The Effect of Potassium Chloride as a Salt Replacer on the Qualities of Processed Cheese

Pranaykumar V. Patel
Graduate Student, Food and Nutrition Sciences

Jayjanmejay B. Patel
Graduate Student, Food and Nutrition Sciences

Dr. Eun Joo Lee
Faculty Advisor, Food and Nutrition Sciences

Abstract

The objective of this study was to evaluate and compare the effects of potassium chloride (KCl) and potassium based emulsifying salts as a salt (NaCl) replacer on the chemical, physical, microbiological and sensory characteristics of pasteurized processed cheese. The treatment 1 (T1) was made using the potassium chloride (KCl) and the treatment 2 (T2) was made using a mixture of 50 % of potassium chloride and 50 % of sodium chloride (NaCl+KCl). The control sample of processed cheese was made using the sodium chloride (NaCl) only. The processed cheese samples were analyzed for chemical (fat, moisture, protein, salt, pH, and meltability), physical (hardness, cohesiveness, springiness, chewiness and gumminess), microbiological (total plate, coliform, yeast, and mold counts), and sensory (color, texture, and saltiness) characteristics. The results of fat content, moisture content, pH and meltability in T1 and T2 were not significantly different than the control, but in the microbial results, the control had the lowest number of microbial counts followed by T1 and T2. The replacement of NaCl using KCl had a significant effect on sensory properties including hardness, bitterness and saltiness of processed cheese. In conclusion, potassium chloride has high potential for use as a salt replacer without changing the chemical properties, but it has limited

application for use in processed cheese because of short shelf life and low sensory qualities compared with the control. A combination of 50% NaCl and 50% KCl was recommended for use as a salt replacer in the processed cheese with other ingredients such like flavor enhancers, which can mask the bitter flavor produced by KCl.
Keywords: sodium reduction, potassium chloride, processed cheese

Introduction

Salt (sodium chloride, NaCl) is the oldest food seasoning, which provides one of the important basic human tastes (saltiness) and preserves foods to extend the shelf life. Salt is one of the required components of the human body for normal physiological activity. Salt mainly consists of two elements: sodium and chloride. There are various types of salts available on the market depending on the size and refining process.

Although salt has various unique functions for the human body as well as in food processing, high amounts of sodium consumption are an increasing social problem in the United States (Murphy et al., 2012). High sodium intake is increasing the risk of heart attack and high blood pressure which are the first and the fourth leading causes of death in the United States (Doyle, 2008; Ostchega et al, 2008). Results for sodium intake and its effects on human blood pressure were derived from scientific research, animal studies and other human surveys (Doyle, 2008; Kesteloot & Joossens, 1988; Cutler et al., 1997; Meneton et al., 2005). The mechanism of the effect of salt on blood pressure could be due to the rise in plasma sodium or to the increase in extracellular fluid volume (De Wardener et al, 2004). Higher dietary sodium intake is also related to bone disease (Doyle, 2008). Calcium and sodium metabolism are interconnected in the human body; as sodium consumption in the diet increases, absorption of calcium ions decreases.

According to *Dietary Guidelines for Americans* (2010), the recommended daily intake of sodium for an adult is 2300 mg per day (USDA, 2010). The average estimated intake of sodium for all American age groups is approximately 3400 mg per day, which is higher than the recommended daily allowances. This guideline also recommends a daily intake of 1500 mg sodium for an individual who is suffering from chronic diseases or who is older than 51. Recently the whole world, including the United States, has concentrated on strategies to reduce salt content in the human diet. The World Action on Salt and Health, a leading group at the international level, is working with industries and governments in 80 countries to reduce sodium intake in the human body (Wash, 2005).

Processed cheese has the highest sodium content product among dairy products. The United States is one of the leading states in the production of processed cheese and produces around 30% volume of total world production (Award et al., 2004). According to the National Agricultural Statistics Service, total cheese production in 2010 was 10.4 billion pounds (USDA, 2011). Cheddar cheese has around 620 mg sodium/100 g cheese, low moisture skim mozzarella cheese has 512 mg sodium/ 100 g and processed cheese has 1,488 mg sodium/100 g (Agarwal et al., 2011). Therefore reduction of salt content in processed cheese would be a great opportunity to reduce sodium intake in the human diet by changing the type of salt.

Generally, processed cheese is made from normal cheese with various ingredients such as emulsifying salt, extra salt, and food colorings for the homogeneous mass condition during heat processing. Unprocessed cheese usually can be separated into a molten protein gel and liquid fat by heat treatment. During heat treatment, emulsifying salts such as sodium phosphate, potassium phosphate, tartrate and citrate have an important role to protect the separation of protein and fat. Emulsifying salt reduces the tendency for tiny fat globules to attach on the surface of protein in the molten cheese. Therefore, sodium reduction of processed cheese can change physical, microbial and sensory properties of processed cheese.

This research project is aimed at reducing the salt in processed cheese by changing the type of salt used to manufacture processed cheese. By changing the type of salt used, the amount of sodium in the human diet can be controlled. The objectives of this research project are 1) to develop a healthy, reduced salt processed cheese and 2) to characterize and quantify the chemical and microbiological properties of processed cheese with the salt (sodium chloride, NaCl) replacer (potassium chloride, KCl).

Materials and Method

Processed Cheese Manufacture

Three different types of processed cheese samples, a control (NaCl), treatment 1 (KCl) and treatment 2 (NaCl+KCl), were made using different formulations for the salt and different emulsifying salts. For the control sample, the salt and emulsifying salts used were sodium-based only. For Treatment 1, the sample was manufactured using potassium-based salt and emulsifying salts. Treatment 2 was manufactured using potassium- and sodium-based salts and emulsifying salts in a 50-50% mixture. Cheddar cheese, anhydrous milk fat, preservatives, acid for pH adjustment were formulated by % weight to produce 4.54 kg (10 lb) quantities of processed cheese each. Sodium citrate, potassium citrate and dipotassium phosphate were used as the emulsifying salts. The level of each ingredient used for the manufacture of individual processed cheese samples is detailed in the following table 1.

Table 1

Formulation for Processed Cheese Samples Using Different Salts (unit: g)

Ingredients	NaCl	KCl	NaCl+KCl
Cheddar cheese	4425.0 (88.50 %)	4425.0 (88.50 %)	4425.0 (88.50 %)
Anhydrous milk fat	141.5 (2.83 %)	141.5 (2.83 %)	141.5 (2.83 %)
Sodium citrates	140.0 (2.80 %)	0.0 (0.00 %)	70 (1.40 %)
Potassium citrates	0.0 (0.00 %)	70 (1.40 %)	0.0 (0.00 %)
Dipotassium phosphate	0.0 (0.00 %)	70 (1.40 %)	70 (1.40 %)
Sodium chloride	25.0 (0.50%)	0.0 (0.00 %)	12.5 (0.25 %)
Potassium chloride	0.0 (0.00 %)	25.0 (0.50 %)	12.5 (0.25 %)
Sorbic acid	10.0 (0.20 %)	10.0 (0.20 %)	10.0 (0.20 %)
Lactic acid	7.5 (0.15 %)	7.5 (0.15 %)	7.5 (0.15 %)
Carotenal	0.8 (0.02 %)	0.8 (0.02 %)	0.8 (0.02 %)

* Formulation based on making10 lb processed cheese

The cheddar cheese (Whitehall specialties, Whitehall, Wisconsin) was mixed with the anhydrous milk fat (MidAmerica Farms, Springfield, Missouri) in the steam cheese cooker (Blen- tech Corporation) at 50 rpm for 30 min at room temperature to achieve a homogeneous paste and then heated until the temperature reached 60 ºC. Salt (Cargill Inc., Minnesota) and emulsifying salts (Cargill Inc., Minnesota) were added into mixture and then five minutes later, the pH of processed cheese was measured using a pH meter (Thermo Electron Corporation, Louisville, Colorado). For the adjustment of the pH to below 5.6, lactic acid (BK Giulini cor., Simi Valley, California) was added to the processed cheese mass. Once the temperature reached 84ºC, it was maintained for five minutes to ensure the microbiological safety of processed cheese. Sorbic acid (Chemical supply, Miami, Florida) and carotenal (International Foodcraft Cor., Linden, New Jersey) were added to the processed cheese for the preservative effect and cheese color. The processed cheese was packed into 5-lb paperboard loaf boxes (Green Bay Packaging, Green Bay, WI) and stored at 10 ºC for further analysis.

Chemical Analysis of Processed Cheese

The moisture, fat, and protein contents of the processed cheese were analyzed using the oven drying method (AOAC Official Method 926.08), AOAC Official Method 920.125 and Kjeldahl method (AOAC Official Method 2001.14) (Horwitz, 2011). Salt content of processed cheese samples was determined using the Quantab Chloride Titrator (AOAC Official Method 971.19). All processed cheese samples were analyzed for pH using the pH meter probe (Electron Corporation, Louisville, CO). Meltability of processed cheese samples was analyzed using the Schreiber test. Circular cheese samples, 39.5 mm diameter and 5mm height, were placed into a Pyrex petri dish. These dishes were transferred to a forced draft oven, which was heated to 232 ºC. Samples were taken out after 5 minutes and cooled at room temperature. The meltability of the cheese samples was determined by the Schreiber test, as previously described by Koca and Metin (2004). The cheese samples (4-6 ºC) were prepared using a glass borer and a sharp knife. The samples (36 mm × 7 mm) were placed on a Petri dish, which was then placed into an electrical oven preheated to 107 ± 1 ºC for 5 min. The samples were removed from the oven and cooled for 30 min at room temperature. Sample expansion was measured using a scale with six lines (A - E) marked on a concentric set of circles. Schreiber meltability was expressed as the mean of six readings using an arbitrary scale (0-10 units) (Park et al., 1984).

Texture Profile Analysis (TPA)

A Texture Profile Analysis (TPA) of cheese sample was measured with the Instron testing machine, Model 3342 (Instron Corp., Norwood, MA). Cheese samples were cut into a one-inch diameter by two-inch height in cylindrical shape with metal cylinders (25 x 50 mm, dia. x height). Four specimens per each treatment were taken at room temperature using the double compression test, which was compressed between two stainless steel 50 mm diameter plates with a load cell of 0.5 kN. Double compression cycles were carried out for the remaining time with the rate of 100 mm/min. The test parameters hardness, cohesiveness, chewiness, springiness, gumminess were calculated from the obtained profile using the Bluehill Software (Instron Inc., Norwood, Massachusetts). Hardness was determined from the maximum force given during the first compression. The extent to which the sample returns to its original height between two compressions was called springiness. Cohesiveness was determined from the energy of the cheese during second compression in relation to first compression. Gumminess was the multiplication product of the hardness and cohesiveness value. Chewiness was the multiplication product of gumminess and springiness (Joshi et al., 2004).

Microbiological Analysis of Processed Cheese

The microbiological analysis included total plate counts (TPC), coliform counts, and yeast and mold counts of processed cheese. Total plate counts (TPC), coliform count, and yeast and mold count of processed cheese samples were done using the AOAC Official Method 989.10. Processed cheese samples were mixed using the stomacher in the laminar airflow chamber and two different dilutions were made: one at 1:10 and one at 1:100 using buffer solution. The diluted samples were then transferred to petrifilm (3M Co., St. Paul, MN) and incubated for 24 hours at 37 ºC. The colony was counted using the colony count meter and all samples were analyzed in duplicate. The formula used for the colony count follows:

$N = \sum C / [(1 x n_1) + (0.1 x n_2)] d$

N = number of colonies per mL

$\sum C$ = sum of all colonies on all plates counted

n_1 = number of plates in lower dilution counted

n_2 = number of plates in next higher dilution counted

d = dilution from which the first counts were obtained

Consumer Sensory Test

The processed cheese was analyzed for consumer sensory test. The sensory study was approved by the Institutional Review Board (IRB) at the University of Wisconsin-Stout. The cheese samples were evaluated by 66 consumer panels, consisting of university students and faculty, and local residents from Menomonie, Wisconsin. For the consumer sensory test, cheese samples were brought from the refrigerator and cut into one-inch square cubes. Each panel member was provided three cheese samples in polystyrene cups coded with three digit random numbers. The consumer sensory test was conducted at room temperature under normal light conditions. Each panel was asked a series of questions pertaining to color, hardness, saltiness, bitterness and chewiness of each sample. A 9-point hedonic scale was used in the sensory evaluation. The intensity of attributes was quantified on a 1 to 9 scale from none (0), moderate (5) and extreme (9).

Statistical Analysis

This study was conducted using a completely randomized design with 4 replications and the data were analyzed using SPSS software (version 19.0) provided by IBM Inc. Data were reported as means and standard deviation of the means. A One Way ANOVA was performed for all three processed cheese samples (control, treatment 1and treatment 2) and the level of significance used for Turkey's mean difference was 5% ($p \leq 0.05$).

Results and Discussion

Effects on Chemical Characteristics

The chemical characteristics of three processed cheese samples were shown in Table 2. According to the Food and Drug Administration (FDA), processed cheese should have a pH below or equal to 5.6. The results of pH measurement for three processed cheese samples, Control (NaCl), Treatment1 (KCl) and Treatment2 (NaCl+KCl), were 5.6, 5.6 and 5.5, which were below the limit set by FDA regulation and had no statistical significance ($p>0.05$) between treatments. Karagozlu et al. (2008) supported the theory that that pH of the white pickled cheese was not changed by the full and partial replacement of sodium chloride with potassium chloride.

Table 2

Effect of Types of Salts on Chemical Characteristics of Processed Cheese

Processed Cheese Samples	Moisture (%)	Fat (%)	Protein (%)	Salt (%)	pH	Meltability
NaCl	39.40[a]	31.39[a]	17.14[a]	2.10[c]	5.57[a]	6.00[a]
KCl	39.90[a]	30.57[a]	17.30[a]	1.25[a]	5.57[a]	5.62[a]
NaCl+KCl	39.51[a]	30.66[a]	17.25[a]	1.87[b]	5.55[a]	5.87[a]

[a,b,c] Means with different letters within the same column are significantly different ($p \leq 0.05$); n=4

The ability of processed cheese to melt upon heating is one of the important parameters for the manufacture of processed cheese. The results of the measurement of meltability depending on different salt types had no statistically significant difference ($p>0.05$); NaCl was 6.0, KCl was 5.6, and NaCl+KCl was 5.9, respectively. This means that salt types did not affect the meltability of processed cheese, which agreed with Shirashoji's report that the type and amount of emulsifying salts in processed cheese did not affect the meltability (Shirashoji et al., 2010).

The moisture contents of cheese samples were 39.4-39.9%, fat contents were 30.6-31.4%, and protein contents were 17.1-17.3% respectively. These results were not statistically significant between treatments ($p>0.05$). Al-Otaibi et al. (2006) found the result that white salted cheese made with a different emulsifying salt mixture had no effect on the moisture content. El-Bakry et al. (2010) reported that types of emulsifying salts used for processed cheese manufacture did not statistically affect the fat content. Ayyash and Shah (2011a) demonstrated that replacing sodium chloride with potassium chloride had no effect on the protein content of low moisture mozzarella cheese.

The sodium content of the processed cheese samples, NaCl, KCl and NaCl+KCl were 2.1%, 1.3%, and 1.9% and the values for salt analysis were statistically significant ($p<0.05$). El-Bakry (2012) reported that use of potassium chloride as an emulsifying salt replacer had a significant effect on the salt content of processed cheese. Therefore, salt type and amount of processed cheese had no effect on chemical characteristics including pH, meltability, moisture, fat and protein contents, only except salt content.

Effects on Textural Characteristics

Texture profiles including hardness, cohesiveness, springiness, chewiness and gumminess were analyzed for the effect of different salts and emulsifying salts on textural characteristics of processed cheese (Table 3).

Table 3

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Table 2

Effect of Types of Salts on Chemical Characteristics of Processed Cheese

Processed Cheese Samples	Moisture (%)	Fat (%)	Protein (%)	Salt (%)	pH	Meltability
NaCl	39.40[a]	31.39[a]	17.14[a]	2.10[c]	5.57[a]	6.00[a]
KCl	39.90[a]	30.57[a]	17.30[a]	1.25[a]	5.57[a]	5.62[a]
NaCl+KCl	39.51[a]	30.66[a]	17.25[a]	1.87[b]	5.55[a]	5.87[a]

[a,b,c] Means with different letters within the same column are significantly different ($p \leq 0.05$); n=4

The cohesiveness of the cheese samples was 0.76-0.80, springiness was 3.22, chewiness was 94.6-110.6, gumminess was 29.3-34.3 respectively and these results were not statistically significant between treatments ($p>0.05$). Much research has been done relative to cheese texture and salt type. Kamleh et al. (2012) reported that substitution of NaCl with KCl had no significant effect on cohesiveness of the Halloumi cheese. Ayyash and Shah (2011b) indicated that substitution of NaCl with KCl had no significant effect on cohesiveness of the Nabulsi cheese. Katsiari et al (1997) result shows reduction of sodium by partial substitution of NaCl with KCl did not have a significant effect on the springiness of Feta cheese. Ayyash and Shah (2011c) indicated that replacement of NaCl with KCl had no significant effect on springiness of the Halloumi cheese. Dimitreli and Thomareis (2007) stated that a change in emulsifying salts had no significant effect on chewiness of processed cheese. In contrast, Kamleh et al. (2012) confirmed that substitution of NaCl with KCl had a significant effect on chewiness of the Halloumi cheese. Ayyash and Shah

(2011b) indicated that substitution of NaCl with KCl had no significant effect on gumminess of the Nabulsi cheese. Katsiari et al. (1997) result shows that reduction of sodium by partial substitution of NaCl with KCl had no significant effect on the gumminess of Feta cheese.

The hardness of the control sample (NaCl) was 45.27, the Treatment 1 (KCl) sample was 37.63, and the Treatment 2 (NaCl+KCl) was 36.23. This data showed that the control (NaCl) was harder than other two treatments and all three samples' hardness data were found statistically significant ($p<0.05$). The reason behind this was that the addition of sodium chloride increased the ionic strength of the cheese matrix, which leads to high solubility of protein. High solubility creates swelling of the protein strands and as a result the protein matrix increases resistance to deformation during compressing, so the hardness of cheese with NaCl increases (Pastorino et al., 2003). Kamleh et al. (2012) reported that the substitution of NaCl with KCl had a significant effect on hardness of the Halloumi cheese. Ayyash and Shah (2011b) reported that partial replacement of NaCl with KCl had also a significant effect on hardness of the Nabulsi cheese.

Table 4

Table 2

Effect of Types of Salts on Chemical Characteristics of Processed Cheese

Processed Cheese Samples	Moisture (%)	Fat (%)	Protein (%)	Salt (%)	pH	Meltability
NaCl	39.40[a]	31.39[a]	17.14[a]	2.10[c]	5.57[a]	6.00[a]
KCl	39.90[a]	30.57[a]	17.30[a]	1.25[a]	5.57[a]	5.62[a]
NaCl+KCl	39.51[a]	30.66[a]	17.25[a]	1.87[b]	5.55[a]	5.87[a]

[a,b,c] Means with different letters within the same column are significantly different ($p\leq0.05$); n=4

Effect on Microbiological Characteristics

The microbiological analysis, including total plate counts (TPC), coliform counts and yeast and mold counts of processed cheese samples was done to determine the effect of emulsifying salts (Table 4). Total plate counts (TPC) for the Control (NaCl), Treatment1 (KCl) and Treatment

2 (NaCl+KCl) samples were 2.03, 2.33 and 2.19; coliform counts were 1.39, 1.78 and 1.58; and yeast and mold counts were 1.69, 2.07 and 1.88 ($\log_{10}$ CFU/g). All these results show a statistically significant difference ($p < 0.05$). Total plate counts (TPC), coliform counts and yeast and mold counts for the Control (NaCl) samples were lower than those of Treatment 2 (NaCl+KCl), followed by Treatment1 (KCl). Bidlas and Lambert (2008), Kamleh et al. (2012), and Reddy and Marth (1995) reported that potassium chloride (KCl) had a lower antimicrobial effect than sodium chloride (NaCl) when KCl was used as salt replacer. Bidlas & Lambert (2008) also reported that sodium chloride (NaCl) had more ability to bind free water, which means that water activity was lower than potassium chloride (KCl) and consequently, bacterial growth was inhibited.

Effects on Sensory Characteristics

The sensory characteristics of processed cheese including color, hardness, chewiness, bitterness and saltiness were tested with 66 participants (Table 5). From the 66 participants, 42.42% were male and 57.58% were female. Regarding panelist age, 27.27% panelists were between 18-20 years of age, 42.42% were 21-25 years, 19.70% were between 26-30 years, 4.55% were between 31-35 years and the remaining 6.06% were 36 years and above. Regarding panelists' cheese eating habits, out of 66 panelists, 30.30% panelists eat cheese on a daily basis, 39.39% eat cheese 2 to 4 times a week, 16.67% eat cheese 2 to 4 times in month, 12.12% eat cheese one time per month and 1.52% panelists mention they never eat cheese. The above data shows that around 70% of the consumer test panelists were between 18-30 years of age who ate cheese at least 2 to 4 times weekly.

The results for the color content of the consumer sensory test were 5.36-5.53 and were not statistically significant ($p>0.05$). This indicated that consumers could not note any color difference between different salt treatments compared with normal cheddar cheese made by salt (NaCl). Award et al. (2004) reported that different emulsifying salts mixtures of processed cheese had no significant effect on the color of processed cheese, while Zekai et al. (2004) stated that a high NaCl content cheese sample received a little higher color score than a lower NaCl content in cheese sample. Karagozlu et al. (2008) observed that more panelists liked the color of a cheese sample that had 100% and 75% of NaCl rather than 100% KCl or 50% mixture of NaCl and KCl.

Table 5

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Table 2

Effect of Types of Salts on Chemical Characteristics of Processed Cheese

Processed Cheese Samples	Moisture (%)	Fat (%)	Protein (%)	Salt (%)	pH	Meltability
NaCl	39.40[a]	31.39[a]	17.14[a]	2.10[c]	5.57[a]	6.00[a]
KCl	39.90[a]	30.57[a]	17.30[a]	1.25[a]	5.57[a]	5.62[a]
NaCl+KCl	39.51[a]	30.66[a]	17.25[a]	1.87[b]	5.55[a]	5.87[a]

[a,b,c] Means with different letters within the same column are significantly different ($p \leq 0.05$); n=4

Regarding hardness data for the consumer sensory test, Treatment 1 (KCl) data was found statistically significant ($p<0.05$) compared with other two treatments. This analysis indicates that there was a significant effect of types of salts used on hardness of processed cheese. Consumers noted that Treatment 1(KCl) cheese had a lower score of hardness than the control and Treatment 2 (NaCl+KCl). This sensory result agreed with the result of hardness in TPA, which showed that the NaCl treatment was harder than the KCl treatment. Pastorino and others (2003) reported that an increase of salt (NaCl) content in cheese increased the hardness of the Muenster cheese. Karagozlu et al. (2008) and Adrino et al. (2011) reported that full and partial substitution of NaCl by KCl reduced the hardness of white pickled cheese. The hardness of the control (NaCl) was 4.96, Treatment 1 (KCl) was 4.36, and Treatment 2 (NaCl+KCl) was 5.06, respectively. The chewiness of the consumer sensory test was 4.94-5.27 respectively and these results were not statistically significant between treatments.

The bitterness of the control (NaCl) was 3.53, the Treatment 1 (KCl) sample was 5.38, and the Treatment 2 (NaCl+KCl) was 4.67; this was found statistically significant ($p<0.05$). This analysis indicates that there was a significant effect of types of salts used on the bitterness of processed cheese. Processed cheese made with KCl had a moderate level of bitterness on the consumer sensory scale (5.38) while cheese made with NaCl had below moderate level bitterness (3.53). That means cheese made from KCl was more highly bitter in taste than the other two salt treatments. Hoffmann et al. (2012) observed that emulsifying salts containing potassium gave a bitter taste to processed cheese. Karagozlu et al. (2008) reported that the full and partial substitution of NaCl by KCl gave bitterness to white pickled cheese and Liem et al. (2011) also confirmed that potassium increase bitterness. To reduce the bitter taste in low sodium processed cheese use one might lower the concentration of KCl in cheese manufacturing. Kamleh et al. (2012) suggested that some ingredients such as sucrose, glutamic acid, yeast extract, and caramel solutions may reduce the bitterness of processed cheese made by KCl due to the masking effect of those ingredients.

Sodium reduction of processed cheese has been studied using various sodium replacers (Metazger and Kapoor, 2007). Gupta et al. (1984) described the use of dipotassium phosphate and tripotassium citrate for manufacturing processed cheese. Their results showed that dipotassium phosphate and tripotassium citrate produced processed cheese with meltability and hardness similar to processed cheese manufactured with disodium phosphate and trisodium citrate, respectively. Kamleh et al. (2012) conducted a study on the reduction of sodium on Halloumi cheese and checked its effect on cheese quality. From their research data they found that Halloumi cheese with added KCl had low saltiness and high bitterness due to the addition of KCl and consequently the overall consumer acceptability of cheese was lower. Some studies (Liem et al., 2011; Ley, 2008; McGregor, 2007) suggested the use of bitterness blockers to block the bitter metallic taste coming from the potassium.

The saltiness of the control sample (NaCl) was 5.87, the Treatment 1 (KCl) sample was 5.32, and the Treatment 2 (NaCl+KCl) was 5.22. The results of saltiness in processed cheeses with different salt treatment was statistically significant ($p<0.05$). This data represents that sodium chloride (NaCl) brings more saltiness than potassium chloride (KCl) and consumers realized the difference in saltiness between NaCl and KCl treatments even though it had a small amount of difference. Karahadian and Lindsay (1984) reported that full sodium cheese was saltier than reduced sodium processed American cheese. Liem et al. (2011) and Kamleh, et al. (2012) also confirmed that KCl reduced saltiness in the processed cheeses compared with NaCl treatment.

Conclusion

To reduce sodium consumption in processed cheese, potassium chloride (KCl) was tested as a salt (NaCl) replacer. Replacing a salt did not have an effect on the chemical characteristics of processed cheese, but it had a significant effect on microbial characteristics. The microbial analysis of processed cheese samples indirectly showed the effect of salt replacement on the shelf life of processed cheese. Compared with the control (NaCl), Treatment 1 (KCl) did not change product color or textures such as cohesiveness, springiness, chewiness and gumminess. However, KCl had a significant effect on the hardness of processed cheese in both the TPA and the sensory test. Consumers realized that KCl treated product was softer than NaCl treated product and TPA results also supported this sensory result. More serious limitations for use of KCl as a NaCl replacer came from the high bitterness and low saltiness of the KCl treatment. In conclusion, potassium chloride has high a possibility for use as a salt replacer without changing the chemical properties, but it has limited ability to produce processed cheese with the same shelf life as processed cheese made with sodium chloride. Therefore, the results of this study suggest that combination of NaCl and KCl are more effective for reducing sodium contents with minimum changes of bitterness, saltiness and texture profiles compared with the sole usage of KCl in the processed cheese.

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