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EFFECT OF LOW-SODIUM SALT UTILIZATION ON SOME CHARACTERISTICS OF GROUND BEEF PATTIES

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Abstract

Effectiveness of a commercial low-sodium salt, PanSalt® (PS), on initial instrumental color [CIE lightness (L*), redness (a*) and yellowness (b*) values], cooking loss and diameter reduction after cooking, and pH value and water holding capacity during refrigerated storage at 4 °C for 2 days was evaluated as compared to regular commercial NaCl (RS) and control (C) without addition of any salt. Furthermore, a sensory triangle test was conducted at Day 1 to determine if RS and PS added samples differed. There was no significant difference in L*, a* and b* values between PS and RS added groups. However, RS and PS addition resulted in lower a* (11.51 and 11.00, respectively) and b* (5.09 and 4.21, respectively) values than the C (a*=14.26, b*=6.87). The pH values of samples ranging from 5.85 to 6.03 during storage did not show significant change due to salt treatments and storage time (P>0.05). PS incorporation resulted in lower cooking loss (15.9%) and diameter reduction (13.2%) after cooking than RS (30.26% and 17.79%, respectively). Initial water holding capacity of ground beef patties incorporated with PS was significantly higher (P<0.05) than the C and RS treated patties at Day 1 and Day 2 however, PS and RS incorporated groups had similar and both higher (P<0.05) water holding capacity than the C. In sensory triangle test, no significant difference (P>0.05) was determined between the RS and PS ground beef patties.

Keywords: Sodium reduction, ground beef patties, technological characteristics, color, sensory analyses

DÜŞÜK SODYUMLU TUZ KULLANIMININ KÖFTELERİN BAZI ÖZELLİKLERİ ÜZERİNE ETKİSİ

Özet

Ticari düşük sodyumlu tuz (PanSalt®) ilavesinin sığır kıymadan yapılan köftelerde başlangıç enstrümental renk değerleri [CIE açıklık-koyuluk (L*), kırmızılık (a*) ve sarılık (b*)], pişirme kaybı ve pişirme sonrası çap azalışı ile 4 °C'de 2 gün depolama süresince pH değeri ve su tutma kapasitesi üzerine etkisi, 4 °C'de 2 gün depolama süresince tuz ilave edilmemiş kontrol (K) ve normal ticari NaCl (NT) ilave edilmiş köftelerle kıyaslanarak belirlenmiştir. Ayrıca, ticari düşük sodyumlu tuz (PS) ve NT ilave edilmiş örnekler arasında duyusal yönden fark olup olmadığı depolamanın 1. gününde, üçgen test ile saptanmıştır. Ticari düşük sodyumlu tuz (PS) ve NT ilave edilen gruplar arasında L*, a* ve b* değerleri açısından önemli bir fark bulunmamıştır (P>0.05). Bununla birlikte, NT ve PS ilave edilmiş örneklerin a* (sırasıyla 11.51 ve 11.00) ve b* (sırasıyla 5.09 ve 4.21) değerlerinin, K grubunun a* (14.26) ve b* (6.87) değerlerinden önemli ölçüde (P<0.05) düşük olduğu saptanmıştır. Örneklerin depolama süresince 5.85 ve 6.03 arasında belirlenen pH değerleri tuz ilavesinden ya da depolama süresinden dolayı önemli bir değişim göstermemiştir (P>0.05). PS ilave edilmiş gruplarda sırasıyla %15.9 ve %13.2 olarak belirlenen pişirme kaybı ve çap azalışı değerleri NT ilave edilmiş gruba göre daha düşük bulunmuştur (sırasıyla %30.26 ve %17.79). Başlangıçta belirlenen su tutma kapasitesi PS ilave edilmiş grupta NT ilave edilen gruptan daha yüksek olsa da, depolamanın 1. ve 2. günlerinde her iki grup benzer, ancak, K'dan daha yüksek su tutma kapasitesi göstermiştir. Duyusal değerlendirmede üçgen test sonuçlarına göre, PS ve NT ilave edilen gruplar arasında önemli bir farklılık bulunmamıştır (P>0,05).

Anahtar kelimeler: Sodyum azaltılması, sığır köftesi, teknolojik özellikler, renk, duyusal analiz

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INTRODUCTION

Methods used for improving the shelf-life of meat products can be classified as physical, microbiological and chemical. Addition of salt is a well-known chemical method of meat preservation. Besides its antimicrobial activity, sodium chloride has been utilized in processed meat products since ancient times as flavoring or flavor enhancer and responsible for development of desired textural characteristics (1, 2).

Sodium, which forms 39.3% of salt (3), has many biological functions such as maintaining the correct volume of circulating blood and tissue fluids in the body liquid balance (4). However, excessive intake of sodium is considered to be a potential health treat. High dietary sodium intake is one of the causes of hypertension, which is a major risk factor for cardiovascular and renal disease although other factors such as age, body mass index, activity levels are other factors affecting blood pressure (4, 5).

In Turkey, prevalence of hypertension corrected with age and gender has been reported to be 31.8% (6). In a recent PatenT (Prevalence, awareness, treatment and control of hypertension in Turkey) study, Arici et al. (7) reported that overall 4-year incidence rate of hypertension was 21.4% which reached a maximum of 43.3% in people over 65 years of age. Epidemiological studies have shown that populations with low sodium diets generally do not have a high incidence of hypertension, however, populations that consume high-sodium diets do have a high incidence of salt-induced hypertension (4). High dietary intake of sodium is also associated with other health issues such as bone diseases, gastric cancer and severity of asthma (5).

Sodium is naturally present in most foods and may rarely come insufficient (2). As an important nutrient and an essential ingredient in manufacturing safe foods with desirable organoleptical characteristics and structures, sodium chloride is generally consumed much more than the current recommended amount (5). The maximum sodium intake of an adult diet is recommended to the level of 2.4 g/day (8).

Due to all negative treats related to high dietary sodium intake, research in recent years has focused on reducing sodium intake with replacement of sodium chloride with other alternative mineral salts or mixtures of those at lower sodium content in meat products (2, 9-12). There are some commercial mixtures of these mineral salts as salt replacer one of which is a patented salt replacer, PanSalt®. PanSalt® is produced by removing almost half of the sodium and replacing it with potassium chloride, magnesium sulphate and the essential amino acid L-lysine hydrochloride. The objective of the present study was to evaluate the effectiveness of PanSalt® as a commercialized salt replacer on some quality characteristics of ground beef patties during refrigerated storage.

MATERIALS AND METHODS

Preparation of Ground Beef Patties

Raw beef chunks (approximately 20% fat content) were purchased from two different local supermarkets in Ankara for the two replications and transferred to the Meat Laboratory of Food Engineering Department at Ankara University in refrigerated containers. They were ground twice using an electric meat grinder (ARI, Istanbul, TURKEY) through a plate with 4 mm orifices, hand mixed for 1 min initially and divided into 3 treatments. Treatment groups consisted of 1) Control without any salt addition (C); 2) Regular salt added group with addition of 2% sodium chloride (RS); 3) Low sodium salt added group with addition of 2% PanSalt® (PS). Sodium chloride was a food grade salt (Salina Salt, Kavaklıdere-Ankara) and purchased from a local supermarket in Ankara. PanSalt® used for substitution of sodium chloride was kindly donated by Artisan Gıda (Istanbul), and contained 57.0% sodium chloride, 28.0% potassium chloride, 12.0% magnesium sulphate, 2.0% L-lysine monohydrochloride, and 2.0% silicon dioxide according to manufacturer specification. Each patty treatment was weighed into 50 g portions, and formed into individual patties (9 cm dia). The patties were then over-wrapped with PVC stretch film and held at 4±1°C for 2 days for further analysis.

The pH value and water holding capacity were evaluated during refrigerated storage at 4 °C for 2

days at 1-day intervals. Instrumental color [CIE lightness (L*), redness (a*) and yellowness (b*) values], cooking loss and diameter reduction after cooking were determined initially. Sensory analysis was conducted at Day 1.

The pH Value

Duplicate 10 grams of sample was homogenized with 100 ml distilled water for 1 min using an Ultra Turrax ® T25 (IKA Labortechnik, Staufen, Germany), and pH was measured by Hanna HI 221 pH Meter at Days 0, 1 and 2 of refrigerated storage. Before the pH measurement, pH meter was calibrated with pH 4 and pH 7 buffer solutions.

Instrumental Color

Commission Internationale de l'Eclairage (CIE) lightness (L*), redness (a*) and yellowness (b*) values on the surface of the ground beef patties were measured initially (Day 0) at six random sites using a Minolta Chromameter (CR300 Minolta Inc., Osaka, Japan).

Cooking Loss and Diameter Reduction

Ground beef patties from each group were cooked on individual Teflon pans for 10 minutes for each side of the patties. Cooked patties then cooled to room temperature and cooking loss was determined by calculating weight differences for patties before and after cooking using following equation (13);

$$\text{Cooking loss (\%)} = \frac{\text{raw patty weight-cooked patty weight}}{\text{raw patty weight}} \text{ x100}$$

For diameter reduction, change in diameters of beef patties after cooking was determined by measuring the diameters in 6 locations before and after cooking and calculated as follows (13);

$$\text{Diameter reduction (\%)} = \frac{\text{raw patty diameter-cooked patty diameter}}{\text{raw patty diameter}} \text{ x100}$$

Water Holding Capacity

A press technique reported by Zayas and Lin (14) was used to determine the water-holding capacity of ground beef patties during refrigerated storage. Lower water-holding capacity values indicate greater water-holding capacity.

Sensory Analysis

A triangle test was performed at Day 1 to determine if consumers could perceive a difference between patties formulated with regular salt (RS) and commercial reduced-sodium salt (PS). Ground beef patties from each group were cooked on individual Teflon pans for 10 minutes for each side of the patties. Cooked patties then cooled to room temperature, cut into six pieces and evaluated by 24 panelists recruited from the faculty, staff and students of Food Engineering Department at Ankara University. Upon serving, cooked patty pieces were placed in plastic containers coded with three digit random numbers. Panelists were served three samples of patty for every session simultaneously in random order. Each triangle test set consisted of three samples (two identical samples and one different sample) placed on a tray, and panelists were asked to identify the different sample. Bread and room temperature distilled water were served to cleanse the palate between samples (15).

Statistical Analysis

Data from two replications were analyzed with general linear model (GLM) procedure of SAS (1996). Separation of means was accomplished using the least significant difference (LSD) test at the 5% level of probability.

RESULTS AND DISCUSSION

The pH Value

The pH values of ground beef patties ranged from 5.85 to 6.03 during 2-day refrigerated storage (Table 1). However, no significant change (P>0.05) in pH values was determined due to salt treatments and 2-day refrigerated storage. Similarly Gelabert et al. (17) reported that substituting sodium chloride by potassium chloride or glycine (0-40%) did not have a significant effect on pH values of fermented sausages during processing. Ruusunen et al. (18) indicated that although no difference was examined in the pH of raw frankfurter batters, sodium chloride decreased the pH of low-salt phosphate free frankfurters upon cooking. In the present study the pH value was determined in the raw state. Thus it is not possible to compare the pH values of raw and cooked samples.

Table 1. pH values of ground beef patties during refrigerated storage*.

Storage Days	C	RS	PS
0	5.97±0.03	5.98±0.08	6.02±0.10
1	5.85±0.09	5.90±0.06	5.96±0.03
2	6.03±0.00	6.00±0.06	5.97±0.06

*The mean ± standard deviation. C: Control, RS: regular salt (NaCl) added group, PS: PanSalt® added group.

Instrumental Color

CIE lightness (L*), redness (a*) and yellowness (b*) values of ground beef patties were presented in Table 2. No significant difference in L* values was observed between the treatments (P>0.05). As compared with the C patties prepared without addition of any kind of salt, both RS and PS groups had lower a* and b* values (P<0.05). Although a* and b* values of PS group were slightly lower than RS group, this difference was not statistically significant (P>0.05). Redness as measured with a* value is the most important component of fresh meat color (19-21), and a* value above 10 indicated bright red color (22). The a* value of RS and PS groups are above 10 in the present study (Table 2) indicating that RS and PS incorporated ground beef patties were still in bright red color. Alino et al. (12) noted that partially replacement of sodium chloride with potassium chloride, calcium chloride and magnesium chloride in dried cured loin production did not cause significant change in a* and b* values as compared to traditional sodium chloride salting. On the other hand, Totosaus et al. (9) indicated that incorporation of potassium chloride in low fat, sodium-reduced sausage formulation resulted in more 'red' and less 'yellow' sausages than the control. However, this change in instrumental color values in sausages might be due to reduction of fat content.

Table 2. Instrumental color values of ground beef patties*

Color attributes	C	RS	PS
L*	42.24±3.73^{a}	41.87±2.18^{a}	42.81±3.06^{a}
a*	14.26±2.25^{a}	11.51±0.61^{b}	11.00±1.10^{b}
b*	6.87±1.02^{a}	5.09±0.64^{b}	4.21±0.95^{b}

*The mean ± standard deviation.
a-b: For each attribute, means within a row (between groups) not having a common superscript letter are different (P<0.05). C: Control, RS: regular salt (NaCl) added group, PS: PanSalt® added group.

Cooking Loss and Diameter Reduction

Ground beef patties with PS or RS had significantly lower cooking loss and diameter reduction after cooking as compared to C (Figure 1 and Figure 2). Ruusunen et al. (23) evaluated hams made up of coarsely ground pork with the sodium chloride contents of the 1.1, 1.4, 1.7, 2.0, 2.3 and 2.6% and noted that increases in sodium chloride levels resulted in lower cooking losses in cooked hams. Sodium chloride improves water and fat binding characteristics of meat systems resulting in the formation of a desirable gel texture upon cooking and it decreases the cooking loss due to improved fat and moisture retention (3).

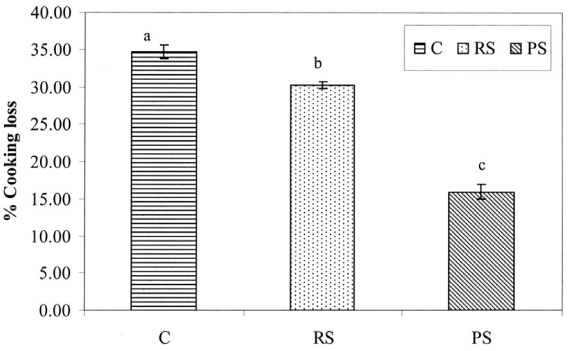

Figure 1.Cooking loss of ground beef patties. Bars ± standard deviation. (a,-c): Bars having common letter between groups are not statistically different (P<0.05). C: Control, RS: regular salt (NaCl) added group, PS: PanSalt® added group.

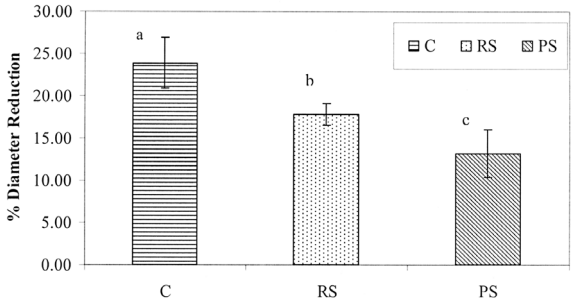

Figure 2. Diameter reduction in ground beef patties after cooking. Bars ± standard deviation. (a,-c): Bars having common letter between groups are not statistically different (P<0.05). C: Control, RS: regular salt (NaCl) added group, PS: PanSalt® added group.

When RS and PS groups were compared, incorporation of commercial reduced sodium salt mixture (PS) containing potassium chloride and magnesium sulfate into ground beef patties in the present study resulted in lower cooking loss and diameter reduction as compared to RS incorporated groups. This cooking loss and diameter reduction lowering effect of PS might be attributed particularly to potassium chloride and magnesium sulfate in PS composition, which result in improvement of water holding capacity in meats. Totosaus et al. (9) stated that when sodium chloride concentration was reduced to 1% from 2.5% and replaced with potassium chloride in sausage formulation, cooking loss significantly decreased, and attributed this to enhancement of the ability of the products to retain water after the thermal treatment with the incorporation of potassium chloride at low concentrations. Similarly, Colmenero et al. (24) stated that potassium chloride resulted in high solubility of proteins due to higher ionic strength in meat batters. Myofibrillar proteins form a stable matrix that retains water during and after heat treatment, thus, cooking yield increases with potassium chloride addition (9). It was also reported that dietary supplementation of pigs with magnesium salts in the last few days prior to slaughter improves water-holding capacity (25-27).

Water Holding Capacity

Initial (Day 0) water holding capacity of ground beef patties incorporated with PS was significantly higher (P<0.05) than the C and RS treated patties (Figure 3), which is also attributed to improved water holding capacity of meat due to magnesium sulfate and potassium chloride in PS formulation. At Day 1 and Day 2, however, PS and RS incorporated groups had similar and both higher water holding capacity than the C (P<0.05). Sodium chloride is utilized in meat products for flavor and texture improvement, and shelf-life extention. It contributes texture of meat products by improving their binding and water-holding properties (3, 28). Therefore, the commercial reduced sodium salt (PS) might be used in ground beef patties instead of sodium chloride without adversely affecting water holding capacity.

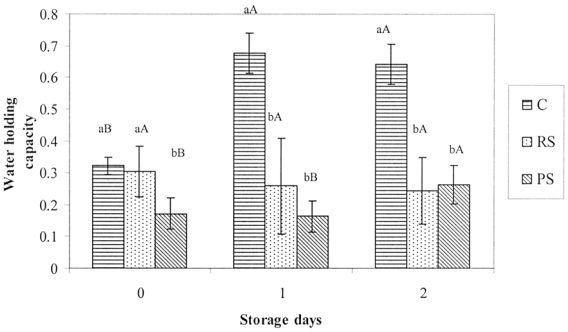

Fig. 3. Water holding capacity values of ground beef patties during refrigerated storage. Bars ± standard deviation. (a, b): Bars having common letter within a day between groups are not statistically different, (A, B): Bars having common letters within a group between days are not statistically different (P<0.05). C: Control, RS: regular salt (NaCl) added group, PS: PanSalt® added group.

Sensory Analysis

In order to determine if RS and PS incorporated ground beef patties differed organoleptically, a sensory triangle test was conducted. Panelists were asked to determine which one of the three sampled products was perceived to be different from the other two. According to the statistical table (critical number of correct responses in a triangle test) as reported by Meilgard et al. (15) for 24 assessors, the number of correct responses should be at least 13 (P<0.05), so that the panel is able to detect a difference between two samples. In the current study with the sensory panel, the number of correct responses was 10 out of 24 showing that no significant difference existed between the RS and PS ground beef patties (P>0.05) considering the triangle test results.

Replacing sodium chloride with other salts might affect sensory characteristics of meat products with the most used substitute potassium chloride imparting a bitter taste at high concentrations (3, 17, 29). However, Armenteros et al. (30) reported that substitutions of sodium chloride up to 50% by KCl in dry-cured loin did not affect sensory properties. Furthermore, Alino et al. (12) noted that dried cured loins salted with 55% sodium chloride, 25% potassium chloride, 15% calcium chloride and 5% magnesium chloride did not differ from the loins salted traditionally (100% sodium chloride) according to the results of sensory analysis, and suggested this treatment to be used successfully for sodium reduction.

CONCLUSION

Due to its negative health impact, the reduction of sodium content in food products has become an important challenge for the food industry. Incorporation of commercial reduced sodium chloride salt (PanSalt®) into ground beef patties in the current study did not result in negative effects on technological and sensory properties of the product as compared with sodium chloride added group. Further studies are needed on sodium reduction in traditional processed meat products in Turkey with possibilities from a technological and sensorial point of view, and consumer's attitude and acceptance of these products.

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