Reduction / substitution of sodium chloride in cheese: impact on the development of the technological flora and the potential of implantation of spoilers

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1. Introduction

- ❖ Sodium reduction in the human diet is currently one of the main concerns for public health agencies and, consequently has become a challenge facing the food industries. In France, dietary guidelines recommend a 20% reduction of salt in foods (ANSES).
- ❖ NaCl fulfills many important functions in cheese such as sensorial properties by giving salty note and controlling the growth of the cheese-ripening microflora as well as those of undesirable microorganism development such as spoilage microorganisms. It has to be noted that the sodium content vary depending on the type of cheese.

➢ The objective of the RedSel project was to investigate the effect of reduced NaCl content in soft and in semi-hard cheeses on (i) main characteristic of cheeses, (ii) microbiological balance with respect to both the cheese-ripening microflora and spoilers (*Pseudomonas fluoresens* and *Yarrowia lipolytica*), (iii) sensorial profile of cheeses.

2. Material and Methods

	≠ levels of chloride	Spoilers or not
Soft cheese fabrication with lactic acid bacteria and ripening microflora (*Geotrichum candidum*, *Penicillium camemberti*)	100% NaCl (Control) = 1.41 % 75% NaCl = 1.02 % 75%/25% NaCl /KCl = 1.34 %	+ or- *Yarrowia* Inoculation level = 10^3 ufc/ml
Semi-hard cheese fabrication with lactic acid bacteria and ripening microflora (*Geotrichum candidum*, *Debaryomyces hansenii* and *Brevibacterium linens*)	100% NaCl (Control) = 1.43 % 75% NaCl = 1.08 % 75%/25% NaCl /KCl = 1.24%	+ or- *Pseudomonas* Inoculation level = 10^5 ufc/ml

Physico-chemical analysis	Microbiological analysis	Sensorial analysis
pH, Aw lactates, lactose lipolysis, proteolysis	Quantification on Petri dishes Metabarcoding 16S RNA seq	with a trained panel **Volatile aroma compounds** GC-MS

3. Low impact of NaCl ↓ on physico-chemical characteristics

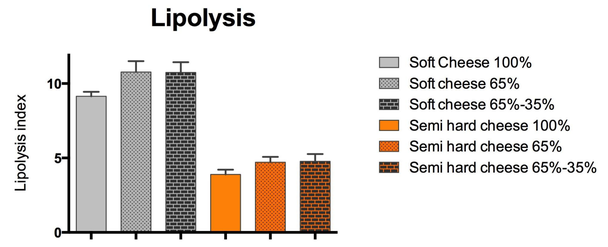
❖ **At the end of the ripening:**

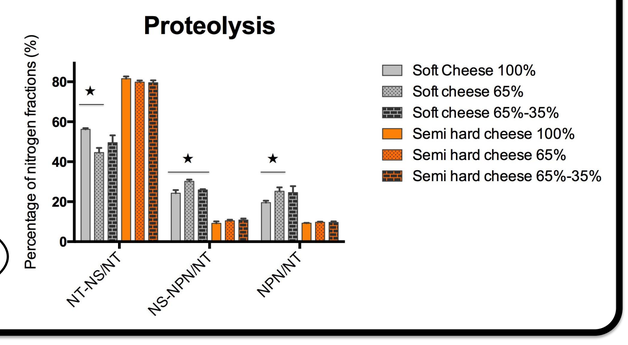
No important ≠ in pH, Aw, fat/dry ratio and moisture index

No important ≠ in sugar consumption

Lipolysis: slight tendency to ↑ when NaCl is ↓ or KCl is used in substitution in both soft and semi-hard cheeses

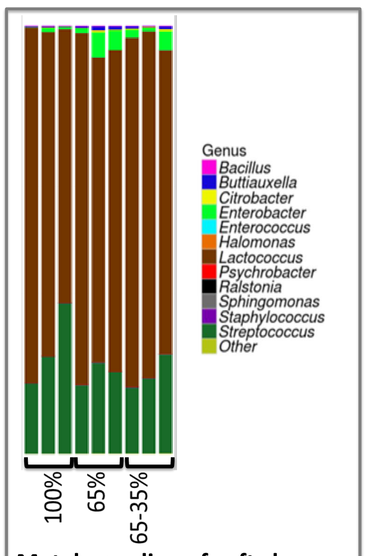
Proteolysis: ↑ when NaCl is ↓ in soft cheeses only



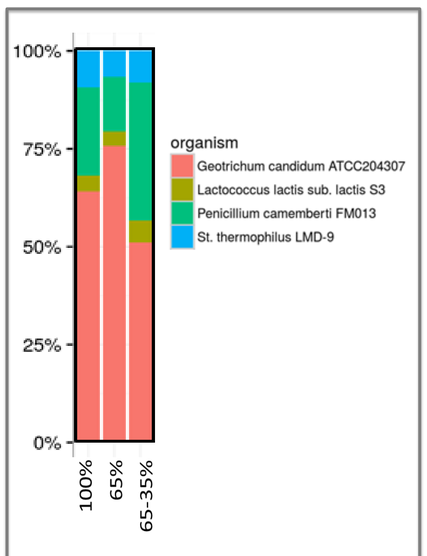


4. Low impact of NaCl ↓ on cheese microbiota

❖ **Microbial counts, metabarcoding and transcriptomic analyzes at the end of the ripening**



Metabarcoding of soft cheeses (Day + 14)



RNA Seq of soft cheeses

Soft cheeses:

- No ≠ in bacterial composition
- Slight ↓ of *P. camemberti* and ↑ *G. candidum* at reduced NaCl content (microbial counts and RNA seq)

Semi-hard cheeses (not shown):

- Very weak impact on global microbial composition

5. Variable impact of NaCl ↓ on organoleptic characteristics

❖ **Soft cheeses:**

- Aroma compounds: ↑ alcohol content at reduced NaCl content ; no impact of substitution by KCl
- Impact of NaCl content on several sensorial characteristics: crust color (↑), flowing (↑), taste and odor intensity (↑), **bitterness (↑)**, metallic /oxidized, taste (↑), smell and aroma of mushroom (↓)
- Impact of KCl substitution: flowing (↑ ↑), **bitterness (↑ ↑)**

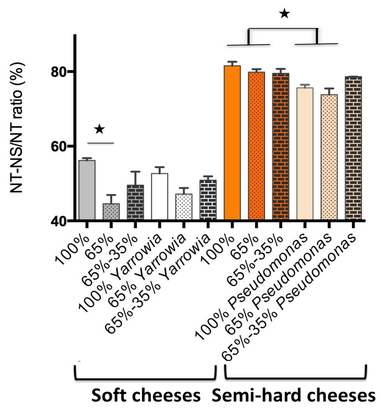
❖ **Semi-hard cheeses:**

- Determination of aroma compounds: no impact of NaCl reduction nor substitution by KCl in comparison with the condition 100% NaCl content
- Impact of NaCl on only 2 sensorial characteristics: **bitterness (↑)** and salty taste (↓)
- Impact of KCl substitution: **bitterness (↑ ↑)**

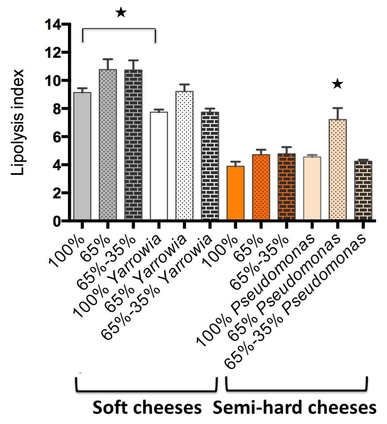
6. Variable impact of NaCl ↓ on development of spoilers

❖ **Very moderate/no impact** of spoilers on the evolution of cheese pH, Aw, moisture indexes and sugar content

❖ **Proteolysis:** no impact of spoilers in soft cheeses and moderate impact in semi-hard cheeses in presence of *Pseudomonas* (in relation with salt content)



❖ **Lipolysis:** moderate (↓) or more important impact (↑) of the presence of spoilers (in relation with salt content) in soft and semi-hard cheeses respectively

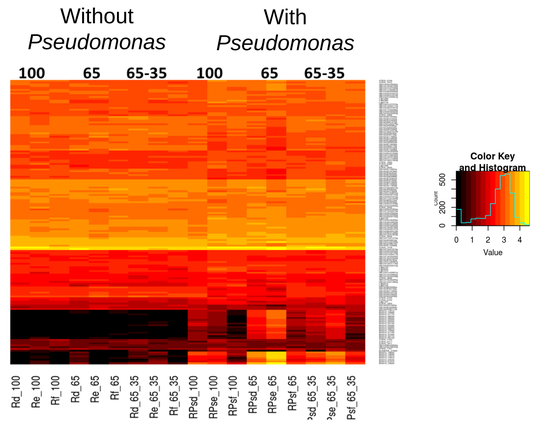


❖ **Cheese microbiota:**

- **In soft cheeses:** very moderate impact of the presence of *Yarrowia* (variation of the relative abundance of starters at the beginning of ripening only: ↑ *S. thermophilus* and ↓*Lactococcus*)
- **In semi-hard cheeses:**

↑ ↑ of *Pseudomonas* relative abundance and metabolism when ↓ NaCl

↑ ↑ protease expression, particularly in the condition of ↓NaCl



Heatmap of genes coding for proteases in semi-hard cheeses (RNA Seq)

Conclusion

- ❖ **Overall, low impact due to a reduction of NaCl ; especially in a model of semi-hard cheese**
- ❖ **Main point of vigilance: development of spoilage microorganisms (especially in a model of semi-hard cheese)**
- ❖ **Compensatory effect of KCl on certain parameters (be careful to bitterness)**

➢ **In conclusion, in an approach to reduce NaCl in the cheese industries, it is necessary to take into consideration the type of cheese technology and the possible contaminations by spoilers**

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