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## **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 fluorescens* and *Yarrowia lipolytica*), (iii) sensorial profile of cheeses.

## 2. Material and Methods

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

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

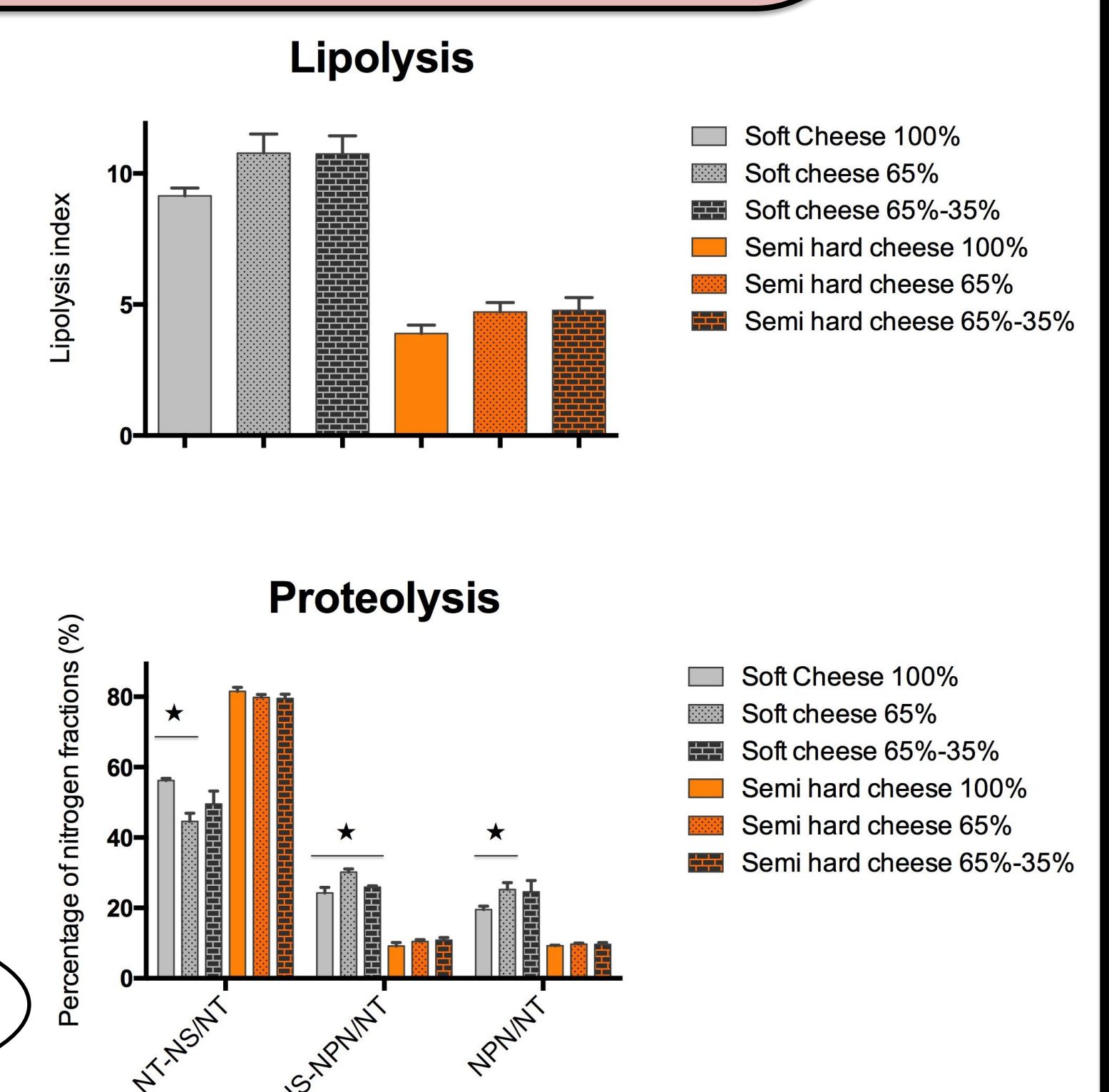
❖ **At the end of the ripening:**

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

No important ≠ in sugar consumption

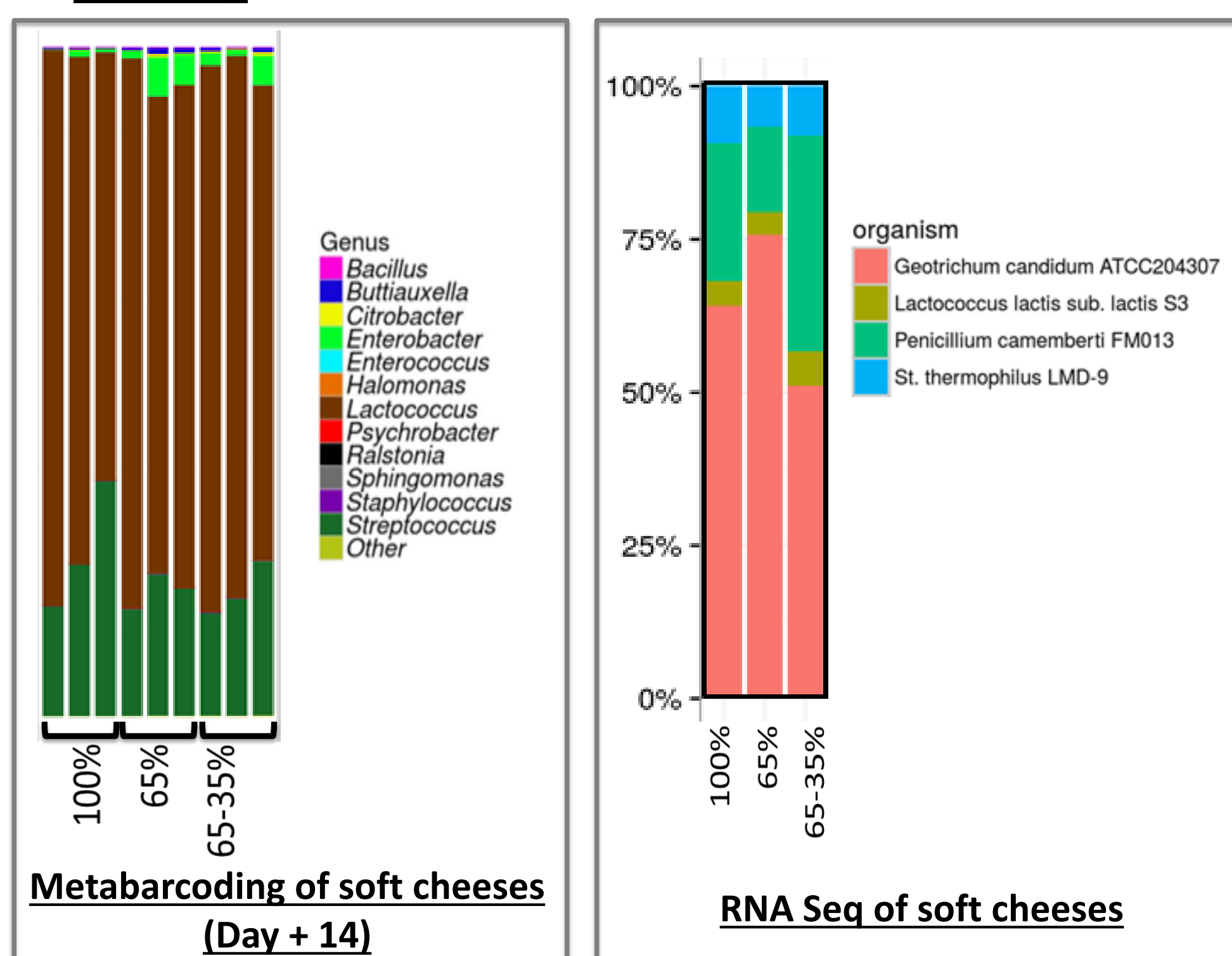
**Lipolysis:** slight tendency to ↑ when NaCl is ↓ or KCl is used in substitution in both soft and semi-hard cheeses

**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**



**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):**

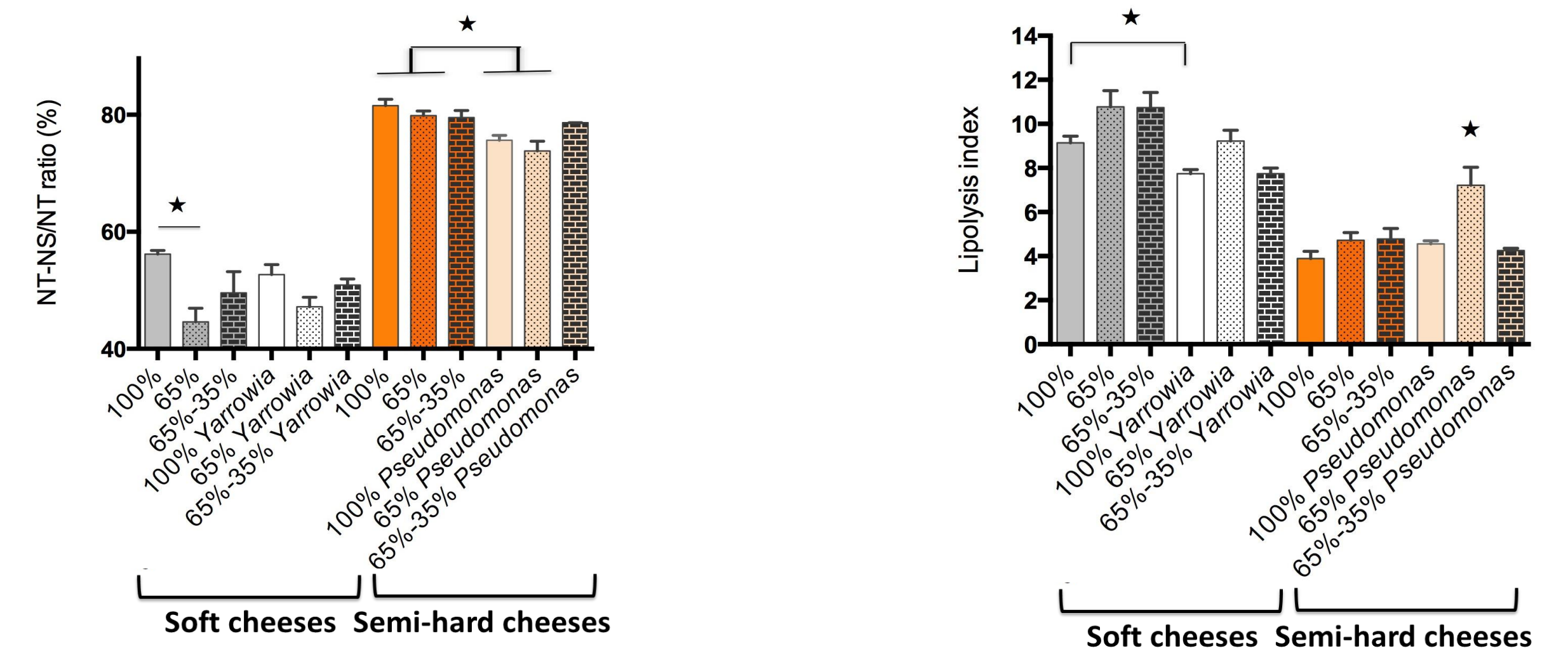
- Very weak impact on global microbial composition

## 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)

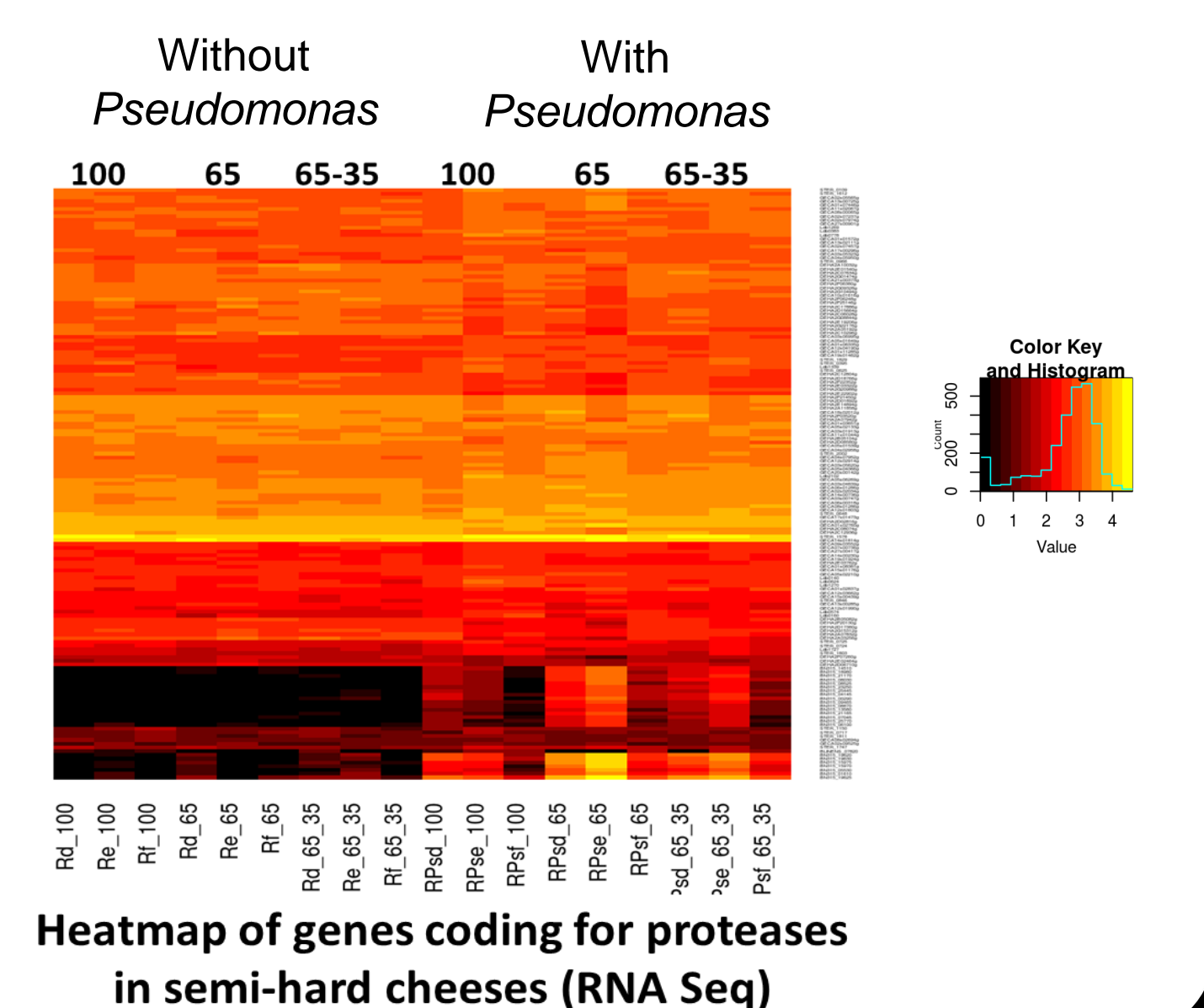
❖ **Lipolysis:** moderate (↓) or more important impact (↑) of the presence of spoilers (in relation with salt content) in soft and semi-hard cheeses respectively



❖ **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



## 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** (↑ ↑)

## 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