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Research Article
Impacts of Sodium Salt Substitution on Sensory and Safety Characteristics of Two Food Models (Beef Burger and Tallaga Cheese)

Eman F. Abdel-Latif and Gehan Kassim

Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Cairo University, Egypt

Abstract
Background and Objective: One of the better strategies for reducing sodium chloride salt in food is substituting it with another similar salt. The main object of this study is reducing sodium chloride salt in high relatively salt content products, ensuring that sensory and safety characteristics of the products are not affected. **Materials and Methods:** The sodium chloride salt was replaced by potassium chloride by different proportions (75, 50, 25 and 100% of KCl) in two food models (beef burger and Tallaga cheese) to reveal the influence of NaCl salt substitution on some sensory parameters and safety through detection the *E. coli* viability in both products. **Results:** The flavour and taste were not significantly influenced in groups with 75% NaCl: 25% KCl in both models. Variable results showed in treatments with 50% NaCl: 50% KCl. However, groups with 75 and 100% KCl received the lowest score findings. While the texture of all groups was not significantly altered by substitution between NaCl and KCl salt in both food models. **Conclusion:** Sodium chloride salt could be replaced by potassium chloride up to 25 and 50% without and/or with a minimal effect on the sensory parameters in both food models (burger and cheese) as well as with a minimal positive effect on controlling the *E. coli* growth on the replacement of 50% NaCl by 50% KCl salt.

Key words: Beef burger, Tallaga cheese, NaCl reduction, *E. coli* viability

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Corresponding Author: Eman F. Abdel-Latif, Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Cairo University, Egypt

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sodium chloride is an essential food ingredient that is used as common salt in food to produce ideal food characteristics. There is a global tendency for reducing sodium salt content in the daily consumed food to control the direct and indirect adverse impacts of sodium on human health. However, sodium represents 40% of sodium chloride salt[1]. Regrettably, people worldwide consume substantially more sodium than their bodies need, especially with the increasing utilization of processed foods that constitute about 70-80% of the daily sodium source intake[2]. Sodium has a close relation to human blood pressure. It also increments the risk of cardiovascular, kidney disease, osteoporosis and indirect cause of obesity[3]. Consequently, national and world organizations establish educational and labelling programs for reduced-sodium content in food. WHO strongly recommends the reduction of daily sodium salt intake to less than 5 g/day (equivalent >2 g sodium/day) in adults to avoid salt-related diseases[2].

Although the application of salt-reduced diet proposal is very hard due to its relation to dietary daily personal behaviour, the individual can be habituated to the foodstuffs with low salt content after a while. However, sodium chloride salt does not apply in food as a flavour enhancer only, but it has been added as a food preservative for keeping the integrity and functional properties of food[4].

Several parameters may be changed when NaCl salt is reduced in food such as acidity, water activity and microbial growth[5] as well as it affects microbial modulation and enzymatic activities in fermented products. Hence, it is crucial to keep the protective salt level during decreasing NaCl salt content, particularly in processed food. That could be achieved by mixing NaCl salt with other salts which have similar saltines characteristic like potassium chloride, calcium chloride and magnesium chloride salts[6]. Thus, satisfying the consumer and manufacturers' requests.

Several salts could be applied in meat emulsions as a protein stabilizer during meat processing, such as potassium, calcium, magnesium chlorides and polyphosphate, which might produce a reduced-sodium formula of meat products[7]. However, potassium chloride is the most salt that could be used to replace sodium chloride salt with minimal changes in meat formula because it has an equal ionic strength as NaCl salt. It interacts similarly with meat proteins. Besides, it's a significant role in the retention of water and free amino acids inside the meat product. As well as it lowers the meat dripping[8].

Likewise, sodium chloride is the main ingredient in cheese processing. Reducing NaCl salt content in cheese adversely affects the structural quality of the cheese if not replaced by another salt[9]. Nevertheless, when sodium chloride salt is mixed with other salts such as Magnesium chloride and calcium chloride (1:1), the cheese texture exhibited alterations, its body becomes greasy, flaky, soft and crumbly with increased concentration of free fatty acids and the extremely sour flavour was observed[10]. But, when NaCl salt was mixed with KCl salt in equal amounts, the cheese texture and the microbial activity were not significantly influenced[11].

From a health point of view, potassium intake helps in decreasing blood pressure[12]. The K^+ ion has a positive correlation balance with Ca^+ in the human body through decreasing calcium renal excretion, preventing renal calculi and maintaining bone mass[13]. However, an increase of potassium ions in the blood more than 5.0 mmol L^{-1} leads to malfunction of the kidney, hypoaldosteronism and Addison disease so should also be controlled[3].

Several studies dealt with the partial substitution of NaCl by many other salts, including potassium chloride salt in different foodstuffs, but not all salt combinations take the consumers' satisfaction. So, it is important to detect the critical limit of substitution of NaCl by KCl salt with a minimal alteration in the sensory and safety characteristics of each foodstuff.

Most cheeses and processed meat products have a relatively high salt content. It was estimated that processed meat products contribute by approximately 20%[14] and cheeses by about 11-20% of the dietary sodium intake[15,16].

In the current study, the impact of NaCl substitution by KCl salt on the sensorial acceptability and viability of *E. coli* in food were investigated in two food models that are chosen for their popularity worldwide (beef burger and Tallaga cheese).

MATERIALS AND METHODS

Study area: Two independent experimental trials were performed at separate times to explore the sensorial acceptability and the viability of *E. coli* with the total and partial substitution of NaCl by KCl salt in a different ratio in meat and dairy food models (beef burger and Tallaga cheese).

Meat model (beef burger): Ten kilograms of frozen beef and two kilograms of fresh fat were purchased from local butcher shops in Giza market, Egypt, they were transported in frozen condition to the laboratory and stored frozen -18°C. Frozen meat and fat were minced at a suitable temperature by 8 and 4 mm plate for meat and fat, respectively, in electrical mincer (Seydelmann NW 114 E, Stuttgart, Deutschland, Germany).

Beef burger manufacture was carried out following Egyptian standard requirements for the beef burger (EOS 1688/2005) as follows: Beef meat 70%, fat 15%, spice mix 0.35%, salt 1.5% and ice 10%. The beef burger ingredients were divided into five equal groups with NaCl salt replacement 0, 25, 50, 75 and 100% with KCl salt. Each group then was subdivided into two subgroups in which one group was prepared by addition of fresh onion and garlic 5% (control BT, BT1, BT2, BT3 and BT4), respectively and the second was left without (control B, B1, B2, B3 and B4). All ingredient of each group was thoroughly mixed by buddle type mixer for five minutes. The obtained pastes were manually formed into 50 g burger patties by using a patty former and packed in foam plates and stored in the freezer at -18°C for further investigation. The burger patties were grilled for 75°C core temperature then, it was cut into portions and directly subjected for examination. Flavour, taste, texture and overall acceptability of cooked beef burger samples were assessed on sensory hedonic with a 5-points scale[17].

Dairy model: Whites soft cheese "Tallaga cheese" was prepared according to El-Kholy *et al.*[18]. The calculated amount of normal fresh cow's milk was pasteurized at 72.3°C/15 sec. then cooled. The microbial rennet (Reniplus® 2000 IMCU g^{-1}) was added at a rate of 0.4 mg/10 kg milk/65°C (manufacturer's instruction), followed by $CaCl_2$ of 0.02%. Milk was divided into two main groups with salt concentrations of 3 and 5%. Each group was subdivided into five different subgroups with NaCl replacement of 0, 25, 50, 75 and 100% KCl salt. The prepared cheese groups with 3% salt content were symbolled by control C_3, C_31, C_32, C_33 and C_34, respectively. While the cheese samples with 5% salt were represented by control C_5, C_51, C_52, C_53 and C_54, respectively. Each panellist asked for the most frequently cited flavour (saltiness, sourness and bitterness), texture and overall acceptability that were scored on the hedonic scale[19]. Scale classifies the cheese quality from 1 to 5 into extremely like (5), good (4), fair (3) & poor (2) and (1) extremely dislike.

The sensory panellists' team consists of 34 members (12 males, 22 females, age range 21-57 years old) who were administrative staff and students at Food Hygiene and Control Department, Faculty of Veterinary Medicine, Cairo University. Tape water and cups were available for mouth wash between samples evaluation. All samples were coded with three-digit numbers and presented at random for judging sensorial attributes.

Experimental *E. coli* contamination: A new production of experimental burger patties and cheese with different NaCl/KCl salts replacement were prepared separately for the viability study. Three based independent replicate experiments at separate times were done.

Strain preparation: *Escherichia coli* (ATCC 25922) strain was obtained from the Animal Health Research Institute, Department of Food Hygiene. The cultures were activated by passed twice at 9 mL of tryptic soy broth, (TSB, Oxoid). Then, incubated at 37°C/18 hrs. One milliliter of the incubated inoculum was added to 100 mL of TSB and incubated with shaking at 37°C/18-24 hrs to have a final concentration of approximately 10^8 CFU mL^{-1} (determined by plating serial dilutions on EMB agar, Oxoid).

Decontamination study: The prepared beef burgers groups with salt treatments (B1, B2, B3) and (BT1, BT2, BT3) as well as control groups (control B and control BT) were inoculated with the prepared *E. coli* strain by dipping the burger patties for 1 min, then were dried in laminar airflow for 20 min[20]. Ten grams of the inoculated examined burgers were stomached with 90 mL of peptone water and serially diluted for determining the count of the inoculated *E. coli* on selective medium (EMB) in duplicate plates. Screening for *E. coli* count in the used minced meat in this experiment was also done to ensure that raw materials used are free from *E. coli*.

Regarding the cheese trail, the NaCl/KCl salt groups (C_31, C_32, C_33), (C_51, C_52, C_53) and control groups (control C_3 and control C_5) were prepared. The *E. coli* strain was inoculated before cheese curd formed as previously mentioned to have a final concentration of *E. coli* about 10^8 CFU mL^{-1}. All the preparations were left undisturbed till the curd constituted and whey was drained off *E. coli* was counted as previously mentioned.

Statistical analysis: Statistical data analysis from three experimental replicates was carried out using SPSS statistics 19.0 for windows. The difference between treatments was determined using a one-way analysis of variance (ANOVA). Differences were considered significant at ($p<0.05$) and comparisons of means were done using *post hoc* (LSD) procedure to show differences among treatments.

RESULTS

Sensory evaluation results: Sensory perception is highly appreciated from consumers' and food industries' points of view to determine the food quality. The mean values of sensory scores (flavour, taste, texture and overall acceptability) of different NaCl/KCl salt substitutions and treatment groups of both food models (burger and cheese) are recorded in Table 1 and 2.

Table 1: Mean values (±SE) of sensorial attributes of grilled burger samples

Salt treatments	Flavour	Taste	Texture	Overall acceptability	Judgment
Untreated burger					
Control B	4.10±0.28[a]	4.50±0.25[a]	4.20±0.16[a]	4.50±0.25[a]	Like (good)
B1	3.80±0.21[a]	4.30±0.20[a]	4.50±0.25[a]	4.30±0.04[a]	Like (good)
B2	2.56±0.04[b]	2.50±0.05[b]	4.50±0.23[a]	2.20±0.07[b]	Poor
B3	2.30±0.08[c]	2.00±0.11[c]	4.50±0.10[a]	2.60±0.15[c]	Poor
B4	1.00 ±0.00[d]	1.00±0.00[d]	4.30±0.18[a]	1.00±0.00[d]	Extremely dislike
Treated burger					
Control BT	5.00±0.00[a]	5.00±0.00[a]	5.00±0.00[a]	5.00±0.00[a]	Extremely like
BT1	4.90±0,09[a]	5.00±0.00[a]	5.00±0.00[a]	5.00±0.00[a]	Extremely like
BT2	4.60±0.07[a]	4.43±0.16[a]	5.00±0.00[a]	4.62±0.20[a]	Good
BT3	2.90±0.42[b]	2.50±0.09[b]	5.00±0.00[a]	3.10±0.29[b]	Fair
BT4	1.00±0.00[c]	1.00±0.00[c]	5.00±0.00[a]	1.00±0.00[c]	Extremely dislike

[a-d]Values with different superscripts are significantly (p<0.05) different salt substitution groups, control B, control BT: 100% NaCl (control groups), B1, BT1 = 75% NaCl: 25% KCl, B2, BT2 = 50% NaCl: 50% KCl, B3, BT3 = 25% NaCl: 75% KCl (wt/wt), B4, BT4 = 100% KCl

Table 2: Mean values ±SE of sensorial attributes of Tallaga cheese samples in both salt concentrations (3 and 5%)

Salt treatments	Flavor	Taste	Texture	Overall acceptability	Judgment
Tallaga cheese with 3% salt					
Control C_3	4.92±0.07[a]	4.78±0.21[a]	4.28±0.10[a]	4.66±0.11[a]	Like (good)
$C_3$1	4.85±0.34[a]	4.28±0.04[a]	4.28±0.17[a]	4.47±0.06[a]	Like (good)
$C_3$2	3.14±0.09[b]	3.21±0.24[b]	4.23±0.24[a]	3.52±0.24[b]	Fair
$C_3$3	1.14±0.10[c]	2.14±0.43[c]	4.12±0.14[a]	2.52±0.18[c]	Poor
$C_3$4	1.00±0.00[d]	1.00±0.00[d]	3.78±0.18[a]	1.92±0.09[d]	Extremely dislike
Tallaga cheese with 5% salt					
Control C_5	4.35±0.26[a]	4.00±0.30[a]	4.32±0.10[a]	4.22±0.19 [a]	Like (good)
$C_5$1	4.14±0.34[a]	4.57±0.27[a]	4.07±0.20[a]	4.33±0.15[a]	Like (good)
$C_5$2	4.57±0.07[a]	4.21±0.24[a]	4.27±0.14[a]	4.35±0.10[a]	Like (good)
$C_5$3	2.00±0.42[b]	2.17±0.58[b]	4.14±0.09[a]	2.77±0.29[b]	Poor
$C_5$4	1.07±0.08[c]	1.87±0.49[b]	3.17±0.13[a]	2.04±0.38[b]	Poor

[a-d] Values with different superscripts are significantly (p<0.05) different salt substitution groups, $C_3$1, $C_5$1 = 75% NaCl: 25% KCl (wt/wt), C_3 2, $C_5$2 = 50% NaCl: 50% KCl (wt/wt), $C_3$3, $C_5$3 = 25% NaCl: 75% KCl (wt/wt), $C_3$4, $C_5$4=100% KCl, Control 3, 5 = 100% NaCl (control)

Substantially, the treated groups of beef burgers with onion and garlic received higher score values for the detected sensory parameters than untreated groups even in control groups (control B and control BT). Both flavour and taste results went in the same pattern as the mean score values were significantly low at p-value (<0.05) in untreated burger samples in groups of B2 (2.56, 2.50), B3 (2.30, 2.00) and B4 (1.00, 1.00) for flavour and taste, respectively, than control B (4.10, 4.50) and B1 groups (3.80, 4.30) for flavour and taste, respectively. On the other hand, the treated groups with onion and garlic showed significantly low results for flavour and taste in only 75 and 100% KCl groups in BT3 (2.90, 2.50) and BT4 (1.00, 1.00) for flavour and taste, respectively. While the groups with 25% and 50% KCl in BT1 (4.90, 5.00) and BT2 (4.60, 4.43) showed high results close to control BT (5.00, 5.00) for flavour and taste, respectively. Concerning the texture, the untreated burger patties revealed lower findings than those of treated groups but, the differences were not significant (p<0.05). Consequently, the highest values of overall acceptability were gone to groups with a low percentage of KCl (25%) (B1, BT1 groups) which were judged as like and extremely like as control groups (Control B and Control BT), respectively. The significantly low results (p<0.05) of overall acceptability of untreated groups were detected in B2, B3 and B4 which were judged as poor, poor and extremely dislike, respectively as well as BT3 and BT4 of treated groups which were judged as fair and extremely dislike, respectively in Table 1.

Regarding the cheese samples in Table 2, the significant low scores (p<0.05) for flavour and taste were recorded in $C_3$2 (3.14, 3.21), $C_3$3 (1.14, 2.14) and $C_3$4 (1.00, 1.00), as well as in $C_5$3 (2.00, 2.17) and $C_5$4 (1.07, 1.87) for flavour and taste, respectively. While higher findings were reported in groups $C_3$1 (4.85, 4.28), $C_5$1 (4.14, 4.57) and $C_5$2 (4.57, 4.21) which were close to the control groups control C_3 (4.92, 4.78) and control C_5 (4.35, 4.00) for flavour and taste, respectively. The texture of all groups was not significantly affected by substitution between NaCl and KCl salt in both salt concentrations (3 and 5%). However, by completely replacing NaCl salt with KCl, the groups $C_3$4 and $C_5$4 showed the lowest results for texture (3.78 and 3.17, respectively). Higher values for overall acceptability were observed in cheese groups with 3% salt concentration in control C_3 (4.66) and $C_3$1 (4.47) groups than cheese with 5% salt concentration within groups control

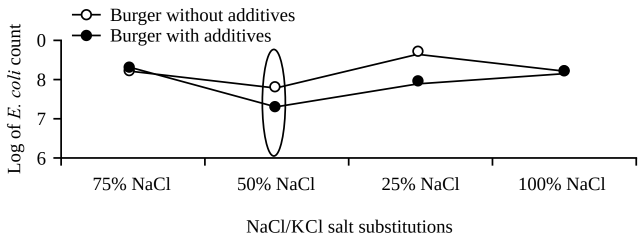

Fig. 1: Optimum reduction in *E. coli* log count CFU g^{-1} with NaCl/KCl substitutions in burger

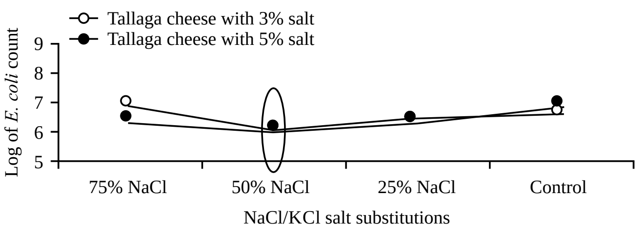

Fig. 2: Optimum reduction in *E. coli* log count CFU g^{-1} with NaCl/KCl substitutions in Tallaga cheese samples

Table 3: Means value (±SE) of log *E. coli* count in burger samples

Salt treatments	Mean of *E. coli* log count±SE
Untreated beef burgers	
Control B	8.20 ± 0.92^{a}
B1	8.20 ± 0.14^{a}
B2	7.78 ± 0.21^{a}
B3	8.66 ± 0.50^{a}
Treated beef burgers	
Control BT	8.15 ± 0.28^{a}
BT1	8.30 ± 0.19^{a}
BT2	7.30 ± 0.31^{a}
BT3	7.90 ± 0.63^{a}

Values with different superscripts are significantly (p<0.05) different

Table 4: Means log value (±SE) of *E. coli* count in Tallaga cheese with salt concentrations (3 and 5%)

Salt treatments	Mean of *E. coli* log count±SE
Tallaga cheese with 3% salt	
Control C_3	6.62 ± 0.49^{a}
$C_3$1	6.88 ± 0.36^{a}
$C_3$2	6.04 ± 0.17^{a}
$C_3$3	6.47 ± 0.18^{a}
Tallaga cheese with 5% salt	
Control C_5	6.85 ± 0.27^{b}
$C_5$1	6.30 ± 0.44^{b}
$C_5$2	6.00 ± 0.25^{b}
$C_5$3	6.28 ± 0.29^{b}

Values with different superscripts are significantly (p<0.05) different

C_5 (4.22) and $C_5$1 (4.33). However, the groups with 3% salt concentration received significantly lower values (p<0.05) by replacing 50% of NaCl with KCl salt and up to 100% in groups $C_3$2, $C_3$3 and $C_3$4 with mean values 3.52, 2.52 and 1.92. While in groups with 5% salt concentration, significant low values (p<0.05) were observed in $C_5$3 and $C_5$4 (2.77 and 2.04, respectively). the completely rejected samples (extremely dislike) were recorded in groups $C_3$4 (100% KCl replacement).

Effect of NaCl substitution by KCl on *E. coli* viability: Depending upon sensorial scores, the results revealed that the total replacement of NaCl by KCl (100% KCl) in burger patties (treated/untreated) and cheese (3 and 5% salt) was unaccepted to the panellists consequently, the consumers. So, the groups B4, BT4, $C_3$4 and $C_5$4 (100% KCl) were excluded from the viability study. The viability of *E. coli* is determined in groups with partial substitution of NaCl/ KCl in untreated/treated beef burger samples and cheese (3 and 5% salt concentrations) was shown in Table 3 and 4.

The *E. coli* counts showed higher values in both treated and untreated groups of beef burger samples than the cheese groups (3 and 5% salt concentrations), but there were no significant differences in results between groups in both food models. However, the mean log values of burger groups exhibited lower values in B2, BT2 groups than the control groups (Control B and Control BT). It was observed that there was about one log reduction CFU g^{-1} in group BT 2 than that occurred in B 1 in Fig. 1 compared to the control groups which decreased from 8.15 (control BT) to 7.30 (BT 2) of the treated beef burger and from 8.20 (control B) to 7.78 (B1) of the untreated beef burger groups in Table 3. The highest reduction level in *E. coli* counts was detected in burger groups with 50% NaCl replacement by 50% KCl.

The cheese groups (3% salt concentration) in Table 4 showed that the lowest mean values for *E. coli* counts were in $C_3$2 (6.04) than that occurred in control C_3 (6.62), $C_3$1 (6.88) and $C_3$3 (6.47), likewise cheese groups with 5% salt concentration recorded the lowest mean values for *E. coli* counts in $C_5$2 (6.00) than that were detected in control C_5 (6.85), $C_5$1 (6.30) and $C_5$3 (6.28). However, the optimum reduction level of *E. coli* counts that were detected in cheese groups with 50% NaCl replacement by 50% KCl as shown in Fig. 2 in both salt concentrations.

DISCUSSION

Beef burger formulation contains about 1.5-1.8% of NaCl salt which plays a significant role in improving burger patties binding through dissociation into ions and cause increasing of myofibrillar proteins solubilization[21]. The results of flavour, taste and overall acceptability in groups B1 and BT (25% KCl) were high and nearly close to the results of control groups

(100% NaCl). On increasing KCl salt replacement up to 50% in untreated burger groups, a significant reduction in results were detected ($p<0.05$) of the sensory parameters than control groups as well as 25% KCl groups (B1 and BT1) due to a slightly unpleasant meaty flavour with an astringent bitter taste that could be detected in the burger patties. While using natural flavouring agents like onion and garlic verified a successful strategy in compensating flavour that lost due to the reduction in NaCl salt[22], so the BT 2 group (50% KCl) of the treated burger group with onion and garlic was accepted and judged good. Although groups with 50% KCl were received lower score sensory results than control groups, the burger patties were still accepted. While the groups with 75 and 100% KCl of both untreated and treated groups recorded significantly reduced results in the sensory parameters (flavour, taste and overall acceptability) and were completely rejected by the panellists due to the detecting unpleasant meaty flavour and astringent bitterness off-flavour which is the main limiting factor in using potassium chloride salt in food. Those results were also confirmed by Carvalho *et al.*[23] on the addition of spices and herbs to beef burgers, the sensory characteristics were improved through masking the meaty off-flavour of fat detected in case of the substitution of NaCl by 25 and 50% of KCl salt. Nonetheless, the treatment with fresh onion and garlic could not overcome the adverse changes in the flavour and taste of beef burger patties by addition of high concentration of KCl salt level in groups BT3 (75% KCl) and BT4 (100% KCl) that revealed significantly lower scores ($p<0.05$) for flavour, taste and overall acceptability than the control groups.

Regarding the texture, the treated burger patties (with fresh onion and garlic) have high scores of texture results but are not significant at $p<0.05$. The changes that had been noticed in texture scores at the different substitution levels between NaCl and KCl salts (25, 50, 75 and 100%) could be attributed also to many other contributing factors which may affect the texture of beef burgers like fat content and beef grad used.

Tallaga cheese also known as "Gebnah Bayda". It is a soft white cheese that has a wide range of salt proportions depending on consumer requests. Tallaga cheese has broad acceptability among consumers owing to its pleasant creamy taste, which is ready to consume as a fresh cheese within one month in refrigerated storage[18].

The highest score results of sensory parameters of cheese were detected in groups with 75% NaCl ($C_3$1 and $C_5$1) which were close to the control groups (100% NaCl) of both salt concentrations (3 and 5%). On replacing NaCl with 50% KCl salt, a trace of slight bitterness and low salty taste was detected in the cheese group with a salt concentration of 3% ($C_3$2). However, the group with a 5% salt concentration ($C_5$2) received higher sensory evaluations. Those results may be attributed to the high salt content in group $C_5$2 (5% salt content) than that present in the $C_3$2 group (3% salt) which enable the NaCl salt to mask the bitterness taste of KCl salt, based on the fact that mentioned before by Gurtovenko *et al.*[24], who found that when two salts like sodium and potassium chloride are mixed in food, an interaction occurs on mouth receptors and the salty taste of sodium salt could cover the bitter taste of potassium salt inside the mouth. In general, the bitterness flavour developed clearly in cheese by decreasing NaCl salt content, as the reduction in NaCl salt content is directly correlated with the degradation of β-casein protein which increases the available sites on the hydrophobic protein portions to be split by the chymosin enzyme[11].

The texture results were not significantly affected at p-value (<0.05) by the replacement of NaCl salt by KCl salt in most groups (75, 50 and 25% NaCl/KCl) as well as control groups (100% NaCl). Nevertheless, cheese samples in groups with 100% KCl ($C_3$4, $C_5$4) showed a slight difference in body texture. The body became slightly softer and grainy. The differences in cheese texture due to the complete absence of sodium chloride salt ensure the considerable role of sodium chloride salt in the protein solubility and curd synaereses during cheese manufacture[25]. Similar findings were also, reported in other cheese types as São João cheese[26], Nabulsi cheese[27] and Turkish white soft cheese[28] due to the replacing of NaCl with KCl salt.

The main reason for choosing *Escherichia coli* in the current study is its ability to be an indicator of product safety. Although most *E. coli* strains are non-pathogenic, some strains are Shiga toxin-producer, which causes a severe food poisoning illness. Contaminated dairy and improperly cooked meat products are the most food products that are incriminated in *E. coli* outbreaks[29].

Substantially, the reduction of *E. coli* counts was not significant at p-value (<0.05) in all groups. However, the highest reduction level in *E. coli* counts was detected in groups with 50% NaCl replacement by 50% KCl (B2, BT2, $C_3$2 & $C_5$2) in both food models (Fig. 1 and 2). Those findings could be confirmed by that found by Gandhi *et al.*[30], who detected that the increasing of KCl salt concentration led to a reduction in *E. coli* counts and the optimum reduction level in *E. coli* counts occurred by replacing 25 and 50% between NaCl/KCl salt, however, the reduction was less than one log reduction in *E. coli* counts compared to the control groups.

The reduction observed in group BT 2 of the treated burger than that occurred in B1 of the untreated burger (Fig. 1) could indicate the beneficial antimicrobial effect of using onion and garlic in the processing of the beef burger. The results of Yadav *et al.*[31] confirmed that *Escherichia coli* is highly sensitive to fresh garlic. It has maximum lethal concentration (MLC) levels that range from 4-32% v/v[32]. While the fresh onion extract has a lesser antimicrobial effect against *E. coli* than garlic[30].

It is worth mentioning that the counts of *E. coli* reduced in the cheese groups with both salt concentrations (3 and 5%) than in beef burger patties (treated and untreated groups) owing to the higher salt content that used in cheese processing compared to the burger (1.5% wt/wt) which is below the effective lethal reduction level of the *E. coli* organism[7]. Those results were emphasized by Gandhi *et al.*[30], who found that the viability of *E. coli* reduced significantly with increasing the sodium chloride level from 2-2.5%. While, on continuously increasing NaCl salt up to 3%, the reduction was not significant as in 2.5% NaCl salt concentration.

The Na^+ and K^+ cations are monovalent cations that have an equivalent antimicrobial effect on bacterial cells by the destruction of their plasma membrane. However, sodium is more potent than potassium[33]. Several other investigations in different meat and dairy products clarified that there are no additional static or lethal effects by Na^+/K^+ replacement[23,26,32] so, the product safety remains unaffected by replacing sodium salt with potassium salt.

CONCLUSION

Sodium chloride salt could be reduced in the beef burger and Tallaga cheese by 25% without any adverse effect on their sensorial quality. However, the substitution of NaCl by 50% KCl salt recorded low sensory attributes scores in beef burgers due to bitter off-flavour taste that could be masked by the addition of 5% fresh onion and garlic to burger formula. While cheese samples with 50:50 NaCl/KCl in the high salt concentration (5%), saltiness could overcome the bitter taste detected in cheese samples with salt level (3%). In both food models, the replacement of NaCl by 75 and 100% KCl has adversely affected the overall acceptability with rejected bitter off-flavour taste. There was a minimal positive effect of substitution 50% NaCl by 50%KCl on controlling the *E. coli* growth in both food models (beef burger and Tallaga cheese) were detected. Further studies should be done in other food models to obtain a reduced-sodium salt diet with a maximum effect on the product safety and a minimum alteration in the quality.

SIGNIFICANCE STATEMENT

This study can be beneficial for food technology development regarding the determination of the critical limits of substitution of the NaCl by KCl salt in both beef burgers and Tallaga cheese. Also, the study will be helpful for the manufacturers to produce the two products without affecting the sensory and safety of the examined products.

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