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The importance of salt in the manufacturing and ripening of cheese

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Introduction

Salt contains the two elements sodium (Na) and chlorine (Cl), which both fulfil important functions in the human body. Sodium plays a role in the regulation of our water balance and the osmotic pressure in the cells, in the acid-base balance and in the control of muscles and nerves. The daily needs of sodium and chlorine for adults are 550 mg Na and 830 mg Cl, which is 1.5 g salt. The actual consumption of salt varies between countries in the rage of 6 – 12 g/day. As high salt consumption is a risk factor for high blood pressure and therefore coronary heart diseases, the WHO recommends a reduction in salt consumption to 5 g/day. Many countries have programs in place to reduce the salt content in people's diets, with stepwise reduction targets. Cheeses have a salt content between 0.4 and about 4 g/100 g, specific to the variety.

The contribution of cheese to the salt content in people's diets depends largely on the composition of the diet, and the salt content of the cheese. In Switzerland with a high cheese consumption of about 21.5 kg/capita per year, cheese contributes 7.5% to salt intake, in Germany with a consumption of 24.6 kg/capita per year it is 10%. Many countries have lower annual consumptions of cheese, e.g. 12 and 15.5 kg/capita in the UK and the USA respectively or 3.7 kg/capita in Brazil. This translates to lower contributions to people's salt intake.

Primary functions of salt in cheese

Salt has several functions in cheese. Rind formation for brine-salted cheeses, inhibition of growth of microorganisms, ripening, texture, water binding, aroma and taste are modulated by salt. It is an important contributing factor for food safety and for the suppression of spoilage bacteria or variety-specific undesired bacteria in cheese. Salt is an important tool for the cheesemaker to influence the ripening process towards the desired variety and quality. Therefore, different cheese varieties need different salt contents, from 0.4% for Emmentaler up to 4 or even 5% for blue cheeses. To obtain the optimal salt content, well defined salting conditions are necessary. For brine-salted, smear-ripened cheeses, the loaf size, water and fat content, brining time, brine concentration, temperature, pH, flow of the brine and salt addition in the smear water are important factors. For curd-salted cheeses, salt loss through whey has to be known and stable to get a defined salt content.

Salt promotes the dewatering and rind formation in brine-salted cheeses. Through its influence on the growth of microorganisms and the activity of enzymes such as rennet and microbial enzymes, it modulates cheese ripening. Starter bacteria are more sensitive to salt than non-starter lactic acid bacteria (NSLAB). Most Lactococci are inhibited from 4% salt-in-moisture while *Streptococcus thermophilus* is inhibited at 2.3%. Pediococci as NSLAB are only inhibited at 10 – 12% salt, so they still grow during ripening in salted cheese. Salt sensitivity is strain-specific. Overall, salt slows down proteolysis, as shown in a Gruyère model cheese. Salt-in-moisture concentrations of 2 – 6% increase the swelling and the solubility of casein. This promotes the fusion of the cheese curd, especially for cheeses with a low pH. It also prevents the separation of serum e.g. in Mozzarella, and reduces free-oil formation during the ripening of Mozzarella. Through the reduction of protein-protein interactions, salt increases the meltability of cheese, e.g. for Raclette cheese and Mozzarella.

Salt is important for its direct taste. It also plays the role of a flavour enhancer and influences aroma and trigeminal sensations. Cheeses that are low in salt are bland and prone to flavour defects such as bitterness or impure flavour. Especially in fat-reduced cheeses, salt influences aroma release. Through the modulation of desired and undesired microorganisms and enzymes, salt modulates the development of cheese flavour.

Food safety and quality

Salt contributes to food safety and quality of cheese. Salt on its own is not a sufficient hurdle against the growth of pathogenic microorganisms, but in association with other factors inhibits the growth of pathogenic bacteria. This is especially important in raw milk cheeses. Shiga-toxin producing *Escherichia coli* O157:H7 grow up to a salt-in-moisture concentration of 8.5%, they are moderately salt tolerant. At low salt concentrations, this serotype can even recover from stress more quickly thanks to salt. Little is known about the influence of salt on other pathogenic serotypes of *E. coli. Staphylococcus aureus* is salt tolerant and can grow at up to 20% salt-in-moisture, optimal growth is in the range of 0.5 to 4.0% salt and higher concentrations drastically slow down growth. Staphylococcal enterotoxin (SE) formation is inhibited with increasing salt concentration and stops at around 10% for the many different SEs. *Listeria* species are salt tolerant as well and grow at up to 10% salt and survive at up to 25% salt-in-moisture. Growth below 2.5% salt increased the virulence of *Listeria monocytogenes.* Salmonella are inhibited by 4 – 6% salt-in-moisture at temperatures of 8 – 12°C, salt and temperature levels reached in cheese (see table).

Clostridium tyrobutyricum spores are mainly present in milk from cows fed with silage. The spores survive pasteurisation and cause late-blowing in hard and semi-hard cheeses through butyric acid fermentation. Cheeses are spoiled and inedible due to the formation of butyric acid. Besides good milk quality and technological treatments to remove spores such as bactofugation or microfiltration, salt is an additional compound useful in the prevention of butyric acid fermentation. Studies showed that salt concentrations of 2.2% and 2.9% in cheese-simulating culture medium at 22°C had an inhibiting and strongly inhibiting effect, respectively. At a lower temperature of 12°C, the inhibiting effect of salt was stronger. In cheese, this effect was observed as well (see table). Similarly, salt plays an important role in the prevention of propionic acid fermentation in raw milk cheeses, e.g. in Gruyère or Appenzeller. With about 5.0% salt-in-moisture, which corresponds to 1.68% salt in cheese, propionic acid fermentation could be prevented in model Gruyère (see table). The recommended salt content of 1.3 to 1.6% in Gruyère, therefore, contributes to control of its quality.

Optimal salt content

Numerous cheese varieties result from the centuries-old tradition of cheese making in many countries worldwide. Each variety has its specific salt content that allows an optimal control of the quality characteristics of each cheese variety. Salt is an important factor of cheese diversity and its culinary richness and heritage. Emmentaler and other Swiss-type cheeses have a rather low salt content to allow the propionic acid bacteria to develop the characteristic eyes and flavour. In contrast, some raw milk cheeses such as Gruyère, Parmigiano Reggiano or Sbrinz contain more salt to reduce the risk of undesired propionic acid fermentation. For Gouda, Raclette and other semi-hard or hard cheeses, salt helps to reduce the risk of butyric acid fermentation. In Cheddar, salt helps to prevent bitterness. In blue cheese, a rather high salt content prevents the growth of occasionally present *Geotrichum candidum* in the veins of the cheese and, therefore, favours *Penicillium roqueforti.* For Raclette and Mozzarella, salt improves their melting properties. To achieve the optimal balance between cheese authenticity and consumer health, cheese manufacturers strive for the right salt content specifically for each variety and for minimal variations.

Table: Salt sensitivity of pathogenic microorganisms and spoilage bacteria in cheese

Bacteria	Effect	Growth limit % salt-in-moisture	Further properties
Shiga-toxin forming *E. coli* O157:H7	Pathogenic	8.5	If salt ↘ ⇨ Recovery from stress ↗ Properties of other path. *E. coli* unknown
Staph. aureus	Pathogenic	20	Salt ↗ ⇨ Formation of Enterotoxin ↘
Listeria monocytogenes	Pathogenic	10	Salt ≤ 2.5% ⇨ Virulence ↗
Salmonella	Pathogenic	4 - 6	3 to 4 % ⇨ More problems possible when salt ↘
Clostridium tyrobutyricum	Spoilage	≈ 2.9	At 22°C: 2.2% inhibiting, 2.9% strongly inhibiting, at 12°C inhibition is stronger. In model Gruyère ripened at 14°C: With 1.25% salt, 53% inhibition compared to growth at 0.71% salt.
Propionic acid bacteria	Spoilage except in Swiss-type cheeses	≈ 5	In model Gruyère ripened at 14°C: At 3.5% salt-in-moisture ÷ about 50% inhibition, strain specific.

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Reference

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