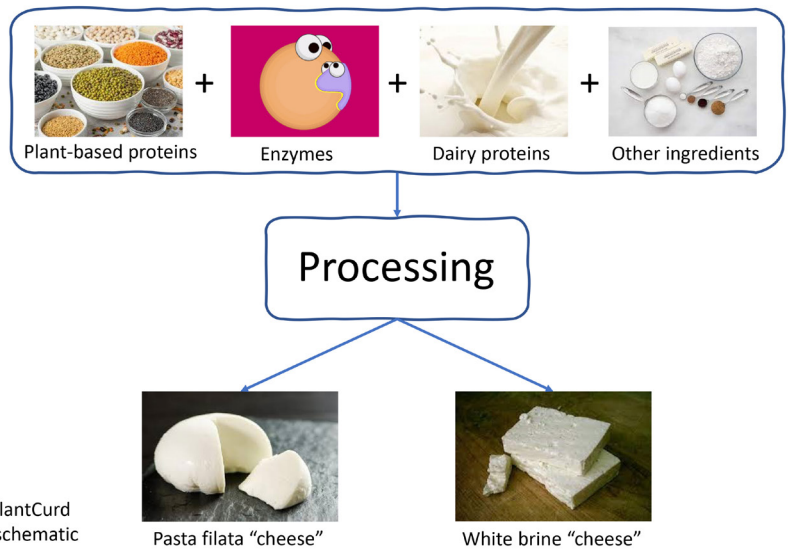

Figure 1: PlantCurd workflow schematic

Project Info

Title: PLANTCURD: Functional Plant Proteins for Cheese Curd
Project manager: Professor Poul Erik Jensen, Department of Food Science, University of Copenhagen
Participants: Arla Foods A.m.b.a.
Project Period: May 2022 – June 2025
Objective: To produce plant-based curds with diverse cheese-like functionalities.
Project under Danish Dairy Research Foundation

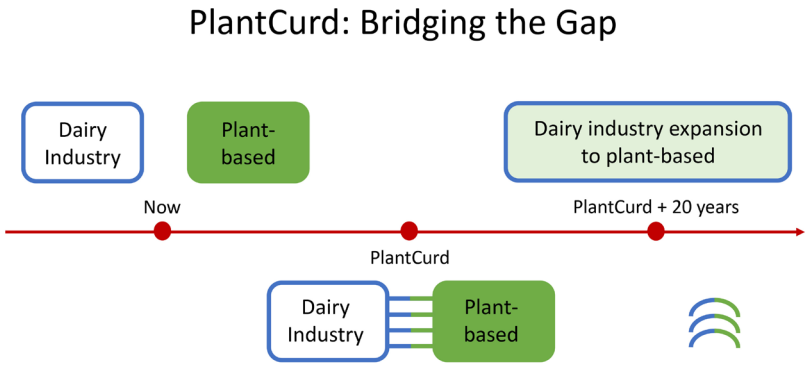

Figure 2: The vision of PlantCurd

diverse cheese-like functionalities. Brittle and crumbly curds will be developed to produce white-brined cheeses, while elastic and rubbery ones will be developed to produce products mimicking pasta-filata cheeses.

We will deliver the scientific knowledge required for producing consumer acceptable plant-based "cheese" products. In order to achieve this goal, various plant proteins, from crop plants that can be grown in Denmark, will be modified using specific enzymes and incubation conditions.

Specifically, the plant proteins will be modified using enzymes (different types of proteases like cysteine-, serine-, aspartic- and metallo-proteases) to produce functional protein building blocks. The proteases will cut the large plant proteins into smaller and more soluble peptides.

We will exploit the fact that seed storage proteins are compactly folded, presenting only a few vulnerable regions for initial proteolytic digestion. In this way we can achieve partial hydrolysis of the large plant proteins resulting in protein building blocks. Other enzymes like protein-glutaminase will convert solvent exposed glutamine residues to glutamate and thereby change the surface properties of the proteins. Type and combination of enzymes and conditions (pH, temperature, and incubation time) will be optimized.

The building blocks will next be treated with yet another enzyme, transglutaminase, that will create cross-links between glutamine and lysine residues in neighboring protein building blocks and thereby coagulate the building blocks to create a curd. Fermentation of the protein building blocks with lactic acid bacteria and added sugars will be used as an alternative approach to create acid-induced protein gels.

These modified plant proteins will then exhibit many of the important functions found in dairy proteins such as gelling or aggregation. The project will next focus on the production of the plant-based "cheese" products. As a minimum, the project will deliver test products such as pasta-filata and white-brine cheeses that are superior to plant-based "cheese" products that are currently on the market.

Industry benefit from this research

PlantCurd will focus on plant-based "cheeses" to the global market. The plant-based "cheeses" will be suited to the vegan and flexitarian segments and will have the largest impact on sustainability. The final product quality of the cheeses will determine the size of the market segment for the plant-based "cheeses". This project is forward looking in terms of addressing the sustainability issue, which poses a challenge to the dairy industry. The project will equip the Danish dairy industry with technical solutions and knowledge to adapt quickly to an ever-changing market and industry environment.

Mozzarella and white-brine cheeses correspond to approximately half of the cheeses produced in Denmark, so making even a partial switch from dairy to plant (or mixed) proteins can potentially result in a significant reduction in the carbon footprint. This transition will be gradual (over the next 10-15 years) and will be a supplement to current cheeses and a decent alternative compared to the plant-based "cheese products" currently on the market. The food quality and safety profiles of the plant-based "cheeses" is assumed to be similar to conventional products as only food grade proteins and enzymes will be used. Long-term (15-20 years), PlantCurd can potentially lead to a significant reduction in Green House Gas Emissions while contributing to dairy industry expansion to the "plant" domain. The production of 1 kg of dairy protein corresponds to 25 kg CO_2 eq, while 1kg of plant protein corresponds to only 2 kg CO_2 eq (i.e., 12.5-fold less).

Summary

There is an increasing interest in producing food in a sustainable fashion. Seed storage proteins has potential as a future protein sources, however obtaining the required functionality is challenging. Cheese is not easy to mimic with plant proteins and it requires a more advanced approach than what is currently applied. In the project, we aim to produce plant-based and mixed plant-and-dairy-based curds with cheese-like functionalities. The plant proteins will be modified using enzymes to produce smaller proteins with many of the important functions found in dairy proteins such as gelling or aggregation. The project will equip the Danish dairy industry with technical solutions and knowledge to create new products.