Would a breakthrough cheese technology be accepted by the consumer?
Marielle Harel-Oger, Christophe Martin, Stephan Marette, Julien Chamberland, Gilles Garric

To cite this version:
Marielle Harel-Oger, Christophe Martin, Stephan Marette, Julien Chamberland, Gilles Garric. Would a breakthrough cheese technology be accepted by the consumer?. ADSA Annual meeting 2023, American dairy science association, Jun 2023, Ottawa, Canada. hal-04150037

HAL Id: hal-04150037
https://hal.inrae.fr/hal-04150037
Submitted on 4 Jul 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives| 4.0 International License
Would a breakthrough cheese technology be accepted by the consumer?

Marielle HAREL-OGER¹, Christophe MARTIN²,³, Stephan Marette⁴, Julien CHAMBERLAND⁵, Gilles GARRIC¹

¹ INRAE, Institut Agro Rennes-Angers, UMR1253 STLO, Rennes, France,
² Centre des Sciences du Goût et de l’Alimentation, CNRS, INRAE, Institut Agro, Université de Bourgogne, F-21000 Dijon, France,
³ PROBE research infrastructure, Chemosensfacility, F-21000 Dijon, France
⁴ Université Paris-Saclay, INRAE, AgroParisTech, Paris-Saclay Applied Economics, 91120 Palaiseau, France,
⁵ STELA Dairy Research Center, Institute of Nutrition and Functional Foods (INAF), Department of Food Science, Université Laval

www6.rennes.inrae.fr/stlo
www6.rennes.inrae.fr/plateforme_lait

#ADSA2023
Outline

1. Why innovate?
2. How can we innovate in cheese technology?
3. Would a breakthrough cheese technology be accepted by the consumer?
4. Questions in progress
5. Conclusion and perspectives
Because the context is evolving constantly ... and we have to adapt

Resources are limited

... Cheese processing is energy and water-intensive and pollutes

Energy, water and pollution

- Scarcity of resources and ... a rise in prices
- **Water** scarcity: -15% of renewable water resources in France in 20 years
- Growing greenhouse gas (55.6 Gt CO₂ eq in 2020, + 55% between 1990 and 2019)

<table>
<thead>
<tr>
<th>Prices</th>
<th>Δ (2021%2020)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>+6.6%</td>
</tr>
<tr>
<td>Gas</td>
<td>+33.2%</td>
</tr>
<tr>
<td>Oil</td>
<td>+21%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cheeses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Needs in Energy</strong></td>
</tr>
<tr>
<td><strong>Needs in fresh water</strong></td>
</tr>
<tr>
<td>Kg eq CO₂/ Kg cheese</td>
</tr>
<tr>
<td>Wastewater</td>
</tr>
<tr>
<td>Whey</td>
</tr>
</tbody>
</table>

Processes must be (more) sustainable/effective: energies, water, materials
Because the context is evolving constantly ... and we have to adapt

**Demand:** (urban) **population growth** and... (9,8 B 2050)

People will continue to eat cheeses in the next decade
- 1/3 of the milk converted into cheese at a global scale (**2022 = 23 Millions T**)
- Especially in **emerging countries**/less in developed countries

<table>
<thead>
<tr>
<th>FAO Perspectives</th>
<th>2022</th>
<th>2031</th>
<th>Δ (%/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World cheese consumption (kT)</td>
<td>25500</td>
<td>28136</td>
<td>+1,15%</td>
</tr>
<tr>
<td>Developed countries consumption (kT)</td>
<td>19806</td>
<td>21393</td>
<td>+0,9%</td>
</tr>
<tr>
<td>Emerging countries consumption (kT)</td>
<td>5694</td>
<td>6743</td>
<td>+2%</td>
</tr>
</tbody>
</table>

But: uses evolved, ... are evolving and will continue to evolve
- **Shift** from cheese board to ingredients with **functional properties**:
  - More than **55% in France** and > **80% in emerging countries**
    - sliceability, shreddability, meltability, stretchability, ...

Cheeses must be adapted to their new uses: functionals/new textures - Flavours

#ADSA2023
## Obesity and related diseases ...

### Growing obesity in France by age

<table>
<thead>
<tr>
<th>Obese</th>
<th>1997</th>
<th>2009</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24 years old</td>
<td>2.1%</td>
<td>4.0%</td>
<td>9.2%</td>
</tr>
<tr>
<td>35-44 years old</td>
<td>7.7%</td>
<td>13.9%</td>
<td>16.7%</td>
</tr>
<tr>
<td>&gt;65 years old</td>
<td>11.2%</td>
<td>17.9%</td>
<td>19.9%</td>
</tr>
</tbody>
</table>

Because **the context** is evolving constantly ... and we have to adapt.

French National Institute of Health and Medical Research

Cheeses must be healthier less: fat, salt and with: microorganisms, probiotics

A lot of expectations and specifications to solve for designing new products

**But: new knowledge** allows us to adapt to new needs and constraints:

* Metagenomic/meta-transcriptomic methods **are effective** to understand new routes for producing **molecules** of interest for **taste** and health (**vitamins**)

* **Decoupling** technological parameters permits **to improve process efficiency/new uses**

#ADSA2023
How can we innovate in cheese technology?

Example of an innovative process by decoupling texture and flavour: GARRIC and al WO 2016/108024

From ‘Innov Process: reorganize and optimize these 4 stages

Traditional cheese making

Long time

Milk

Standardisation

Coagulation

Draining & acidification

Moulding

Salting

Ripening

Cheese

Pasteurisation/Skimming

Membrane filtration

Texture base (LiqPreCheese)

- Protein/Fat
- Whey Protein denat°
- Mineral°
- Lactose
- Accurate biochemical characteristics

90-99%

Coagulation

Mixing

Salting / pH

90-99%

1-10%

1-5 days

Dairy substrates

Controlled bioreactors

Optimized T°, pH, O₂

Selected microorganisms

Flavour bases: 1 to 4

Cheese

Standardisation

Coagulation

Draining & acidification

Moulding

Salting

Ripening

Cheese

Accurate biochemical characteristics

90-99%
A large range of texture: by controlling...

- **LLOYD texture meter TA +**: 50 N force applied on a 1 cm diameter disk
- Firmness defined as the max force reached at the first displacement of the probe

Large range of texture obtained from the coagulation step

- **Strong influence** of **pH** and **temperature**
- No influence of coagulant and NaCl content
- **Firmness** ranging from **spreadable to firm** (semi hard cheese)

Texture Profile Analysis

- **LLOYD texture meter TA +**: 50 N force applied on a 1 cm diameter disk
- Firmness defined as the max force reached at the first displacement of the probe
Designing the flavour bases

4 microbial species

- Lactococcus lactis
- Hafnia alvei (HA)
- Yarrowia lipolytica (YL)
- LL + HA + YL

Types and doses of MO => mimic existing cheeses or to create new flavours/complex-strong

Blind test

Flavour Intensity score (mean 12 judges)

- Control
- Lactococcus lactis
- Hafnia alvei (HA)
- Yarrowia lipolytica (YL)
- LL + HA + YL

Descriptors and flavours

- Mild
  - Butter
  - Cauliflower
  - Lipolysed, rancid
- Complex
  - Fruity

Sensory analysis

- Panel of experts, 12 judges
- 5 points rating scale

Culture

- Optimized growth conditions (substrates, T°, pH, O₂, time…)
- Production of key flavour compounds

Molecules

- Diacetyl
- Sulfur compounds
- Branched-chain alcohols
- Short-chain fatty acids
- Methyl ketones
- Branched-chain aldehydes
- Propionic acid

GC-MS analysis

- off flavour compounds

H. alvei + Y. lipolytica

K. lactis

Lactococcus lactis

Hafnia alvei

Yarrowia lipolytica

Lipolysed, rancid

Fruity

Complex

Semi hard cheese

Soft cheese

[Propio freudenreichii]

Yarrowia lipolytica

Hafnia alvei

Lactococcus lactis

Control

Blind test

Types and doses of MO => mimic existing cheeses or to create new flavours/complex-strong

#ADSA2023
• The objective of the work was to study the reaction of consumers to a radically new manufacturing process applied to a traditional product like Camembert.

Method: a traditional cheese and two cheeses resulting from a new sustainable process were evaluated by 142 consumers (compared acceptability)

Commercial traditional bloomy soft cheese (CC): Ortolan® Milleret Bourgogne, France

Mild flavoured New Cheese (MFNC) => buttery notes (From’Innov process)

Typical Flavoured New Cheese (TFNC) => copying a Camembert (From’Innov process)
Raw Whole milk
- Pasteurisation (92°C/2 min)
- Cooling (4°C/15h)
- Heating (50°C)
- Ultrafiltration
- Filtration retentat*

Hafnia alvei *
Yarrowia lipolytica*

Growth factors
- Culture in fermentation reactor (30°C/2 or 3 days)
- pH, redox, O²

Aromatic NIZO

Texture matrix
- Geotrichum candidum
- Penicillium camemberti (surface flora)

Aromatic matrices
- Mixing [GDL*], NaCl
- Acidification (27°C/30 min/pH 5.6 +/- 0.1 upH)
- Molding (silicone moulds)
- Incubation (25°C/2 h)
- Cooling (< 6°C/15h)
- Ripening (15°C, 2 days/12°C, 7 days, 95%HR)

Accurate flow chart used Principle of the From’Innov new two cheeses
The * indicates the differences between the two experimental cheeses

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>TF</th>
<th>MF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtration retentat</td>
<td>90.5</td>
<td>95.2</td>
</tr>
<tr>
<td>Hafnia alvei</td>
<td>4.0</td>
<td>-</td>
</tr>
<tr>
<td>Y lipolytica</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>Aromatic NIZO</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Surface flora</td>
<td>2 doses</td>
<td>2 doses</td>
</tr>
<tr>
<td>NaCl</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Glucono Delta Lactone</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Typical Flavoured New Cheese
Mild Flavoured New Cheese

Constant and less polluted by-product

10 days
Method: 5 stages

1. Blind test ⟷ First evaluation: 1. the subjects were asked to rate how much they liked each cheese on a 10-points linear scale.

Ex: cheese N° 1, 2, and 3

I don’t like it at all (0)  I really like it (10)

Overall liking score for the 3 cheeses obtained using an unstructured linear scale, ranging from “I don’t like it at all” (left end, score = 0) to “I really like it” (right end, score = 10).
1. Blind test 2. the subjects had to give their Willingness To Pay (WTP) for each cheese using a multiprice list

The subjects had to tick the price point they considered acceptable for each cheese.
2. Blind test  The subjects were asked to successively taste the three cheeses and specify their level of satisfaction with the intensity of nine sensory properties with a Just About Right scale: JAR penalty analysis

Penalty analysis: Percentage of responses on the x-axis and the penalty scores on the y-axis (mean drops). In red, the properties perceived as too intense / present. In blue, properties perceived as not intense / present enough. In grey, the sensory properties for which the response percentage is too low to conclude (< 25% of the panel).
3. Information: we then gave subjects information about the manufacturing processes of the three cheeses, the subjects had to give their WTP: WTP2

“A new manufacturing process has been developed by INRAE. It makes it possible to obtain cheeses by following a manufacturing process different from the traditional process. Compared to the traditional cheese-making process (coagulation, draining, salting then ripening), the new process reorganizes and optimizes the manufacturing phases (draining, salting, ripening and coagulation). The optimization of the stages makes it possible to obtain a finished product that can be consumed 10 days after manufacture, compared to 20 days for a conventional process.”

4/5. Information: The subjects received information concerning the advantages for the sustainability (Group 1) or health (Group 2) linked to the new cheese-making process and then had to give their WTP again: WTP 3 and WTP 4

CHAMBERLAND and al, Journal of Cleaner Production - 2019

From’Innov

<table>
<thead>
<tr>
<th>Biochemical characters</th>
<th>CC</th>
<th>Mild F</th>
<th>Typical F</th>
<th>Δ NC/CC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl % (m/m)</td>
<td>1.53</td>
<td>1.18</td>
<td>1.21</td>
<td>- 22%</td>
</tr>
<tr>
<td>Fat % (m/m)</td>
<td>30</td>
<td>21.5</td>
<td>21</td>
<td>- 29%</td>
</tr>
<tr>
<td>Dry Matter % (m/m)</td>
<td>50</td>
<td>44.6</td>
<td>44.2</td>
<td>- 11%</td>
</tr>
<tr>
<td>Ca mg (m/m)</td>
<td>429</td>
<td>531</td>
<td>539</td>
<td>+ 20%</td>
</tr>
</tbody>
</table>

6. Questionnaire: We did a demographic profile and a short study of subjects’ consumption of cheeses

#ADSA2023
Results

1. The CC cheese was preferred in the blind test and WTP 1 higher as a consequence

Overall Liking scores obtained by the three products (average liking score, standard error, and p value from the Tukey HSD test).

Proof of concept and not commercialized cheese

Evolution of Willingness To Pay (WTP) during the experiment

Δ** denotes significant difference at 1% as tested by the Wilcoxon test

Ortolan: CC
Flavoured Cheese: TFNC
Mild (flavoured) cheese: MFNC
2. Information on the classic versus innovative process significantly increase the WTP gap:
   - Significantly due to the increase in Commercialized Cheese (CC)
   - Non significantly due to the decrease in New Cheeses (NC)

3. However, information on health and sustainability (or the inverse) narrowed the WTP gap significantly
   - Without significant differences in any order of information

4. Finally, the WTP for the 2 NC were not significantly different with the CC
   - Despite all the information (perceived negatively then positively) the final score for the 2 NC is significantly higher than the initial assessment, and equal for the CC

Δ** denotes significant difference at 1% as tested by the Wilcoxon test
1. **By testing** the effects of a lower NUTRISCORE (from D to C) and the addition of probiotics on subjects’ WTP

We are able to decrease fat and salt to reach a C NUTRISCORE and add probiotics without bad acceptance.

2. **By testing** a semi hard cheese produce with the new technology with functionalities (meltability, stretchability, sliceability and shreddability) ... and new flavours on subjects’ WTP (very challenging)

We are able to obtain a better sustainability with a shorter ripening and create new flavours.
Questions in progress

3. Then: How to adapt new products to market expectations

1. to copy or to improve existing products

2. to create new products:

“How to obtain aroma in solubilized soft cheese” by Marielle HAREL-OGER (as we did for the Typical flavoured camembert): very new!

Despite the buffering capacity => (upcoming publication)

The spyder diagram (JAR) permits us to understand how to modulate parameters to join market expectations.

Commercial  Typical Flavoured NC  Mild Flavoured NC  Just right
1. Because the trade in cheese will go on and increase, **we have patented this uncoupling technology by drying simultaneously or separately the texture matrix and flavour matrices (EP3240430A1).**

We have now to **measure** by **Life Cycle Analysis** the **footprint of this technology** in comparison with the others.

2. Because rehydrating cheese powder is convenient (in some countries without dairy sector), **we develop new powders with functionalities and flavours** for domestic or industrial uses.

---

**Cheeses will continue to be traded ...**

- 14% of the world cheese production is traded
- +15% at a global scale 2015/2021 vs +29% 2021/2030 in China

---

**Questions in progress**

Finally... the next frontier will be:

**CNIEL 2022**
**OECD-FAO 2022**
These results show that:

There is no major opposition to the application of technological innovations to traditional products such as cheese and: for a new technology information concerning health and sustainability is positively accepted.

1. We copied a Camembert cheese but for the future we are able to propose breakthrough cheeses
   * for Western countries: sweet cheeses with different layers, texture, flavours, presentation
   * or for Emerging countries: healthier, sustainable and adapted to demand: => acceptability/need?

2. Can we adapt this technology to plant based product?

3. The last stage will be to understand if the dairy sector is ready to adopt such a technology: who could appropriate it and when? Major industries, SMI, farmers, artisans, ...
Thank you for your attention
www6.rennes.inrae.fr/stlo
www6.rennes.inrae.fr/plateforme_lait

For more information: gilles.garric@inrae.fr
33(0)7 60 32 85 91

Marielle HAREL-OGER¹, Christophe MARTIN²,³, Stephan Mariette⁴, Julien CHAMBERLAND⁵, Gilles GARRIC¹

¹: INRAE, Institut Agro Rennes-Angers, UMR1253 STLO, Rennes, France,
²: Centre des Sciences du Goût et de l'Alimentation, CNRS, INRAE, Institut Agro, Université de Bourgogne, F-21000 Dijon, France,
³: PROBE research infrastructure, Chemosensfacility, F-21000 Dijon, France
⁴: Université Paris-Saclay, INRAE, AgroParisTech, Paris-Saclay Applied Economics, 91120 Palaiseau, France,
⁵: STELA Dairy Research Center, Institute of Nutrition and Functional Foods (INAF), Department of Food Science, Université Laval, Québec, Canada