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Impacts of curd washing on the development of the functional properties of Raclette cheese

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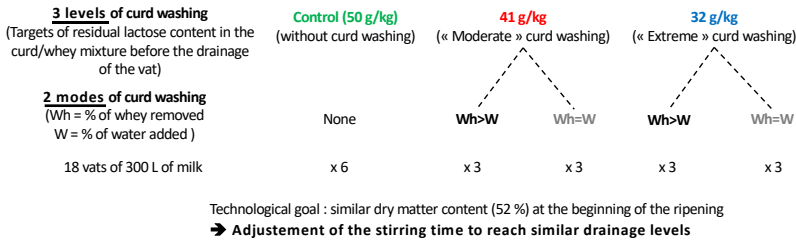
Introduction

A cheese variety is partly characterized by its functional properties, such as its rheological and cooking properties. Semi-hard cheese varieties like Raclette present a soft and homogenous matrix with good melting properties. Curd washing is a crucial manufacturing stage for the development of these properties because it allows to manage the early composition of the aqueous phase of the cheese curd, mainly the lactose content. Nevertheless, it is an expensive stage of the manufacture because it needs addition of water, which increase the amount of water consumed and the amount of whey to manage for the factory, whose management is expensive in energy. This stage of the cheese manufacture could be optimized through two parameters, among others, we chose to study. The first is the **level** of curd washing (the intensity of dilution) that could be adjusted according to the desired properties of the cheese. The other is the **mode** of curd washing, i.e. the volumes of whey withdrawn and water added to the vat to reach the level that could be adjusted to reduce water consumption and the volume of whey produced. However, the optimization of these parameters requires a better understanding of their impacts, which are poorly described in the literature.

The aim of this study was to determine the impact of the **level** and **mode** of curd washing on the functional properties of cheese and to describe the mechanisms by which these parameters contribute to the development of these properties. These parameters have been studied in the context of cheeses with similar dry matter contents to specifically study the impact of the modification of the aqueous phase by curd washing.

Materials & methods

Experimental cheesemaking



Analyses	Methods
Lactose	HPLC-UV detection
Lactates	HPLC-UV detection
INSOL Ca	Ionic chromatography-conductivity detection
pH	penetrometry
Buffering capacity	Acid/base titration
SN/TN, NPN/TN	ISO 27871 standard
Hydrophobic peptides	RP-HPLC (relative area of the peaks at the end of elution)
Rheology (15 °C)	Uniaxial compression tests
Meltability (225 °C)	Schreiber test
Threading ability (60 °C)	Threads length measurements
Elasticity (60 °C)	Extrusion resistance force

INSOL Ca = Casein-bound calcium
SN = Soluble nitrogen

TN = Total nitrogen
NPN = Non-protein nitrogen

Results

Table 1: Composition on day 1 according to the curd washing parameters

	Sign.	Level			Mode	
		Control	41 g/kg	32 g/kg	Wh>W	Wh=W
Dry matter (%)	N.S.	52.2 ^a	52.5 ^a	52.0 ^a	N.S.	52.0 ^a 52.4 ^a
Fat (%)	N.S.	25.7 ^a	25.7 ^a	26.0 ^a	N.S.	25.8 ^a 25.9 ^a
Lactose (g/kg)	***	2.0 ^a	0.4 ^b	0.1 ^b	N.S.	0.2 ^a 0.2 ^a
Lactates (g/kg)	***	17.2 ^a	16.7 ^a	14.0 ^b	N.S.	15.4 ^a 15.3 ^a
INSOL Ca (%)	***	0.37 ^a	0.38 ^a	0.43 ^b	N.S.	0.41 ^a 0.41 ^a
pH	***	4.97 ^a	4.97 ^a	5.10 ^b	N.S.	5.04 ^a 5.04 ^a
Buffering capacity	***	0.49 ^a	0.49 ^a	0.39 ^b	N.S.	0.71 ^a 0.71 ^a

N.S.: Not Significant; *: p<0.05; **: p<0.01; ***: p<0.001

No significant differences in dry matter and fat contents because of the technological goal.

Impacts of the level of the curd washing only

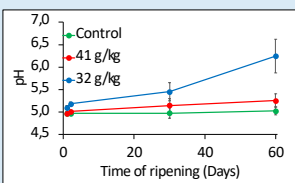


Fig. 1: Evolution of the pH of cheeses during the ripening

Table 2: Physico-chemical characteristics of ripened cheeses (60 days of ripening)

	Sign.	Level			Mode	
		Control	41 g/kg	32 g/kg	Wh>W	Wh=W
Dry matter (%)	N.S.	53.4 ^a	53.8 ^a	53.6 ^a	N.S.	53.8 ^a 53.6 ^a
Fat (%)	N.S.	26.9 ^a	27.0 ^a	27.0 ^a	N.S.	27.0 ^a 27.0 ^a
pH	***	5.03 ^a	5.26 ^b	6.24 ^b	N.S.	5.74 ^a 5.76 ^a
SN/TN (%)	***	24.0 ^a	24.0 ^a	27.7 ^b	N.S.	25.9 ^a 25.9 ^a
NPN/TN (%)	***	13.5 ^a	14.1 ^a	15.7 ^b	N.S.	14.8 ^a 15.0 ^a
Hydrophobic peptides (RA %)	**	32.9 ^a	36.9 ^a	60.6 ^b	N.S.	52.8 ^a 50.9 ^a

N.S.: Not Significant; *: p<0.05; **: p<0.01; ***: p<0.001

RA % = percentage of relative area in the chromatographic spectrum

Impacts of the level of the curd washing only

Table 3: Rheological and cooking properties of the ripened cheeses

	Sign.	Level			Mode	
		Control	41 g/kg	32 g/kg	Wh>W	Wh=W
MP (kPa)	***	545.1 ^a	347.8 ^b	66.0 ^c	N.S.	199.9 ^a 213.9 ^a
ef (%)	***	26.1 ^c	37.8 ^b	80.0 ^a	N.S.	59.6 ^a 58.2 ^a
of (kPa)	***	87.9 ^b	83.6 ^b	145.4 ^a	N.S.	110.3 ^a 118.8 ^a
Stretchability (cm)	*	15.2 ^a	30.5 ^{ab}	44.9 ^b	N.S.	45.0 ^a 30.4 ^a
Meltability (-)	**	3.4 ^a	3.0 ^b	3.0 ^b	N.S.	3.0 ^a 3.1 ^a
Elasticity (kgF)	***	0.7 ^b	0.9 ^b	1.3 ^a	N.S.	1.1 ^a 1.0 ^a

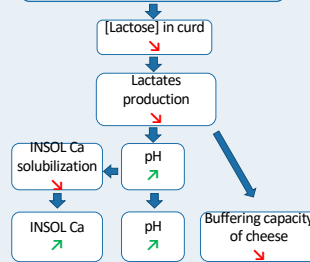
N.S.: Not Significant; *: p<0.05; **: p<0.01; ***: p<0.001

Impacts of the level of the curd washing only

Discussion

Increased level of curd washing

Control → 41 g/kg → 32 g/kg



During the manufacture

Increasing level of curd washing leads to:

- An increase in osmotic pressure differences between the aqueous phase of the curd and the whey
- Curd's lactose content decreased because of its diffusion in the whey

During the acidification

Acidification stopped when lactose was limiting (in the 32 g/kg cheeses on day 1; **Table 1**)

- pH stopped decreasing
- INSOL Ca stopped solubilizing

On day 1

The earlier the acidification stopped:

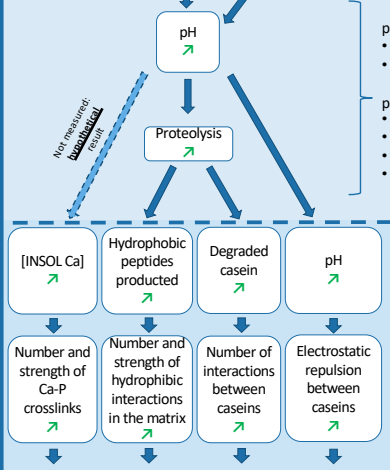
- The higher the pH of the cheese and the higher its [INSOL Ca] (**Table 1**)
- Removal of solutes (whey prot., organic acids, mineral...) decreased the buffering capacity of the cheese (**Table 1**)

pH increased during the ripening in cheese due to:

- Deacidification by ripening microflora
- Alcaline molecules (NH₃) released by proteolysis

pH increased faster in the 32 g/kg cheeses (**Fig. 1**) because of:

- Lower [lactates]
- Faster proteolysis (higher pH enhanced the enzymatic activities)
- Faster release of NH₃
- Lower capacity to buffer the NH₃



In the specific framework of our experiment (similar dry matter contents), these 4 variables were affected by the level of curd washing and can explain the impact on the functional properties of the ripened cheese.

The 4 variables reflect 4 different types of interactions structuring the cheese matrix. Changing the number and strength of each type of interaction by changing the level of curd washing affects the microstructure of the cheese and therefore its functional properties.

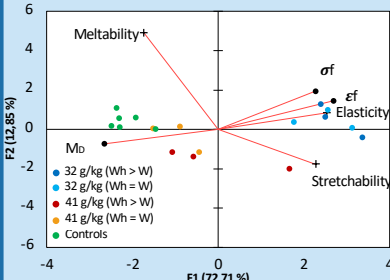


Fig. 2: Multifactorial analysis of the rheological (●) and cooking properties (+) of cheese

The increase of the level of curd washing led to a matrix with:

- A higher mechanical resistance (**σf**)
- A higher deformability (**ef**)
- A lower stiffness (**Mb**)
- A greater elasticity
- A greater stretchability
- A lower meltability

Conclusion

At a determined dry matter content, the modification of the composition of the aqueous phase of the curd by the level of curd washing affects the microstructure of the ripened cheese through variables such as pH, the content of INSOL Ca, the proportion of degraded caseins and the content of hydrophobic peptides. Hence, the increase of the curd washing level leads to the development of a more deformable matrix with a higher mechanical resistance. Since the curd washing mode has no impact on all these variables, our study opens up the prospect of controlling the development of the functional properties of cheese while economically optimizing this stage of production with the mode.