



Systems biology applied to cheddar production

Duration: 2014 – 2018

Highlights

- One of the challenges in the milk processing industry is producing high quality cheeses on a consistent basis.
- Many factors influence quality, including the microbiological composition of milk and the effectiveness of starter cultures and bacteriophages.
- This project investigates these factors using a “systems biology” approach to better understand the impact of the microbiological network on cheddar production.
- Systems biology integrates different levels of information to develop an operating model for the entire system.
- Systems biology uses techniques to quantify changes in the genome, transcriptome, proteome and metabolome in response to a given situation (cheddar, in this case).
- This ambitious project will generate new results that will put dairy processors in a very competitive position internationally.
- Functional assembly (from the genome to the metabolome) will also provide added-value in order to better understand and intervene in regards to the major variables affecting these products.

Objectives

- OBJECTIVE 1 - Determine the microbiome and virome of milk and cheddar.
- OBJECTIVE 2 - Determine the microbial and viral transcriptome of milk and cheddar.
- OBJECTIVE 3 - Determine the microbial and viral proteome of milk and cheddar.
- OBJECTIVE 4 - Determine the metabolome of milk and cheddar.
- OBJECTIVE 5 - Determine the biology of the cheddar system. This inclusive objective will allow us to pinpoint trends during the ageing process for cheddar. A mathematical algorithm which will use all of the information produced (OBJECTIVES 1 to 4) will be developed to calculate divergence between the samples.

Results and potential benefits

- OBJECTIVE 1: Various batches of Cheddar cheese are monitored after the first day of production and then at various intervals. A protocol has been adapted to separate bacteria and phages from milk matrices. A number of new *Lactococcus lactis* genomes (draft) are now available. We have also built a database containing sequences of DNA from microbial species known to be part of the microbiome of various cheeses. The microbiome of approximately 60 cheeses is already available.
- OBJECTIVE 2: We have developed a protocol for isolating RNA from dairy samples (milk, cheese).
- OBJECTIVE 3: Using different proteomic approaches and a *Lactococcus lactis* bacteriophage model system, we were able to detect 78% (38/50) of the phage proteins and 56% (1,332/2,383) of the bacterial proteins. We have identified 209 *L. lactis* proteins that are uniquely expressed during infection through p2 phage.
- OBJECTIVE 4: We have developed a protocol for extracting and analyzing non-volatile metabolites and lipids contained in cheese using LC-MS-MS. We have generated over 750GB of data for approximately 60 cheeses. Our preliminary tests have showed great metabolic and lipid diversity in the analyzed samples. We have observed both increases and decreases in ions based on the ageing stage of the cheese. The identified metabolites could serve as a marker of quality and be linked with certain organoleptic properties.
- OBJECTIVE 5: This last integrating objective is not yet completed. Ultimately, we will propose a mathematical algorithm that will integrate all of the data. It will allow us to pinpoint trends during the cheese ageing process and identify specific indicators of cheddar quality. Ultimately, this approach will create a network which will allow for interpretation of the microbial and viral composition of cheddar. It will also provide new insights on how to modulate the ageing process in order to improve consistency and quality.



Professionals trained

Marie-Laurence Lemay, PhD student in microbiology

Pier-Luc Plante, PhD student in bioinformatics

Alexia Lacelle-Côté, master's student in microbiology

Frédéric Raymond, post-doctoral researcher in bioinformatics

Simon Labrie, post-doctoral researcher in microbiology

Jessie Bélanger, undergraduate student in microbiology

For further information

Information will primarily be distributed in two ways:

- The knowledge acquired, as well as a user-friendly bioinformatic tool, will be made directly available to dairy farmers through meetings with members of the Novalait steering committee and during the Novalait Techno Forum.
- We also plan to publish our results in respected international journals with the review committee (for example, Appl. Environ. Microbiol.).

Financial contributions

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- Fonds de recherche du Québec – Nature et technologies
- Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec
- Novalait

The industrial partner has provided cheese and lactic ferments.

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Contact persons

Project supervisor:

Sylvain Moineau

Department of Biochemistry
Microbiology and Bioinformatics

Université Laval
1045 av. de la Médecine
Quebec City (QC) G1V 0A6

418 656-3712

sylvain.moineau@bcm.ulaval.ca

<http://www.moineau.bcm.ulaval.ca>

Contributors:

Jacques Corbeil

Université Laval

Alexander Culley

Université Laval