3.3 Partial substitution of sodium chloride by potassium chloride in natural cheeses

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3.3.1 Introduction

Increasing international awareness of the potential negative effects of a high-sodium diet (see Chapter 1) has led to moves in many countries to reduce sodium intake in the general population, through a mix of public health information campaigns and targeted reformulation of industrially-prepared foods to reduce their sodium content. For many foods (such as soups, sauces and canned or bottled foods) this can technically be achieved simply by adding less salt, though market acceptance of ‘reduced salt’ product variants is often poor. However, this approach cannot be used for cheese. During cheese manufacture and ripening (flavour formation and structural maturation), salt plays multiple roles in determining the curd composition, structure and physical characteristics of different cheese varieties, influencing development of flavour and aroma, and enhancing food safety (see Chapters 2 and 3). Consequently, even small reductions in salt can result in poor cheese quality and loss of varietal characteristics.

The technical challenge is to reduce sodium levels without significantly changing the physical chemistry of cheese, thereby preserving the environment in which the structural, chemical, enzymological and microbiological events that determine all cheese characteristics take place. The most widely investigated approach is the partial substitution of potassium chloride for sodium chloride.

Both sodium and potassium are Group 1 metallic elements. The metal halide salt potassium chloride (KCl) has a molar mass of 74.55 g/mol which is higher than that of sodium chloride (NaCl, 58.44 g/mol). Potassium chloride is odourless and has a white or colourless vitreous crystal appearance. The majority of KCl produced is used as an ingredient in fertilizers, since the growth of many plants is limited by their potassium intake. It can be used as a salt substitute in food, but is usually mixed with NaCl. It increases saltiness slightly, and increases off-tastes, such as bitter, chemical and metallic. Adding NaCl in combination with KCl in aqueous solutions increases saltiness and decreases off-tastes (Sinopoli and Lawless, 2012). Potassium chloride is approved as food additive and flavour enhancer in the European Union (with the number E 508) and approved as an additive in cheese by Codex Alimentarius (CODEX STAN 283-1978), though country-specific regulations around the world mean that it is not necessarily approved for inclusion in cheese in all countries.
Research literature from more than 30 years analyzing the use of potassium chloride in different cheeses is summarized in the sections that follow.

### 3.3.2 Cheddar cheese

Cheddar is one of the few common dry-salted cheese varieties, but is one of the most widely produced cheese types. Some manufacturers might find that reduction in average salt content can be achieved by minimizing variability in the salting process (Agarwal et al., 2011), but this will not achieve major reductions. Reducing the target salt level without modification of the cheese making procedure adversely affects Cheddar flavour and texture (Rulikowska et al., 2013). Carefully keeping the correct moisture content can help to maintain acceptable rheological properties when salt is reduced, but flavour defects occur (Møller et al., 2013). For these reasons, replacement of sodium with potassium has been explored and is currently used commercially on a limited scale.

One of the first investigations on use of KCl was published by Lindsay et al. (1982). Cheddar cheese curd from a single batch was salted to contain 1.25, 1.5, or 1.75% NaCl, or blends of 0.55% NaCl and 0.70% KCl, or 0.66% NaCl and 0.84% KCl (1:1 molar ratio of the two salts). Descriptive sensory analysis of the cheese samples after ripening for 9 months showed that all of them were acceptable although some bitterness was observed, especially in the cheese containing 0.84% KCl. Mean consumer preference scores showed that some consumers recognized and preferred the fully salty taste of cheese with higher NaCl concentrations over those with less NaCl or the mixture, but it can be speculated that many consumers would not consider theses samples inferior to the normal commercial cheese (Lindsay et al., 1985).

Fitzgerald and Buckley (1985) salted the curd after cheddaring with 2.5% NaCl, 3.2% KCl (an equivalent amount on a molar basis) or with a blend of NaCl and KCl (1.25% NaCl, 1.59% KCl; 1:1 molar ratio). The samples were manufactured to contain 1.6% residual NaCl or equivalent amounts on a molar basis. It is not surprising that the Cheddar salted with 3.2% KCl alone was ‘extremely bitter and totally unacceptable’ after 4 months of ripening. Additionally, there was extensive lipolysis. All fatty acid patterns in cheese salted with 1:1 NaCl:KCl were very similar to the control cheese. Results of proteolysis and texture (by compression or cutting) of this variant were not significantly different from results of the control cheese. Sensory scores for texture and flavour were not significantly different as well. Therefore, this cheese salted with NaCl/KCl combination appears to be an alternative to Cheddar salted with only NaCl. Magnesium and calcium chlorides were also applied, but cheeses were not satisfactory.

Reddy and Marth (1991) published a review citing the former studies. Their subsequent papers dealt with milled commercial Cheddar curd. The curd was divided and the lots were salted with NaCl, KCl or mixtures of the both salts. The lots contained about 1.4 or 1.6% NaCl, 1.7% KCl, or NaCl/KCl mixtures
with about 1%/0.5%, 0.8/0.8%, 0.5%/1.0%, and 0.7%/1.0%. After ripening of
36 weeks all results of total free fatty acids (FFA) induced no detectable
rancidity. Therefore, replacement of one-third or more of the NaCl in Cheddar
cheese with KCl did not enhance development of hydrolytic rancidity in the
product (Reddy and Marth, 1993a). Proteolysis of the same lots has also been
analyzed (Reddy and Marth, 1993b). Peptide material soluble in trichloracetic
acid and free amino acids (FAA) were measured during the ripening period.
There were no significant differences attributable to the various salt
treatments in levels of the two parameters. Sensory analyses of peptide
extracts of selected cheeses indicated that KCl may not have inhibited or
masked development of bitterness to the same extent as did NaCl when
starter bacteria or other factors caused formation of bitter peptides in cheese.
By inhibiting responsible enzymes from rennet and starter bacteria, NaCl
retards formation of bitter peptides (Stadhouser et al., 1983). Microflora of the
Cheddar lots has been analyzed too (Reddy and Marth, 1995a). Populations
of aerobic microorganisms, lactic acid bacteria (LAB), non-starter lactic acid
bacteria (NSLAB), aerobic spores, coliforms, and yeasts and moulds were not
significantly different in cheeses with 1.5-1.75% salt. Staphylococcus aureus
and Escherichia coli were not detected in any of the samples. Another paper
(Reddy and Marth, 1995b) dealt with the effect of using KCl to replace some
or all of the NaCl (on a weight basis) for salting cheeses made with three
different starter cultures. There were no major differences in the classes
of organisms that comprised the lactococci or NSLAB of cheeses salted NaCl,
KCl or mixtures of NaCl/KCl. However, such studies have not
comprehensively examined microbial populations at the species or strain
level.

Koenig and Marth (1982) reported that the use of 1:1 mixture (weight basis) of
NaCl and KCl did not enhance the potential for formation of enterotoxin in
experiments with Cheddar cheese inoculated with Staphylococcus aureus.
Larson et al. (1993) evaluated the behaviour of Listeria monocytogenes and
Salmonella Heidelberg in rennet whey salted with NaCl, KCl, or a 55/45
mixture of these salts. There were no indications that behaviour of the two
pathogens correlated with the type of salt used. NaCl and KCl appeared to
function interchangeably in simulated cheese safety systems.

An extensive consumer evaluation (>500 panelists) of industrial Cheddar was
carried out by Reddy and Marth (1994). Overall mean scores showed that the
acceptability of cheese with about 1.0% NaCl and 0.5% KCl was not
significantly different from cheese with about 1.5% NaCl. However, as the
concentration of KCl increased from about 0.5 to about 1.0%, the cheese
gradually became less acceptable. It was demonstrated that a partial
substitution of NaCl by KCl is possible without adversely affecting its flavour
characteristics when 0.5% NaCl was replaced with the same amount of KCl.

Grummer et al. (2012) hypothesized that by targeting salt replacer
concentrations to produce the same water activity ($a_\text{w}$) as in full sodium
cheese, changes in cheese quality would be minimized (Grummer and
Schoenfuss, 2011). Reduced-sodium Cheddar was made using blends of
NaCl with KCl or with KCl ’modified’ to mask bitterness. Sodium levels in
reduced-sodium Cheddar were <400 mg/100 g cheese, compared with 665 mg/100 g in the control full-sodium cheese. In spite of identical a\textsubscript{w} of 0.96, the reduced-sodium samples had a slightly lower pH value than the control cheese after one month of ripening indicating that the starter culture was possibly less inhibited, although it is unclear whether this is a general consequence of use of non-sodium salts (Grummer et al., 2012). Variation in cheese hardness was observed, although this might be an effect of variable moisture content rather than a direct effect of the salts themselves. Bitterness ratings for cheese made with NaCl-KCl blends were not significantly different from the full-sodium control, although it should be noted that assessments were made on cheeses only after 6 months of ageing. The authors concluded that KCl can be used successfully to achieve large reductions in sodium when replacing a portion of the NaCl in Cheddar cheese. Parallel trials of calcium chloride and magnesium chloride did not give satisfactory cheeses.

**Conclusion**
Partial substitution of NaCl with KCl seems to be possible without significant adverse effects on quality characteristics. Investigations indicate that substitution of up to 30% of the NaCl might be possible for some Cheddar-style cheeses, with a maximum of 0.5-0.7% KCl in the cheese.

### 3.3.3 Semi-hard cheeses
Several studies have dealt with the properties of low-fat Fynbo, a semi-hard cheese with a short ripening period, buck-wheat flavour, originally produced in Fyn, Denmark. Zorilla & Rubiolo (1994a; 1994b) modelled NaCl and KCl movement during salting in a brine of 100 g/l NaCl and 100 g/l KCl and during ripening. A numerical integration method allowed the estimation of NaCl and KCl concentrations as a function of cheese position and brining time for conventional periods. By integrating the equations associated with salting and ripening stages for cylindrical geometry (Zorilla and Rubiolo, 1998), the analytical solutions are convenient to obtain because they have a quicker convergence than the numerical solutions and are useful in the study of any changes in the solute concentration profile in the Fynbo cheese used.

Zorilla et al. (1996) continued to study commercial low-fat Fynbo cheese delivered in plastic vacuum bags. The brine solution here and in further studies contained 190 g/l NaCl or 100 g/l NaCl and 100 g/l KCl. After 10 hours of brining, the cheeses were vacuum-packed and ripened for 1-30 days. Results showed that a primary proteolysis of the \(\alpha_{S1}\)-casein by rennet took place. This proteolysis was affected more by the salt concentration than by the type of salt substitution. Therefore, the NaCl replacement by KCl did not affect this type of cheese proteolysis. The kinetics of \(\alpha_{S1}\)-casein degradation during ripening was further analyzed in four different zones of the Fynbo loaves (Zorilla and Rubiolo, 1997). Similar kinetic parameters were obtained for a cheese salted with the NaCl/KCl brine and for the control cheese. It was confirmed that proteolysis was affected by the higher salt concentration in the range analyzed, but NaCl replacement by KCl did not affect cheese proteolysis kinetics.
Additionally, the effect of two ripening temperatures (12 and 16 °C) was analyzed during 1-90 days (Laborda and Rubiolo, 1999). Proteolysis was determined by peptide analysis of the water-soluble nitrogen (WSN) fraction. There were no differences attributable to salt treatments. Analysis of WSN extracts indicated differences in hydrophilic peptides for cheeses ripened at the two temperatures, but profiles were similar for cheeses salted with NaCl and with NaCl/KCl. The central and external zones of cheeses ripened at 5, 12 or 16 °C were analyzed for moisture and chloride contents, maturation index, and casein degradation (Sihufe et al., 2003). NaCl replacement by KCl did not affect any of the parameters studied. Total salt concentration and ripening temperature affected proteolysis significantly. No significant differences in the kinetic parameters of β-casein proteolysis were observed between cheeses salted with NaCl and those salted with the NaCl/KCl brine (Sihufe et al., 2005). Kinetic constants were significantly affected by region within cheese and ripening temperature.

Sieber and Schär (1990) produced semi-hard Appenzeller cheese with different brines. The brine contained saturated amounts of NaCl or of 1:1 and 3:1 mixtures of NaCl/KCl (molar ratio). The cheeses were brined for 24 hours after pressing and, additionally, smeared with the corresponding brine during ripening for four months. The control cheeses with NaCl had a higher dry matter (about 65%) than the cheeses with KCl (62-63%). Therefore, a penetration test resulted in significantly different texture parameters. The sensory analysis showed a bitter flavour of the cheeses brined with the NaCl/KCl mixtures.

Edam cheese, produced at industrial scale, was salted in brine (18% salt) containing a mixture of NaCl and KCl, at a 1:1 molar ratio for 12-24 hours (Wachowska, 2011). The cheeses were compared with a control sample salted in traditional brine for 24 hours. No significant differences were observed in the microflora of the differently brined cheeses during the ripening period of six weeks. None of the cheeses contained E. coli bacteria or coagulase-positive staphylococci in 0.1 g. The type of brine used also had no significant effect on changes in the number of spores of anaerobic saccharolytic bacteria.

Iwanczak et al. (1995) salted commercial Camembert, semi-soft Camping, Tilsit and Gouda cheese in brines containing NaCl or a 1:1 mixture of NaCl/KCl. The cheeses were taken out of the brines after 25, 50, 75, and 100% of the standard salting times for each cheese type and analyzed for chemical parameters. Increased potassium content did not affect cheese proteolysis during ripening. On the other hand, cheese proteolysis increased when the sodium content decreased. Organoleptic evaluation of cheeses confirmed that it is possible to produce high quality cheeses with increased potassium content and decreased sodium content. The best organoleptic characteristics for cheeses salted with NaCl/KCl mixture were achieved using salting times 50 or 75% shorter than standard.
Bona et al. (2007b) tried to substitute NaCl partially by KCl in salting of Brazilian semi-hard Prato cheese. Commercial Prato curd was salted at rest for 11 hours in a brine of 15 g NaCl/100g and 5.6 g KCl/100 g. Cylindrical samples were removed from the cheeses periodically to determine the NaCl and KCl concentrations. From the predicted results it was estimated that a salting time between 5 and 6 hours would be sufficient to salt Prato cheese, because the final internal saline solution was in agreement with that recommended for the product (about 1.25% NaCl and 0.75% KCl). The multicomponent (NaCl and KCl) diffusion that occurred during the salting was modelled and simulated in this study by the so-called finite element method (FEM). FEM can be adapted to calculate the mean concentrations of salts in cheese ripening, to improve the process productivity and also to provide better quality control. Simulated saline distribution profile by FEM showed that agitation during brining resulted in halved brining time (Bona et al., 2007a).

**Conclusion**
The results of multiple studies indicate that partial replacement of NaCl by KCl is possible, at least for some cheese types, using brines containing KCl at equal or lower concentrations than NaCl. Shortening the brining time can be used to limit KCl uptake. The acceptable limit is about 0.7% KCl in the final cheese.

### 3.3.4 Cheeses ripened in brine

#### 3.3.4.1 Feta and Feta-type cheese

Feta and Feta-type cheeses belong to the high-salt varieties. Therefore, attempts to produce low-sodium products are useful. The partial substitution of NaCl by KCl in Feta cheese made of ewes' milk was investigated by Katsiari et al. (1997). The drained curd was placed into cans for dry salting with 3% fine-grain NaCl (control) or a mixture of NaCl and KCl (3:1, and 1:1) for two days. Afterwards, the cans were filled with brine containing 7% salt of the above mixtures, sealed, and held until the pH dropped <4.6. Cold storage for up to 240 days concluded processing. It was found that the substitution of sodium by potassium in Feta cheese (equivalent to about 2.8% total salt according to chlorine content) is feasible without any adverse effects on its quality. The cheeses made with mixtures of NaCl/KCl showed no significant differences in compositional, physicochemical (pH, \(a_w\)) and textural properties in comparison with the control cheese. A trained five-member panel familiar with Feta cheese had evaluated the cheeses with about 45 % DM after 60, 120 and 240 days of ripening. The control cheese received numerically higher flavour scores than the NaCl/KCl salted cheeses, and the tendency toward lower scores of the 1:1 NaCl/KCl mixture was due to a slightly bitter-metallic aftertaste, especially after aging for 240 days. Despite this minor flavour defect, the cheeses were very acceptable and all differences were not significantly. The Na:K ratio (molar basis) decreased from 31.5 in the control cheese to 4.0 and 1.4 in the cheeses salted with 3:1 or 1:1 mixture of NaCl/KCl, respectively (Katsiari et al. 1997). The results of lipolysis showed that the acid degree values (ADV) of control and experimental cheeses were
similar at all sampling ages (3-240 days). Moreover, there were neither qualitative nor significant quantitative differences in the individual FFA at 40 and 240 days (Katsiari et al. 2000a). Proteolysis was monitored during Feta aging by using six different methods. It was similar in control and experimental cheeses at all sampling ages (Katsiari et al., 2000b).

Aly (1995) manufactured UF Feta-type cheese coagulated by yogurt starter and GDL. The UF retentate made of cows' milk was mixed with 2.0% NaCl (control), 1.5% NaCl and 0.5 % KCl, 1.0% NaCl and 1.0 %KCl, or 0.5% NaCl and 1.5 % KCl. The samples were distributed in cans and left to complete coagulation. Analysis during and after cold storage for 30 days indicated that substitution of NaCl by KCl did not significantly influence moisture, fat, total N, pH or proteolysis, but significantly decreased the acidity of the cheese throughout the storage. Sensory evaluation by five judges showed that Feta cheese without defects in flavour could be manufactured using 2% of a 1:1 NaCl/KCl mixture which gave only 4.1 mg Na/g cheese.

**Conclusion**

Greek Feta cheese could be manufactured with a 1:1 mixture of NaCl and KCl. This substitution showed no significant effect on the comprehensive parameters analyzed. However, a slight bitter-metallic aftertaste was observed, especially after a long aging period. In the studies reviewed total salt content of the cheeses was about 2.8%. UF Feta-type cheese was produced without sensory defects in flavour using 2% of a 1:1 NaCl/KCl mixture which gave about 4 mg Na/g cheese.

**3.3.4.2 Other white brine cheeses**

Ashrafi et al. (2009) tried to minimize sodium in Iranian white brine cheese using a chemometric approach. Influence of ripening time and different ratios of NaCl/KCl in brine and on sodium and potassium content, proteolysis, lipolysis, dry matter (moisture content), microbiological parameters and sensory quality was explored using a mixture design. The optimum conditions for minimization of sodium in Iranian white brine cheese were: 27.1:72.9 KCl:NaCl in brine, and ripening time of 40 days. Sodium and potassium contents in the cheese samples made at optimum conditions were predicted to be 2.43 and 1.32%, respectively. When the KCl content of salt in brine increased to 10%, the sensory score decreased and remained constant up to 27.7% KCl of salt in brine. Higher KCl concentrations led to significantly low sensory acceptability.

Dorosti et al. (2010) aimed also at partial replacement of NaCl with KCl in cheese-making brine of Iranian white cheese. The cheese samples were ripened for up to 56 days in brines containing either 10% NaCl (control) or a mixture of NaCl:KCl 1:1 and 3:1. The physical and chemical properties (DM, salt, pH, and acidity), proteolysis and textural hardness were not significantly different. It was concluded that a reduction of NaCl down to 50% in brine had no effect on the compositional quality of the cheese produced. Sensory quality was not analyzed.
Güven and Karaca (2001) analyzed proteolysis in Turkish white cheese salted and ripened in brines prepared from various salts. The brines containing 14% salt were made of NaCl, or made of a 0.44/0.56 mixture of NaCl/KCl. The cheese samples were brined for 3 hours, transferred to glass jars with the same brine and stored at 4°C for 12 weeks. The effect of different brines on total N, water-soluble N, NPN, casein N and proteose-peptone N contents of cheeses were found to be insignificant. The content of salt in cheese and sensory results were not given.

Another study of Turkish white (pickled) cheese was published by Karagözülü et al. (2008). The coagulated curd was pressed in frames before brining overnight in 15-16% salt. After pre-ripening for 24 hours, the cheeses were vacuum-packed, and stored at 4°C for 90 days. The NaCl proportion of the different brines decreased from 100 to 75, 50, 25, and 0%, whereas the KCl content increased correspondingly. Analysis during ripening comprised the content of main ingredients, other chemical and physical parameters, and sensory evaluation. The authors indicated that the cheese could be produced with the mixture of 75:25 NaCl:KCl without negative effects on cheese quality. This cheese contained about 840 mg/100 g sodium and 140 mg/100 g potassium after 90 days of storage.

3.3.4.3 Semi-hard and hard cheese in brine

The effect of partial substitution of NaCl with KCl on Halloumi cheese during storage has been studied. Halloumi is a semi-hard cheese of the eastern Mediterranean region with no rind and no gas holes, and its texture is elastic and compact. The specific characteristic of its manufacture is that the pressed curd is heated at 90-95°C for 30-35 min in deproteinized whey before cold brining for up to 8 weeks. Ayyash and Shah (2010) used four different brine solutions with 18% total salt each: NaCl (control), and NaCl:KCl with 3:1, 1:1, and 1:3. No significant effect was observed in terms of moisture, fat, protein, LAB count, lactic and citric acid, and pH values at the same storage period. Acetic acid counts of Halloumi cheeses kept in higher KCl brine (1:1 or 1:3) were slightly higher compared with the two other cheeses. Sensory properties were not evaluated. A study on proteolysis of these Halloumi cheeses kept in various ratios of NaCl and KCl brine solutions showed similar proteolytic peptide patterns (Ayyash and Shah, 2011). Sodium and potassium ions had also similar effects on calcium in cheese. Increase in sodium and potassium contents decreased calcium contents and increased primary and secondary proteolysis. The effect of NaCl substitution on texture profile and microstructure of the Halloumi cheeses was also analyzed (Ayyash et al., 2011). No significant difference was found in textural hardness, cohesiveness, adhesiveness, and gumminess. Microstructure showed a compact and closed texture. Calcium content negatively correlated with hardness and sodium and potassium contents.

The work of Kamleh et al. (2012) included instrumental textural characteristics, descriptive sensory analysis, consumer acceptance trials, and
microbiological analysis of lightly salted Halloumi cheese after 8 weeks of cold storage. Three different brines contained only 10% salt each. They were made up of NaCl:KCl at 100:0, 70:30, or 50:50. No differences were found between different salt treatments except for minor differences in descriptive analysis (bitterness, crumbliness, moistness). The sensory properties, coupled with the chemical, physical, and microbiological results, suggest that Halloumi cheese could be successfully manufactured using NaCl/KCl brine instead of the commercial NaCl brine. This is especially true at lower brine concentrations and at lower substitution percentages.

Katsiari et al. (1998) manufactured Kefalograviera cheese with less sodium by partial replacement of NaCl with KCl. Kefalograviera is a traditional Greek ewes’ milk hard cheese with a high salt content (≥3%). The curd was immersed for two days in brine containing 20% salt. The salt consisted of NaCl (control) or 1:1 and 3:1 mixtures of NaCl and KCl. Afterwards, the cheeses were surface dry-salted nine times with the same salt mixtures. Finally, they were washed with weak brine (14% NaCl or NaCl/KCl mixtures) 23 days after manufacture. After drying, they were packed and ripened up to 90 days at 10-12 °C. Analysis of the cheeses as applied to Feta cheese (Katsiari et al., 1997) indicated that a 50% substitution of sodium by potassium in Kefalograviera cheese is feasible without any adverse effects on its quality. The samples made with mixtures of NaCl/KCl showed no significant differences in compositional, physicochemical, textural and sensory properties in comparison with the control cheese. However, the slightly lower flavour scores of the cheeses salted with the 1:1 NaCl/KCl mixture resulted from a slightly burning-metallic aftertaste mainly after 180 days, typical of KCl. The Na:K ratio (molar basis) decreased from 35.3 in the control cheese to 4.2 and 1.4 in the cheeses salted with 3:1 or 1:1 mixture of NaCl:KCl, respectively. Results of lipolysis and proteolysis of the Kefalograviera cheese were published in two further papers (Katsiari et al., 2001a; 2001b). The parameters analyzed corresponded again to that in former studies applied to Feta cheese (Katsiari et al., 2000a; 2000b). All data indicated that the partial replacement of NaCl with KCl in the manufacture of Kefalograviera cheese did not significantly influence lipolysis and proteolysis during cheese aging.

3.3.5 Fresh cheeses

Gomes et al. (2011) investigated the partial replacement of NaCl with KCl in the production of Minas fresh cheese ‘Frescal’, one of the most consumed dairy products in Brazil. The fresh white cheese is slightly salted, must be juicy, soft, slightly granulated, with a mild taste, and has a shelf life of about 20 days under refrigeration. The experimental curd was submitted to dry salting. Four treatments were tested replacing 0, 25, 50, and 75% of NaCl by KCl, while keeping the final concentration of salt consistent (0.8%) in relation to the total mass of the final product. The cheeses were vacuum-packed and stored at 5°C for 21 days. Analysis comprised content of DM, fat, protein, salt, and proteolysis, pH and hardness after compression. The substitution of NaCl with KCl resulted in no differences among the different treatments, except for changes in hardness. The consumer test at the first day of storage indicated
that it is possible to manufacture an acceptable low-sodium Minas fresh cheese by partial substitution (25%) of NaCl with KCl at the salting step.

3.3.6 Future development and adoption of cheese technologies

Recent decades have seen an increase in research activities working on partial replacement of sodium chloride with potassium chloride. However, it is clear that the very complex role of sodium and the great variety of cheese types employing very different manufacturing processes and leading to different product properties represent challenging issues. Even where potential applications for KCl have been demonstrated, the transfer of these new research results into industrial applications (and into new cheese products or low-sodium variants of existing cheese types) is not a trivial technical exercise. Flavour defects, particularly bitterness and loss of salty flavour, remain a problem. Beyond the scope of this review, research continues on proteolysis-related bitterness reduction by enzymes, cultures or other ingredients, masking of KCl-specific flavours, or enhancement of salt perception through the use of flavour enhancers and novel salt distribution strategies.

New cheeses and production processes are also possible. For example, a manufacturing process for low fat cheeses from recombinated ultrafiltered milk (UF cheese) and added inulin as fiber source has been developed (Miocinovic et al., 2011) using salting with 2% of mixed salt (NaCl:KCl 3:1). Analysis included the influence of coagulation parameters and type of salt used. Cheese composition (about 22% DM and 16% FDM), proteolysis, scanning electron microscopy and sensory analysis were determined during 8 weeks of cold storage. Maintenance of pH values within an optimal interval enabled the retaining of the initial texture of cheeses throughout the storage period with soft and creamy consistency. The appearance of this type of product on the market may be significant in terms of meeting the increasing needs of consumers that are more in line with modern trends in functional food production.

3.3.7 References


