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Effects of Different Chloride Salts and Fat Levels on the Quality Characteristics of Beef Patties

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Abstract

The aim of this study was to investigate the effects of different chloride salts (four formulation with NaCl, KCl, $CaCl_2$, and $MgCl_2$) at 2% w/w level on the pH, color, sensory, and cooking properties of beef patties formulated with two levels of tail fat (10% and 20%). The results indicated that the use of $CaCl_2$ and/or $MgCl_2$ resulted in a significant ($P < 0.01$) decrease in the pH values of both uncooked and cooked beef patties. The salt factor significantly influenced the a^* value of uncooked beef patties ($P < 0.05$). It also affected the a^* ($P < 0.01$) and b^* ($P < 0.01$) values of cooked beef patties.. The highest L^* value ($P < 0.05$) in uncooked beef patties was observed with 20% fat usage. Use of $CaCl_2$ and/or $MgCl_2$ in the salt formulation significantly affected the cooking yield, moisture retention ($P < 0.01$), patty diameter, and shrinkage parameters ($P < 0.05$). On the other hand, the fat factor significantly influenced all cooking properties at the $P < 0.01$ level, except for the decrease in thickness. Except for salinity and bitterness, the salt factor significantly influenced the sensory scores of the samples. The use of $CaCl_2$ and/or $MgCl_2$ in the salt mixture for beef patties resulted in lower sensory scores for the product's sensory parameters. In conclusions, KCl was found to produce satisfactory results as a substitute for NaCl. In contrast, it was concluded that $CaCl_2$ and/or $MgCl_2$ salts were not suitable substitutes for NaCl.

Keywords: Beef patty; Cooking properties; Sensory properties; Color; Chloride salts.

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1. Introduction

Beef patties are fresh meat products composed of ground muscle meat with varying levels of fat and salt. To enhance flavor and textural properties, non-meat ingredients such as spices and textured soy protein can be incorporated into the formulation, and a heat treatment like cooking or frying is typically applied prior to consumption (Heinz and Hautzinger, 2007).

Animal fat and sodium chloride (NaCl) play a significant role in patty production by improving sensory and textural properties. However, fat and salt are increasingly associated with various health issues, including cardiovascular diseases. To mitigate the adverse effects of animal fat on human health, numerous studies have focused on fresh meat products, achieving promising results (Yılmaz, 2004; Serdaroğlu, 2006; Tobin et al., 2012; Poyato et al., 2015; Gibis et al., 2015; Salcedo-Sandoval et al., 2015).

Regarding salt consumption, health authorities recommend a daily intake of 6 g of NaCl for optimal health (Desmond, 2006). Various strategies have been explored to produce low-sodium meat products, including reducing the NaCl content in formulations, partially or entirely replacing NaCl with other chloride salts, substituting a portion of NaCl with non-chloride salts, using binders, and employing alternative processing techniques (Verma and Banerjee, 2012). Among these approaches, the partial or complete substitution of NaCl with other chloride salts has been applied successfully to several meat products (Soglia et al., 2014; Monteiro et al., 2015; Marchetti et al., 2015; Kaban et al., 2022; Şimşek et al., 2023; Yalınkılıç, 2023).

The production processes of beef patties differ from other meat products made using techniques such as fermentation, curing, and smoking, making it challenging to predict the effects of different chloride salts. Studies aimed at determining the effects of different chloride salts in patty and burger production

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have investigated the impact of using KCl and/or $CaCl_2$ as part of salt formulations containing NaCl (Ketenoğlu and Candoğan, 2011; Lilic et al., 2015; Ramos et al., 2020; Nayak and Pathak, 2022; Ünal et al., 2024). However, $MgCl_2$ is another salt that can be used in combination with KCl and $CaCl_2$ as a substitute for NaCl and has been demonstrated to affect the quality characteristics of various meat products to which it is added. In this context, the investigation of the effects of salt formulations containing $MgCl_2$ on the quality characteristics of low-sodium patties is crucial for providing a more comprehensive understanding of findings from previous studies. Furthermore, the use of different levels of animal fat in patty formulations is a significant factor affecting the sensory properties of the product (Tobin et al., 2012). However, the investigation of the effects of salt mixtures containing $MgCl_2$ and other chloride salts on the quality characteristics of patties with varying fat levels has emerged as a notable gap in the literature. This study focused on the potential use of different chloride salts as part of NaCl reduction strategies in meat products. It specifically aimed to explore the feasibility of using chloride-containing salts (NaCl, KCl, $CaCl_2$, and $MgCl_2$) and different fat levels (10% and %20) in beef patty formulations and to investigate their effects on the color, sensory, and cooking properties of patties.

2. Material and Methods

2.1. Production of beef patty

The beef round and sheep tail fat were purchased from a local slaughterhouse in Erzurum, Türkiye. The beef was trimmed with a sharp knife to remove excess fat and connective tissue. Both the beef and tail fat were ground separately using a meat grinder with a 3 mm plate. To prepare the patty doughs, the ground beef and fat were combined to achieve two fat levels: A (90% ground beef + 10% ground tail fat) and B (80% ground beef + 20% ground tail fat). Eight different patty doughs (four from Dough A and four from Dough B) were prepared for each replicate, and these were salted with the chloride salt or salt mixtures as described in Table 1. The salt formulations were adopted from Yalınkılıç et al. (2023).

The salt or salt mixtures were added at a concentration of 2% (w/w) based on the total dough weight. To ensure homogeneous salt diffusion, the salted doughs were rested in a cooler at 4°C for 6 hours. The patties were then shaped using a patty mold. The patties were cooked on a hot plate for 5 minutes on each side at 150°C.

To specifically evaluate the effects of different chloride salts and fat levels on the patties, spices or any additional ingredients were excluded from the patty formulations. The experiments were conducted in two replicates. Analyses of pH, color, and cooking properties were performed on both uncooked and cooked patties, while sensory evaluations were conducted only on the cooked samples.

2.2. Determination of moisture content

The moisture content of the beef patty samples was analyzed according to the AOAC (2005) standard method.

2.3. pH Analysis

The pH meter was calibrated using appropriate buffer solutions prior to measurement. Subsequently, 10 g of homogenized sample was weighed in duplicate, and 100 ml of distilled water was added to each. The mixtures were homogenized using an ultra-turrax device (IKA Werk), and the pH values were determined with a pH meter.

2.4. Color analysis

Following the cooking process, patties were allowed to cool to room temperature to ensure uniform measurement conditions. Measurements were taken directly from the surface of the patties (Başlar et al., 2024). The color intensity of the samples (L^*, a^*, and b^*) was measured using a calibrated Minolta colorimeter (CR-400, Minolta Co., Osaka, Japan). The measurements were performed based on the criteria specified by the International Commission on Illumination (CIE) in the CIELAB three-dimensional color measurement system.

Table 1. The fat and salt mixture used in formulation of beef patties

Group	*Tail Fat (%)*	*Salt Composition* NaCl (%)	*KCl (%)*	*$CaCl_2$ (%)*	*$MgCl_2$ (%)*
C/10	10	100	-	-	-
C/20	20	100	-	-	-
S1/10	10	50	50	-	-
S1/20	20	50	50	-	-
S2/10	10	40	40	20	-
S2/20	20	40	40	20	-
S3/10	10	30	40	20	10
S3/20	20	30	40	20	10

2.5. Cooking properties

The cooking properties were determined using the methods outlined by Serdaroğlu and Değirmencioğlu (2004).

2.5.1. Cooking yield

Cooking yield was calculated for each group using five beef patty samples. The weights of the samples were recorded before and after cooking, and the percentage yield was determined using the following equation (Eq. 1):

$$\mathrm{CY} = \frac{\mathrm{W}_c}{W_u} \times 100 \qquad \text{Eq.1}$$

where CY is cooking yield (%), W_c is the weight of the cooked sample (g), and W_u is the weight of the uncooked sample (g).

2.5.2. Moisture retention

Moisture retention (%) was calculated using the cooking yield data combined with the moisture content of the cooked beef patties. The following equation (Eq.2) was used:

$$\mathrm{MR} = \frac{\mathrm{CY} \times MC_c}{100} \qquad \text{Eq.2}$$

where MR is moisture retention (%), CY is cooking yield (%), and MC_c is the moisture content in the cooked sample (%).

2.5.3. Change in patty diameter

The percentage reduction in patty diameter was calculated by measuring the diameters of both uncooked and cooked patties. The change in patty diameter (%) was determined using the following equation (Eq.4):

$$\mathrm{CD} = \frac{\mathrm{D}_u - D_c}{\mathrm{D}_u} \times 100 \qquad \text{Eq.3}$$

where CD is the change in patty diameter (%), D_u is the diameter of the uncooked patty (mm), and D_c is the diameter of the cooked patty (mm).

2.5.4. Change in patty thickness

The percentage reduction in patty thickness was calculated by comparing the thickness of uncooked and cooked patties. The change in patty thickness (%) was determined using the following equation (Eq.4):

$$\mathrm{CT} = \frac{\mathrm{T}_u - T_c}{\mathrm{T}_u} \times 100 \qquad \text{Eq.4}$$

where CT is the change in patty thickness (%), T_u is the uncooked patty thickness (mm), and T_c is the cooked patty thickness (mm).

2.5.5. Shrinkage

The shrinkage percentage was determined using the diameter and thickness measurements of the uncooked and cooked patties. The shrinkage (%) was calculated using the equation (Eq.4):

$$\mathrm{CY} = \left(\frac{(\mathrm{T}_u - \mathrm{T}_c) + (\mathrm{D}_u - \mathrm{D}_c)}{(\mathrm{T}_u + \mathrm{T}_c)}\right) \times 100 \qquad \text{Eq.4}$$

where S is the shrinkage (%), T_u is the uncooked patty thickness (mm), T_c is the cooked patty thickness (mm), D_u is the uncooked patty diameter (mm), and D_c is the cooked patty diameter (mm).

2.6. Sensory analysis

Cooked beef patty samples from each experimental group were subjected to sensory evaluation by a panel of 20 trained panelists for each replicate. The panelists were selected based on their prior experience with sensory analysis and were trained to recognize and score the specific attributes being assessed. Following the cooking, samples were served on white plates coded with random three-digit numbers to prevent bias. Panelists were instructed to cleanse their palate with water and white bread between samples to avoid flavor carryover. Appearance, texture, smell, bitterness, salinity, juiciness, and overall acceptability parameters were assessed using a 9-point scale.

2.7. Statistical analysis

The data obtained in the study were subjected to variance analysis (ANOVA) using the SPSS 13 software package. Means of the treatment groups were further compared using Duncan's multiple comparison test.

3. Results and Discussion

3.1. Effects on pH value

The effects of different chloride salt mixtures and fat levels on the pH values of uncooked and cooked patties are presented in Table 2. The salt factor significantly affected the pH values of both uncooked and cooked patties at the $P < 0.01$ level. The pH of uncooked patties ranged between 5.55 and 5.81. Cooking increased the pH across all groups (5.72–6.15). The increase in pH observed in cooked patties is likely attributed to nitrogenous compounds released as a result of heat-induced changes in the proteins within the product composition (Sohn and Ho, 1995; Alugwu et al., 2022).

Table 2. pH values of uncooked and cooked beef patties.

Group	Uncooked patties	Cooked beef patties
C/10	5.78±0.08^{b}	6.10±0.11^{b}
C/20	5.77±0.07^{b}	6.10±0.11^{b}
S1/10	5.80±0.06^{b}	6.13±0.09^{b}
S1/20	5.81±0.07^{b}	6.15±0.10^{b}
S2/10	5.58±0.06^{a}	5.73±0.06^{a}
S2/20	5.56±0.05^{a}	5.72±0.09^{a}
S3/10	5.58±0.03^{a}	5.80±0.11^{a}
S3/20	5.55±0.06^{a}	5.77±0.11^{a}

Values within the same column with different lowercase letters (a, b, c) differ significantly based on Duncan's test ($P < 0.05$). Control: 100% NaCl; Salt 1: 50% NaCl+50% KCl; Salt 2: 40% NaCl+40% KCl+20% $CaCl_2$; Salt 3: 30% NaCl+40% KCl+20% $CaCl_2$+10% $MgCl_2$.

In contrast, the lower pH observed particularly in cooked products containing $CaCl_2$ and/or $MgCl_2$ is likely attributable to the relative binding properties of divalent salts to the negative charges of proteins (Nayak et al., 1998). The highest pH values were recorded in both uncooked and cooked patties in the control groups (C/10 and C/20), which contained 100% NaCl, as well as in the treatment groups (S/10 and S/20), which used a 50% NaCl and 50% KCl mixture. No statistically significant differences in pH values were observed between these groups ($P > 0.05$). Conversely, patties containing $CaCl_2$ and $MgCl_2$ (S2/10, S2/20, S3/10, S3/20) exhibited significantly lower pH values compared to the control groups, both in uncooked and cooked samples ($P < 0.05$). This study is consistent with the findings of Ünal et al. (2024), who reported that the use of KCl in the salt formulation for turkey burgers did not alter the pH values of the product compared to the control group, while the inclusion of $CaCl_2$ led to a decrease in pH values. In contrast to our results, studies in the literature have also indicated that the use of KCl in patty and burger formulations can increase the product's pH (Nayak and Pathak, 2022; Ramos et al., 2020). Additionally, the fat factor did not have a statistically significant effect ($P > 0.05$) on the pH values of either uncooked or cooked patties.

3.2. Effects on color parameters

Table 3 presents the color parameters (L^*, a^*, b^*), illustrating the effects of different salt mixtures and fat levels on the color properties of uncooked and cooked patties. Color plays a critical role in the sensory perception and consumer acceptability of meat products (Yalınkılıç and Çiğdem, 2004). The salt factor significantly influenced the a^* value of uncooked patties ($P < 0.05$) and both the a^* (P < 0.01) and b^* ($P < 0.01$) values of cooked patties. The fat factor significantly affected only the L^* value of uncooked patties at the $P < 0.05$ level, while it did not exhibit a statistically significant effect ($P > 0.05$) on other color parameters of either uncooked or cooked patties. Similar to our findings, Serdaroğlu (2006) reported that varying fat levels (5%, 10%, and 20%) in beef patties increased the L^* value of uncooked patties but had no effect on their a^* and b^* values. The researchers associated this color change with the yellow-white characteristics of the fat used in the formulation. A study conducted by Nayak and Pathak (2022) on chevon meat patties produced with NaCl, KCl, and $CaCl_2$ revealed that the substitution of KCl did not cause any alterations in the product's color parameters. Similarly, Ramos et al. (2020) observed that the substitution of KCl in beef burgers containing varying ratios of NaCl and KCl, stored for 120 days, had no significant impact on the burgers' color parameters. In uncooked patties, the L^* value ranged from 39.68 to 43.18, with the highest brightness observed in the S3/20 group, which contained 20% fat and included $CaCl_2$ and $MgCl_2$. Following cooking, a decreasing

Table 3. Color of uncooked and cooked beef patties

Group	Uncooked patties			Cooked beef patties		
	L^*	a^*	b^*	L^*	a^*	b^*
C/10	40.18±3.86^{a}	16.00±1.43^{a}	4.27±1.68^{a}	39.90±0.83^{cd}	8.84±0.59^{c}	3.58±0.47^{ab}
C/20	41.54±1.48^{abc}	16.18±1.91^{ab}	4.83±1.15^{a}	37.58±1.70^{a}	8.52±0.69^{c}	3.39±0.79^{a}
S1/10	39.68±2.53^{a}	17.13±1.77^{abc}	3.92±0.74^{a}	40.21±2.05^{d}	8.30±0.67^{bc}	4.97±0.97^{c}
S1/20	41.17±0.86^{abc}	17.98±1.18^{bc}	5.05±0.82^{a}	38.02±1.43^{ab}	8.41±0.69^{c}	4.04±0.59^{b}
S2/10	40.03±1.50^{ab}	18.32±1.58^{c}	4.81±0.82^{a}	40.74±1.84^{d}	7.50±0.48^{a}	5.56±0.39^{c}
S2/20	42.07±2.74^{bc}	17.06±1.53^{abc}	4.83±1.35^{a}	38.57±1.04^{abc}	7.75±0.32^{ab}	5.59±0.52^{c}
S3/10	40.14±1.76^{ab}	16.19±2.32a^{b}	4.05±0.54^{a}	39.34±0.64^{bcd}	7.66±0.36^{a}	5.37±0.65^{c}
S3/20	43.18±1.13^{c}	15.66±1.91^{a}	5.05±1.03^{a}	38.63±0.91^{abc}	7.81±0.47^{ab}	5.35±0.40^{c}

Values within the same column with different lowercase letters (a, b, c) differ significantly based on Duncan's test ($P < 0.05$). Control: 100% NaCl; Salt 1: 50% NaCl+50% KCl; Salt 2: 40% NaCl+40% KCl+20% $CaCl_2$; Salt 3: 30% NaCl+40% KCl+20% $CaCl_2$+10% $MgCl_2$.

trend in L^* values was observed, with the most pronounced reduction occurring in the C/20 group containing 20% fat. The redness values (a^*) in uncooked patties ranged from 15.66 to 18.32, with slightly higher values observed in patties containing $CaCl_2$ and $MgCl_2$. However, a decrease in a^* values was noted after cooking, with the highest redness value measured in the C/10 group, which contained 10% fat and used only NaCl. On the other hand, the b^* values in uncooked patties ranged from 3.92 to 5.05. After cooking, an overall increase in b^* values was observed, with the highest value recorded in the S2/10 group. Generally, groups containing NaCl (C/10 and C/20) exhibited higher a^* and L^* values after cooking. In the study conducted by Ünal et al. (2024) on turkey burger production, it was concluded that the use of KCl or $CaCl_2$ as a substitute for NaCl significantly influenced the L^* and b^* values of the cooked product. They also observed that the L^* value of the cooked product was lower than that of the uncooked burger, while the a^* value was higher. In the present study, apart from the effects of salt and fat factors, the differences observed between uncooked and cooked beef patties are likely attributable to pH changes during cooking, reactions occurring on the surface of the product in contact with the heat source, and the fat and moisture loss associated with the cooking process (Ramos et al., 2020).

3.3. Effects on cooking properties

The effects of different salt mixtures on the cooking properties of patties are presented in Table 4. As presented in the table, the salt factor significantly influenced the cooking yield and moisture retention properties of cooked patties at the $P < 0.01$ level, while its effect on the decrease in patty diameter and shrinkage parameters was significant at the $P<0.05$ level. The fat factor, on the other hand, significantly affected all cooking properties at the $P < 0.01$ level, except for the decrease in thickness ($P > 0.05$). Across the groups, the C/10 group containing only NaCl demonstrated superior performance, achieving the highest cooking yield (75.14%), moisture retention capacity (46.22%), and the lowest decrease in diameter (17.86%) compared to the other groups.

In the C/10 group, the decrease in diameter was determined to be the lowest at 17.86%, enhancing the product's ability to maintain physical stability during cooking. In contrast, cooking performance was negatively affected in groups containing $CaCl_2$ and $MgCl_2$. In the S2/20 group, the cooking yield was found to be 60.44%, moisture retention 32.39%, and the decrease in diameter 27.20%. Similarly, in the S3/20 group, the cooking yield was found to be 61.87%, moisture retention 33.21%, and the decrease in diameter 27.16%. These findings can likely be attributed to the reduction in product pH caused by the inclusion of $CaCl_2$ and $MgCl_2$ in the salt mixtures. The pH values of cooked patties containing these divalent salts were observed to be closer to the isoelectric point of red meats, which likely contributed to a decrease in water-holding capacity and subsequently impacted the cooking properties of the product (Cassens, 1994). Consistently, Rahman and Perera (2007) emphasized the critical role of pH and water content in determining the quality of meat and meat products. Salts that contribute to higher pH levels, such as NaCl and KCl, resulted in better water-holding capacity, lower diameter and thickness loss, and reduced shrinkage in patties. In contrast, the pH-lowering effects of $CaCl_2$ and $MgCl_2$ led to adverse outcomes in these parameters. A study on chevon meat patties found that the use of KCl and $CaCl_2$ alongside NaCl in the formulation had no significant effect on the cooking properties of the product (Nayak and Pathak, 2022). Similarly, in frozen beef burgers, the use of NaCl and

Table 4. Cooking values of cooked beef patties

Group	*Cooking Yield (%)*	*Moisture Retention (%)*	*Diameter reduction (%)*	*Decrease in beef patty thickness (%)*	*Shrinkage (%)*
C/10	75.14±3.68[d]	46.22±1.84[f]	17.86±4.10[a]	23.15±13.06[ab]	12.88±3.91[a]
C/20	65.35±4.79[bc]	36.29±2.78[cd]	22.03±2.38[bc]	27.47±9.81[ab]	16.90±2.16[ab]
S1/10	72.06±2.50[d]	42.89±1.90[e]	19.39±4.33[ab]	20.41±13.41[b]	15.40±4.82[ab]
S1/20	65.12±3.19[bc]	35.54±1.81[bc]	25.35±3.14[c]	32.61±11.80[ab]	19.28±4.01[bc]
S2/10	66.41±3.84[c]	37.41±3.07[cd]	20.03±2.78[ab]	36.64±20.78[a]	14.15±3.89[a]
S2/20	60.44±4.87[a]	32.39±2.58[a]	27.20±3.75[d]	28.41±9.36[ab]	20.81±4.05[c]
S3/10	67.12±4.74[c]	38.83±3.59[d]	20.39±3.22[ab]	24.49±13.74[ab]	15.44±2.62[ab]
S3/20	61.87±4.61[ab]	33.21±2.01[ab]	27.16±2.52[d]	27.95±7.02[ab]	21.26±2.75[c]

Values within the same column with different lowercase letters (a, b, c) differ significantly based on Duncan's test ($P < 0.05$). Control: 100% NaCl; Salt 1: 50% NaCl+50% KCl; Salt 2: 40% NaCl+40% KCl+20% $CaCl_2$; Salt 3: 30% NaCl+40% KCl+20% $CaCl_2$+10% $MgCl_2$.

KCl was found to result in no statistically significant change in cooking loss values (Ramos et al., 2020). Consistently, Ünal et al. (2024) concluded in their study on turkey meat patties that the inclusion of KCl and $CaCl_2$ in the product formulation did not significantly affect the moisture retention or cooking yield parameters. The differences between the findings of this study and those of other studies are likely attributable to variations in the cooking techniques and durations employed. Specifically, in the aforementioned three studies, the cooking methods included preheated convection oven cooking at 180°C for 14 minutes, preheated grilling at 170°C until an internal temperature of 72°C was reached, and hot plate cooking at 180°C for 8 minutes, respectively. According to the data presented in Table 4, a slight decline in cooking properties was observed in patty groups containing 20% fat (including the control group). Notably, groups containing 20% fat with $CaCl_2$ (S2/20) and $MgCl_2$ (S3/20) exhibited greater reductions in cooking yield, moisture retention capacity, diameter, and shrinkage values. Similar to our findings, Serdaroğlu (2006) reported that an increase in fat content in beef patties adversely affected cooking properties. Specifically, when 20% fat was used, lower cooking yield, fat retention, and moisture retention values were obtained compared to 5% and 10% fat levels, which in turn resulted in greater reductions in product diameter.

3.4. Efects on sensory properties

The results in Table 5 present the effects of different salt mixtures and fat levels on the sensory properties of patties. The salt factor significantly influenced appearance, aroma, juiciness, and overall acceptability parameters at the $P < 0.01$ level, while its effect on texture parameter was significant at the $P < 0.05$ level. However, the salt mixture did not have a statistically significant effect ($P > 0.05$) on the saltiness and bitterness parameter. Similarly, the fat factor did not exhibit a significant effect ($P > 0.05$) on any of the parameters examined. In terms of overall acceptability, the control groups containing only NaCl (C/10 and C/20) achieved the highest scores, with 7.0±1.2 and 7.0±1.0, respectively. The control groups (C/10 and C/20) also demonstrated superior performance in appearance (7.7–7.9), texture (7.2–7.4), and juiciness (7.3–7.2) compared to other groups. Moreover, the use of KCl in combination with NaCl (S1/10 and S1/20) showed no statistically significant difference in sensory properties compared to the control samples. This finding is particularly significant as it highlights the potential of KCl as an acceptable substitute for NaCl.

Salt mixtures containing $CaCl_2$ and $MgCl_2$ were found to significantly deteriorate the sensory properties of the patties at a statistically significant level. The groups containing these salts had the lowest overall acceptability scores, recorded as 5.7±1.3 and 5.4±1.4, respectively. The patties showed the most unfavorable average results in terms of appearance, texture, aroma, and bitterness parameters when these salts were used. The unfavorable outcomes in sensory parameters are likely related to the negative results observed in the cooking properties of the groups containing salt mixtures with $CaCl_2$ and $MgCl_2$. On the other hand, studies extensively investigating the effects of salt mixtures containing NaCl, KCl, $CaCl_2$, and $MgCl_2$ on various meat products have also found that salt mixtures containing $CaCl_2$ and $MgCl_2$, in particular, have adverse effects on the sensory quality characteristics of the products (Armenteros et al., 2009; Yalınkılıç et al., 2023). Similar to our findings, a study on beef burgers utilizing varying ratios of NaCl and KCl reported that the replacement of NaCl with different proportions of KCl did not result in significant differences in the product's color, aroma, flavor,

Table 5. Sensory properties of cooked beef patties

Group	*Appearance*	*Texture*	*Smell*	*Bitterness*	*Salinity*	*Juiciness*	*Overall Acceptability*
C/10	7.7±0.6^{bc}	7.2±0.9^{ab}	6.3±1.3^{b}	2.1±1.8^{a}	5.1±1.7^{a}	7.3±1.5^{c}	7.0±1.2^{c}
C/20	7.9±0.7^{c}	7.4±0.8^{b}	6.8±1.5^{b}	1.9±1.7^{a}	5.6±1.8^{a}	7.2±1.3^{c}	7.0±1.0^{c}
S1/10	7.2±0.8^{abc}	7.0±1.3^{ab}	6.5±1.1^{b}	3.0±2.5^{a}	4.9±2.0^{a}	6.6±1.4^{bc}	6.4±1.3^{bc}
S1/20	7.2±1.0^{abc}	6.7±1.0^{ab}	6.5±1.2^{b}	3.0±2.3^{a}	5.0±1.8^{a}	6.0±1.3^{ab}	6.5±0.8^{bc}
S2/10	6.4±1.3^{a}	6.6±1.4^{ab}	5.7±1.5^{ab}	2.7±2.0^{a}	4.5±1.7^{a}	5.9±1.6^{ab}	6.0±1.2^{ab}
S2/20	6.6±1.3^{a}	6.6±1.0^{a}	5.7±1.7^{ab}	2.8±2.1^{a}	4.5±1.5^{a}	5.4±1.5^{a}	5.7±1.1^{ab}
S3/10	6.6±1.9^{a}	6.7±1.3^{ab}	5.2±1.9^{a}	3.4±2.3^{a}	4.5±1.6^{a}	5.7±1.4^{ab}	5.7±1.3^{ab}
S3/20	6.9±1.4^{ab}	6.4±1.5^{a}	5.7±1.7^{ab}	3.2±2.2^{a}	5.1±2.0^{a}	5.5±1.3^{a}	5.4±1.4^{a}

Values within the same column with different lowercase letters (a, b, c) differ significantly based on Duncan's test ($P < 0.05$). Control: 100% NaCl; Salt 1: 50% NaCl+50% KCl; Salt 2: 40% NaCl+40% KCl+20% $CaCl_2$; Salt 3: 30% NaCl+40% KCl+20% $CaCl_2$+10% $MgCl_2$.

texture, or overall acceptability scores (Ramos et al., 2020). In another study examining the effects of NaCl, KCl, and $CaCl_2$ on the sensory characteristics of chevon meat patties, it was found that the type of salt used did not influence the overall appearance of the product. However, the lowest scores for flavor, saltiness, juiciness, mouth-coating, and overall acceptability, except for texture, were recorded in groups containing only NaCl + KCl (Nayak and Pathak, 2022). Conversely, Ünal et al. (2024) concluded in their study on turkey patties that the use of NaCl, KCl, and $CaCl_2$ did not cause any significant differences in the sensory characteristics of the product, including color, flavor, aroma, texture, and overall acceptability.

4. Conclusions

In the production of beef patties, formulations predominantly containing NaCl were found to have a positive impact on the quality characteristics examined in this study. The findings demonstrated that NaCl yielded significantly better results compared to other tested salts in terms of both cooking properties and sensory quality, highlighting KCl as the most effective substitute for NaCl. Conversely, salt mixtures containing $CaCl_2$ and $MgCl_2$ had adverse effects on both the cooking and sensory properties of the product. This suggests that the use of these salts as substitutes for NaCl would likely lead to negative outcomes in terms of consumer acceptability for beef patties. Furthermore, an increase in fat content was observed to have particularly detrimental effects on the cooking properties of the product. To mitigate the adverse changes in cooking properties associated with higher fat levels, the incorporation of various fiber sources into patty production could be explored in future studies

Declaration of Competing Interest

The author declares that they have no financial or non-financial competing interests.

Author's Contributions

B. Yalınkılıç (0000-0002-6195-7821): *Methodology, Research, Data Analysis, Writing, Editing.*

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