Would a breakthrough cheese technology be accepted by the consumer?

Marielle Harel-Oger, Christophe Martin, Stephan Marette, Julien Chamberland, Gilles Garric

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Would a breakthrough cheese technology be accepted by the consumer?

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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*

1 • *Why innovate?*

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 CO_2 eq in 2020, **+ 55%** between 1990 and 2019)

Prices	Δ (2021%2020)
Electricity	+6.6%
Gas	**+33.2%**
Oil	**+21%**

Processes must be (more) sustainable/effective:
energies, water, materials

	Cheeses
Needs in Energy	**4.9 – 8.9** MJ/kg cheese
Needs in fresh water	**1.2 – 3.8** l/l milk
Kg eq CO_2/ Kg cheese	~ **1** [0.6 Fresh – 1.2 Hard]
Wastewater	**0.9+/- 0.5** l/l milk
Whey	90% of the milk

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

FAO Perspectives	2022	*2031*	Δ (%/y)
World cheese consumption (kT)	**25500**	*28136*	+1,15%
Developed countries consumption (kT)	**19806**	***21393***	**+0,9%**
Emerging countries consumption (kT)	**5694**	***6743***	**+2%**

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

Obesity and related deseases …

Growing obesity in France by age

Obesity	1997	2009	2020
18-24 years old	2.1%	4.0%	9.2%
35-44 years old	7.7%	13.9%	16.7%
>65 years old	11.2%	17.9%	**19.9%**

Because the context is evolving constantly … and we have to adapt

Inserm

French National Institute of Health and Medical Research

NUTRI-SCORE A B C D E

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**

2 • *How can we innovate in cheese technology?*

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

Traditional cheese making

Long time

Milk

Standardisation

Coagulation

Draining & acidification

Moulding

Salting

Ripening

Cheese

Milk

Pasteurisation/Skimming

Membrane filtration

Texture base (LiqPreCheese)

- *Protein/Fat*
- *Whey Protein denat°*
- *Mineral°*
- *Lactose*

90- 99%

Accurate biochemical characteristics

Dairy substrates

Controlled bioreactors

Optimized T°, pH, O_2

Selected microorganisms

Flavour bases: 1 to 4

Mixing

Salting / pH

Coagulation

1 - 10%

Short time

1-5 days

Cheese

From'Innov Process:

reorganize and optimize these 4 stages

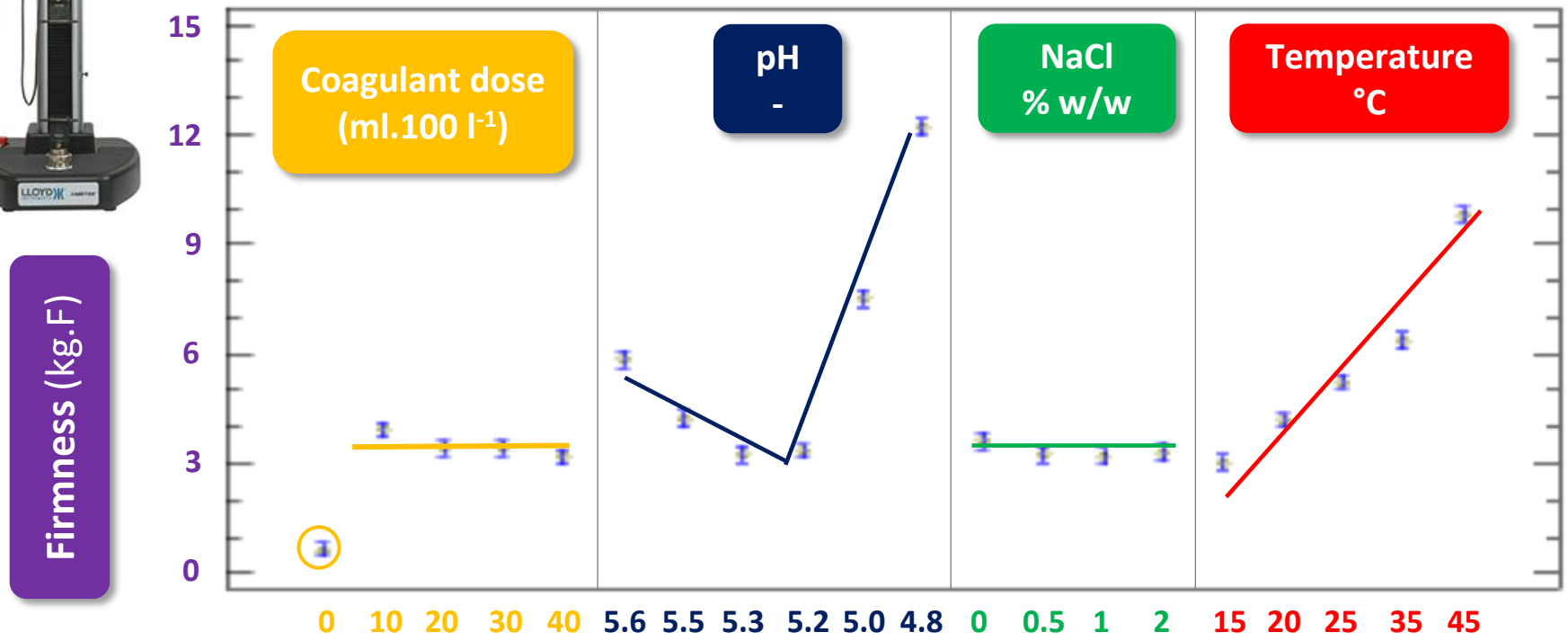
A large range of texture: by controling…

- *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**

Texture Profile Analysis

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)**



Designing the flavour bases

4 microbial species

Culture

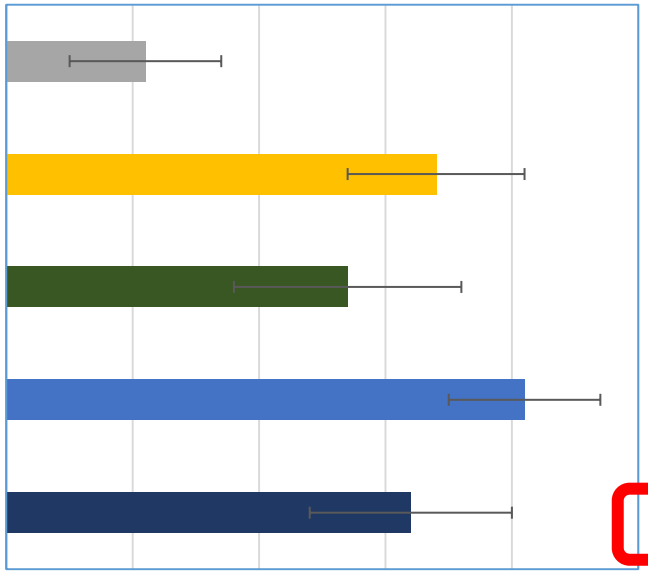
- **Optimized growth conditions** (substrates, T°, pH, O_2, time…)
- Production of **key flavour compounds**

Semi hard cheese

Soft cheese

- *Control*
- *Lactococcus lactis*
- *Hafnia alvei (HA)*
- *Yarrovia lipolytica (YL)*
- *LL + HA + YL*
- *[Propio freudenreichii]*

Blind test



Flavour Intensity score (mean 12 judges)

Descriptors and flavours

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

Molecules

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

Sensory analysis

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

GC-MS analysis

- off flavour compounds

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

3 • *Would a breakthrough cheese technology be accepted by the consumer?*

MARTIN and al, Food Quality and Preference - 2023

Acceptability of a sustainable technological innovation applied to traditional soft cheese: Information concerning the benefits for health and the environment can compensate for a lower hedonic appreciation

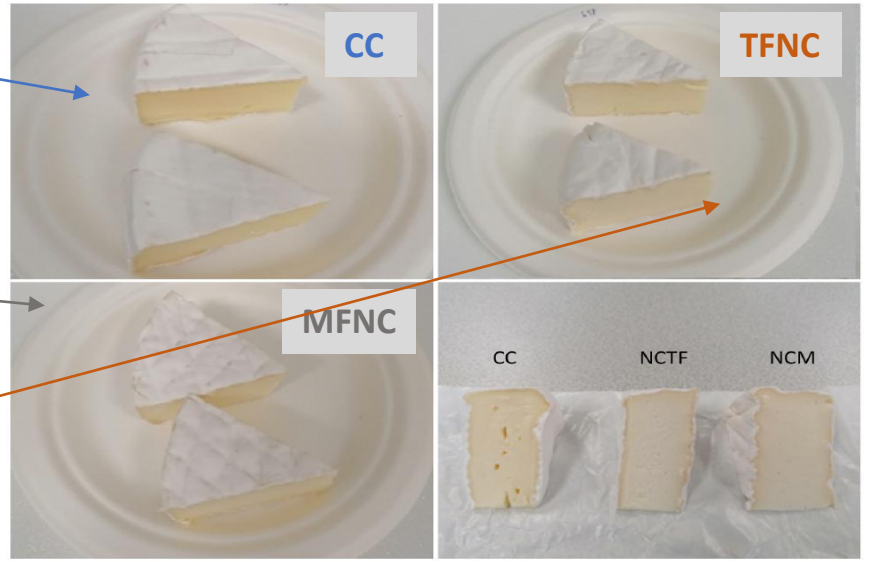
- **The objective** of the work was to study the reaction of consumers to a radically new manufacturing process applied to a traditional product like Camembert.

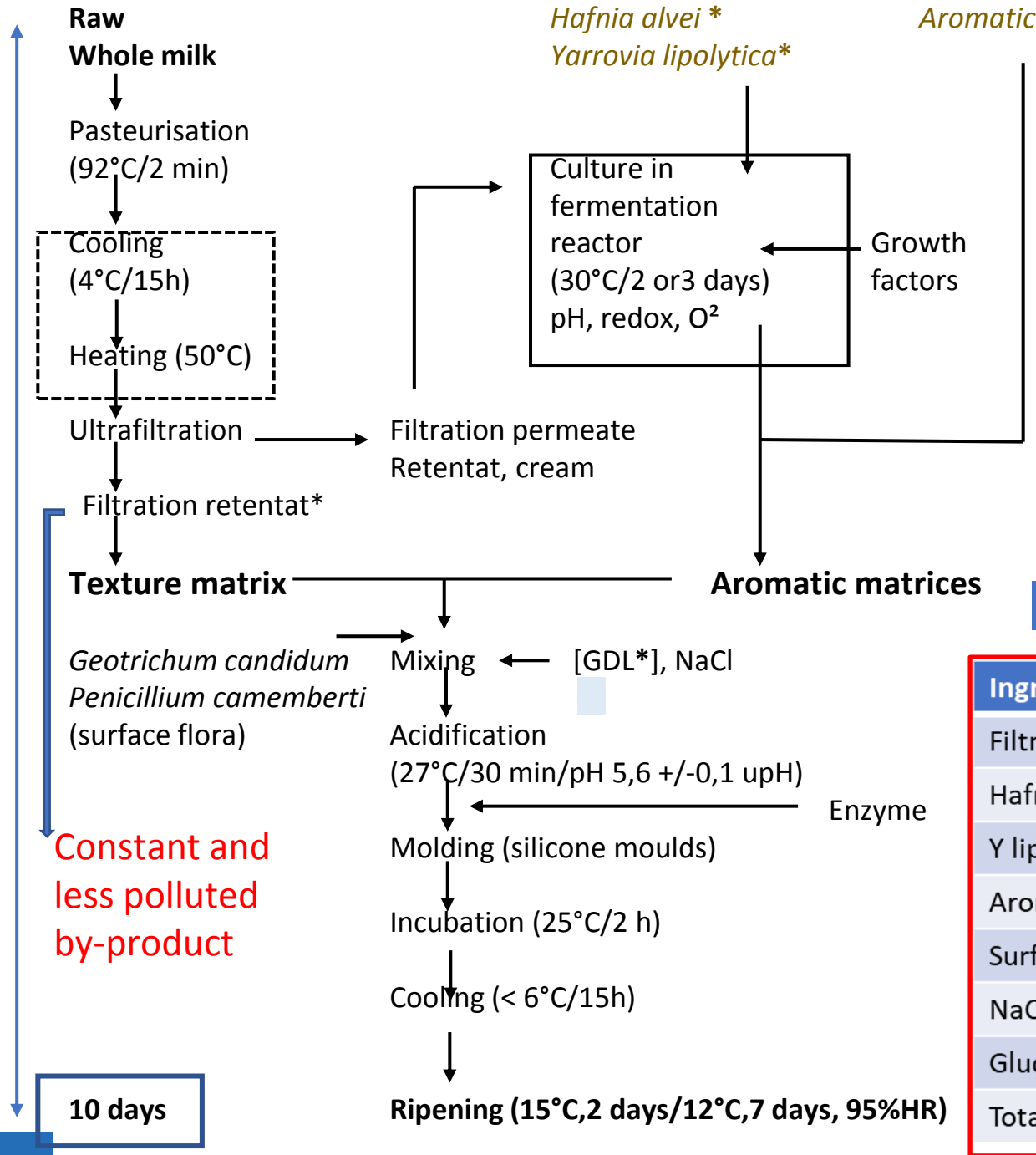
- **Method:** a traditional cheese and two cheeses resulting from a new sustainable process were evaluated by 142 consumers (compared acceptability)

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)





Accurate flow chart used Principle of the From'Innov new two cheeses

The * indicates the differences between the two experimental cheeses

Ingredients (%, w/w)	Typical Flavoured New Cheese TF	Mild Flavoured New Cheese MF
Filtration retentat	90.5	95.2
Hafnia alvei	4.0	-
Y lipolytica	0.5	-
Aromatic NIZO	2.0	2.0
Surface flora	2 doses	2 doses
NaCl	1	1
Glucono Delta Lactone	2.0	1.8
Total	100	100

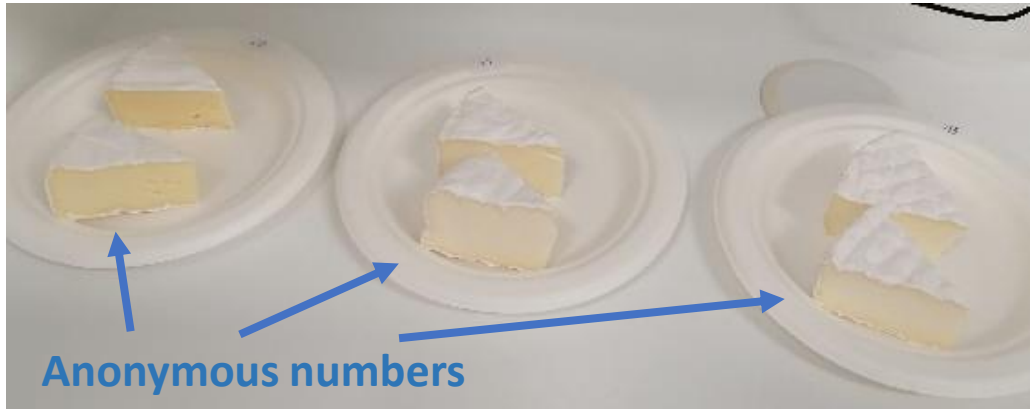
Method: 5 stages

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 WTP (1) ⇨ **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 consired acceptable for each cheese

Nouveau Procédé

1 unité de 250g

Mild Flavoured New Cheese

	Oui	Non	Peut-être
1,00 €	☐	☐	☐
1,10 €	☐	☐	☐
1,20 €	☐	☐	☐
1,30 €	☐	☐	☐
1,40 €	☐	☐	☐
1,50 €	☐	☐	☐
1,60 €	☐	☐	☐
1,70 €	☐	☐	☐
1,80 €	☐	☐	☐
1,90 €	☐	☐	☐
2,00 €	☐	☐	☐
2,10 €	☐	☐	☐
2,20 €	☐	☐	☐
2,30 €	☐	☐	☐
2,40 €	☐	☐	☐
2,50 €	☐	☐	☐
2,60 €	☐	☐	☐
2,70 €	☐	☐	☐
2,80 €	☐	☐	☐
2,90 €	☐	☐	☐
3,00 €	☐	☐	☐

Procédé classique

1 unité de 250g

Commercial Cheese

	Oui	Non	Peut-être
1,00 €	☐	☐	☐
1,10 €	☐	☐	☐
1,20 €	☐	☐	☐
1,30 €	☐	☐	☐
1,40 €	☐	☐	☐
1,50 €	☐	☐	☐
1,60 €	☐	☐	☐
1,70 €	☐	☐	☐
1,80 €	☐	☐	☐
1,90 €	☐	☐	☐
2,00 €	☐	☐	☐
2,10 €	☐	☐	☐
2,20 €	☐	☐	☐
2,30 €	☐	☐	☐
2,40 €	☐	☐	☐
2,50 €	☐	☐	☐
2,60 €	☐	☐	☐
2,70 €	☐	☐	☐
2,80 €	☐	☐	☐
2,90 €	☐	☐	☐
3,00 €	☐	☐	☐

Nouveau Procédé

1 unité de 250g

Typical Flavoured New Cheese

	Oui	Non	Peut-être
1,00 €	☐	☐	☐
1,10 €	☐	☐	☐
1,20 €	☐	☐	☐
1,30 €	☐	☐	☐
1,40 €	☐	☐	☐
1,50 €	☐	☐	☐
1,60 €	☐	☐	☐
1,70 €	☐	☐	☐
1,80 €	☐	☐	☐
1,90 €	☐	☐	☐
2,00 €	☐	☐	☐
2,10 €	☐	☐	☐
2,20 €	☐	☐	☐
2,30 €	☐	☐	☐
2,40 €	☐	☐	☐
2,50 €	☐	☐	☐
2,60 €	☐	☐	☐
2,70 €	☐	☐	☐
2,80 €	☐	☐	☐
2,90 €	☐	☐	☐
3,00 €	☐	☐	☐

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**

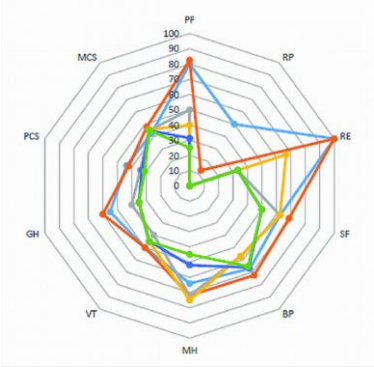
Appearance and Smell
- Aspect of the rind
- Intensity of the smell
- Colour of the paste

Mouthfeel
- Firmness
- Sticky
- Fatty

Flavours and aromas
- Salty
- Acid
- Bitter

Ex : criterion (Salty)

not enough at all	not enough	Just about right	Too (salty)	Too much
☐	☐	☒	☐	☐



JAR permits to establish a « spyder diagram »

Typical Flavoured New Cheese

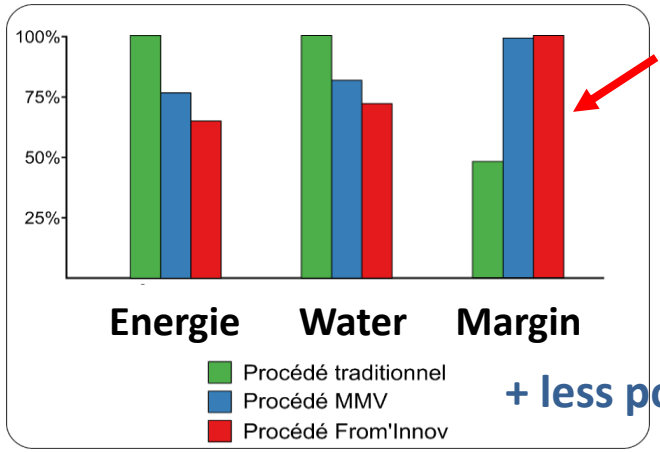
Penalty analysis: Percentage of responses on the x-axis and the penalty scores on the y-axis (mean drops). In red, the properties perceived as too intense / present. In blue, properties perceived as not intense / present enough. In grey, the sensory properties for which the response percentage is too 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

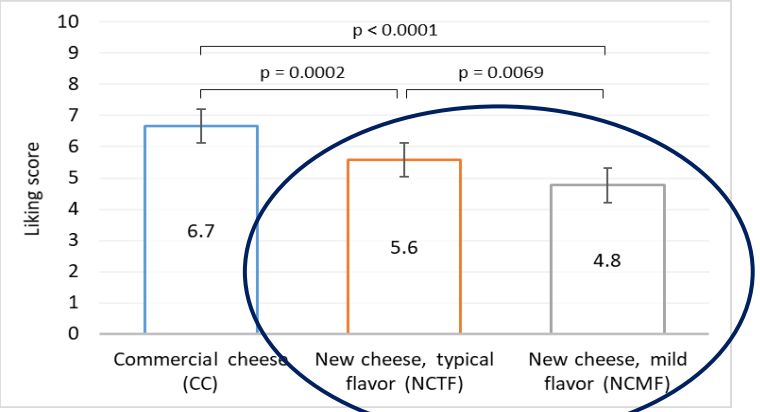
+ less polluting!

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

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

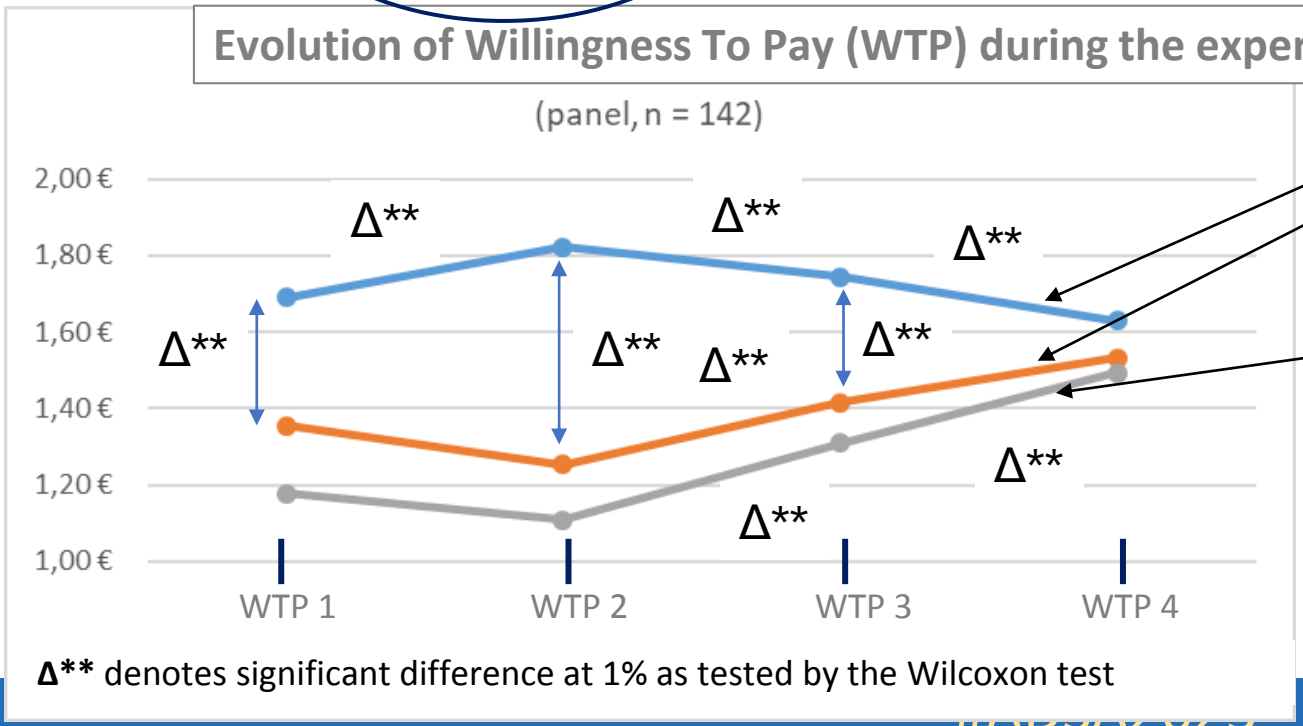
Results

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



Overall Llking 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



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

Results

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)

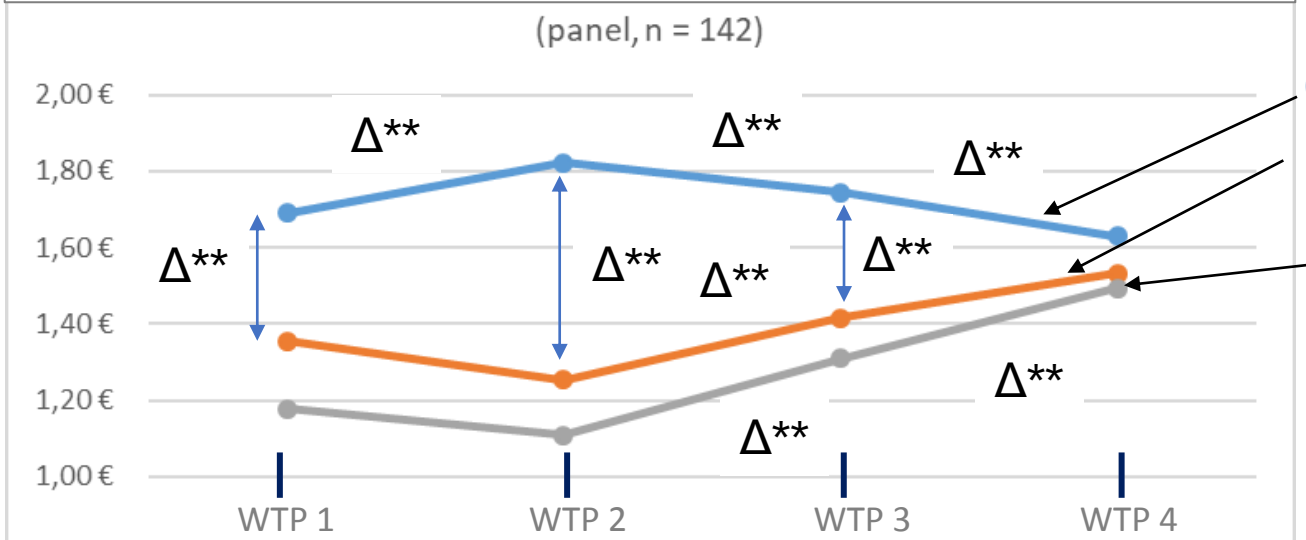
3. However, information on health and sustainability (or the inverse) **narrowed the WTP gap significantly**

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**

Evolution of Willingness To Pay (WTP) during the experiment



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

4 • *Questions in progress*

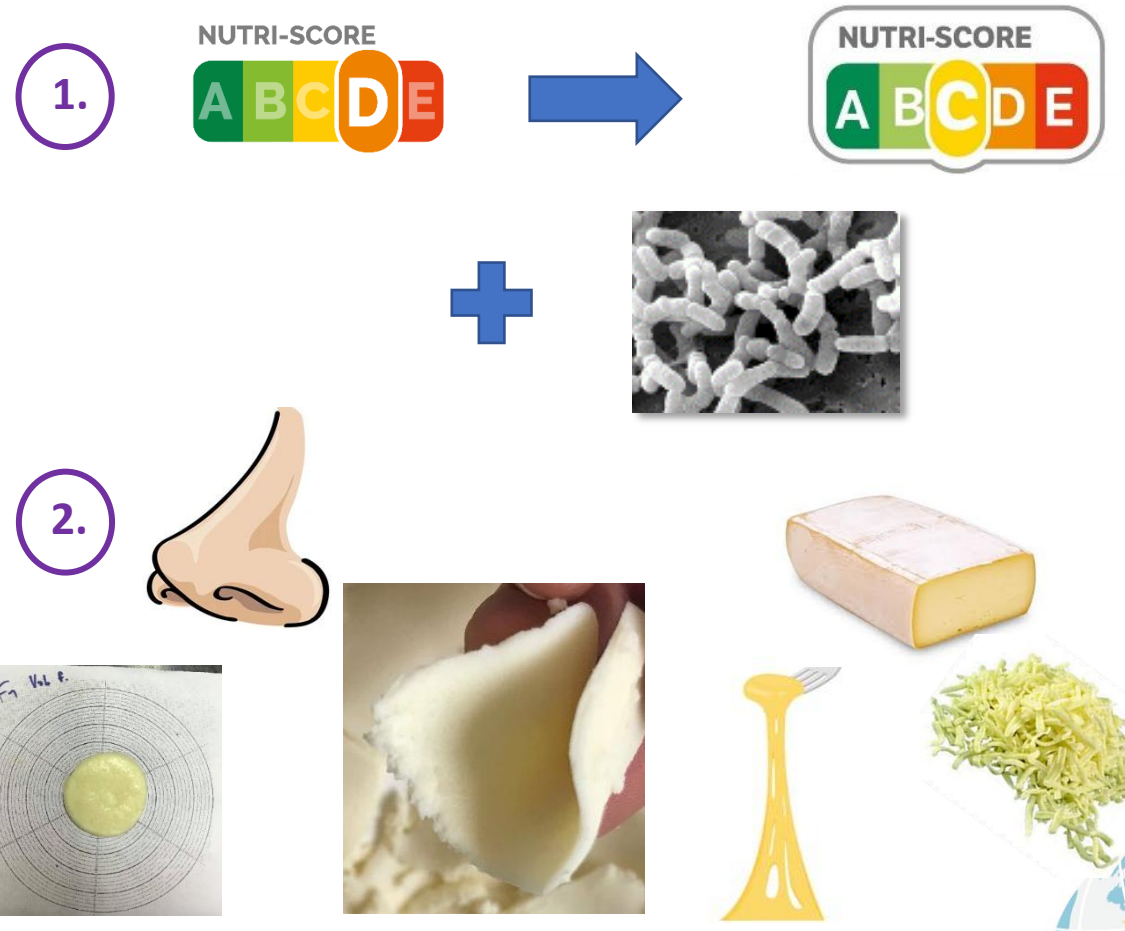
With the same methodology, we are continuing our investigations…

1. **<u>By testing</u>** 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. **<u>By testing</u>** a **semi hard cheese** produce with the new technology with **functionalities** (meltability, stretchability, sliceability and shreddability) … and **new flavours** on **subjects' WTP (very challenging)**

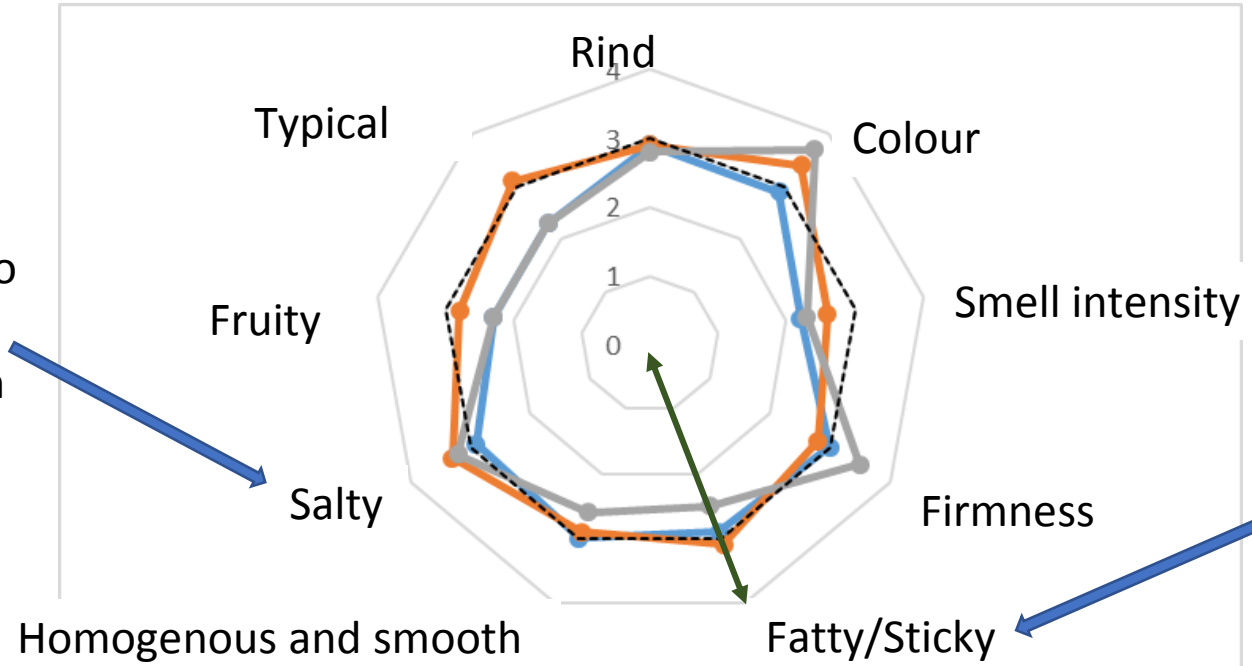
We are able to obtain a <u>better sustainability</u> with a shorter ripening and create new flavours



4 • *Questions in progress*

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

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

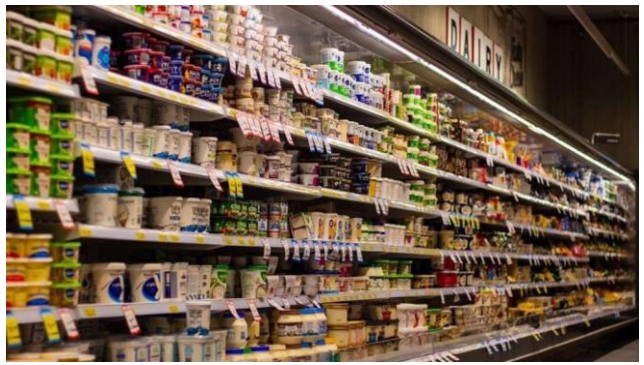


1. **to copy** or **to improve** existing products

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)



• *Questions in progress*

Finally… the next frontier will be:

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

CNIEL 2022
OECD-FAO 2022

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

Innovative cheesemaking concept

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**

Work in Progress

Next steps ?

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

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