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Full Length Research Paper

Effect of textured soy protein and tomato pulp on chemical, physical and sensory properties of ground chicken döner kebab

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The purpose of this research was to determine the effectiveness of textured soy protein, tomato pulp and their combination on inhibition of lipid oxidation which affects the shelf life of meat products. In addition, microbiological, chemical, textural and sensory properties of döner kebab were determined in this study. According to the results of the study, cooking loss significantly decreased in döner kebab by using combination of textured soy protein and tomato pulp ($P < 0.05$). It was determined that using tomato pulp was effective for controlling lipid oxidation in döner kebab during 10 days of storage at 4°C compared to other treatments ($P < 0.05$). The results show that using textured soy protein with or without tomato pulp have effect on oxidation, pH, color values, texture, color intensity, firmness, juiciness and flavor properties of döner kebab compared to the control group. Although, all of döner kebab groups received high scores for the overall acceptability, döner kebabs manufactured with textured soy protein were the most preferred döner kebab group in terms of taste ($P < 0.05$).

Key words: Döner kebab, soy protein, tomato pulp.

INTRODUCTION

Döner kebab which is an important traditional Turkish meat product has an important place in Turkish cuisine from Central Asia and it is sold under different names such as dona kebabs, döner kebabs, shawirma, gyros, souvlaki and donair (Kilic, 2003; Kayisoglu et al., 2003; Vazgecer et al., 2004; Gonulalan et al., 2004). Döner kebab is generally produced from lamb and beef in Turkey. However, high cost of red meat is disadvantage for production of döner kebab. Since chicken and turkey meat are low cost and more digestible than lamb and beef, poultry meat has become popular for production of döner kebab in recent years (Kayardı et al., 2005). Consumer demands for healthier food products have increased and this situation is compelling to manufacturer to produce more healthy foods. The high cost of animal proteins sources resulted in more production of foods substituted with vegetable proteins. Plant-based proteins are the most exploited products for this purpose. These proteins are used as non-meat ingredients for bringing bioactive components into meat products. Soy proteins also play important role for the production of foods with health-enhancing activity. Soy proteins have an important role in human health since they are a good source of essential amino acids. When soy proteins are combined with other protein source such as meat, the food with the higher nutritious value can be formed. In addition, soy proteins are effective for preventing cardiovascular disease, cancer and osteoporosis (Anderson et al., 1995). Thus, soy proteins are becoming one of the most commonly used non-meat ingredient in the meat industry. In the meat industry, soy protein is the most widely used vegetable protein, due to its biological value, its properties as an emulsifier, stabilizer and its capacity to increase water-holding capacity and improve the texture of the final product. With its hydrating capacity, soy protein can considerably decrease the final cost of the product to the benefit of the manufacturer (Kayardı et al., 2005; Abushita et al., 1997).

Tomatoes and its products are currently subject of interest in both animal and human nutrition because they are excellent sources of natural antioxidants largely in the form of carotenoids, phenolic compounds, tocopherols,

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Table 1. Formulations of döner kebab groups (%).

Ingredient (%)	Group								
	Control	S1	S2	T1	T2	ST1	ST2	ST3	ST4
Ground Chicken Meat	100	85	70	100	100	85	85	70	70
Textured Soy Protein	0	15	30	0	0	15	15	30	30
Tomato Pulp	0	0	0	2.5	5	2.5	5	2.5	5
Salt	2	2	2	2	2	2	2	2	2
Black pepper	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Red pepper	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Garlic powder	1	1	1	1	1	1	1	1	1
Onion powder	1	1	1	1	1	1	1	1	1

S1: 15% Textured Soy Protein; S2: 30% Textured Soy Protein, T1: 2.5 % Tomato Pulp, T2: 5% Tomato Pulp, ST1: 15% Textured Soy Protein and 2.5% Tomato Pulp, ST2: 15% Textured Soy Protein and 5% Tomato Pulp, ST3: 30% Textured Soy Protein and 2.5% Tomato Pulp, ST4: 30% Textured Soy Protein and 5% Tomato Pulp.

and ascorbic acid (Abushita et al., 1997; Martinez-Valverde et al., 2002). Tomatoes and tomato products contain 60 to 74% of the carotenoids and among the carotenoids, lycopene is one of the most well known (Clinton, 1998).

Lycopene is a vital anti-oxidant that helps in the fight against cancerous cell formation as well as other kinds of health complications and diseases. Lycopene has the antioxidant capacity two times higher than beta-carotene and 10 times higher than alfa-tocopherol, which makes its presence in foods matter of considerable interest (Di Mascio et al., 1989; Ribaya-Mercado et al., 1995). Epidemiological studies have shown that an increased consumption of tomatoes which has a very high level of antioxidant content is associated with a reduced risk of lung and other types of cancers (Shekelle et al., 1981; Micozzi et al., 1990).

The aim of this study was to investigate the effectiveness of the use of textured soy protein (TSP) and tomato pulp (TP) on limiting lipid oxidation in chicken döner kebab. In addition, microbiological, chemical, textural and sensory properties of döner kebabs which are produced using textured soy protein and tomato pulp were determined.

MATERIALS AND METHODS

Ground chicken meat, textured soy protein, tomato pulp and spices (red pepper, black pepper, salt, garlic powder and onion powder) were used for döner production. Ground chicken meat was purchased from Gülköy integrated meat plant in Isparta, Turkey. The meat materials were transported on ice to the laboratory. pH values were determined before use. Raw meat was used in döner manufacture on the same day it was received and stored at 4°C for approximately 1 h until use. Texturized soy proteins were obtained from Ülker Soyet (Istanbul, Turkey). Spices were provided by Arifoğlu Baharat ve Gıda San. Ltd. (Istanbul, Turkey). The study was planned as three replications.

Preparation of Döner Kebab

Ground chicken meat was thawed at 4°C before use, kneaded for 5 min at 4°C and then randomly divided into nine treatment groups equally. Each group was formulated as shown in Table 1. Ingredients used in döner kebab manufacture for each treatment group were expressed as a percentage of the total amount of textured soy protein and meat combination. Each ground meat batch was formulated by adding various levels of textured soy protein (TSP) and tomato pulp (TP). Nine treatment groups as follows; S1: 15% TSP, S2: 30% TSP, T1: 2.5 % TP, T2: 5% TP, ST1: 15% TSP and 2.5% TP, ST2: 15% TSP and 5% TP, ST3: 30% TSP and 2.5% TP, ST4: 30% TSP and 5% TP. Each treatment meat batch was kneaded for 15 min to obtain a uniform döner kebab mixture. After this process, the mixture was stored for 1 h at 4°C. Then, the mixture was placed on döner kebab stick. Each surface of rectangular-shaped block of döner was cooked for 4 min. Thus, each surface of döner was cooked equally. At the end of the each cooking time of 4 min, cooked surface was cut at 0.5 cm thickness. Cooking and cutting processes were applied as this way for whole döner block. After cooling down to room temperature (23 to25°C), döner samples were weighed before and after cooking to measure cooking losses, then vacuum packaged and stored at 4°C for 30 days.

Sensory evaluation

The degree of difference and descriptive sensory analysis were performed at the Department of Food Sciences at the Suleyman Demirel University by a group of twenty non-smoker panelists experienced in the sensory evaluation of foods, using procedures described in the IFT Guideline (1981). Each panelist was seated in individual booth with white illumination and water was provided for rinsing the mouth between samples. Döner kebab sample from each treatment was randomly chosen, presented in dishes coded with random three-digit numbers, reheated 40 s at microwave oven and served to the panelists. The panelists evaluated the appearance attributes (integrity, color and color intensity), juiciness, ease of fracture, firmness, greasiness, flavor, off-flavor, meat flavor intensity, off-odor and the overall acceptability of the döner kebabs. Döner kebab attribute intensities were rated on 9 point scale.

Texture measurement

Lloyd LF Plus Texture Analizer (Ametek Precision Instruments, Germany) connected to a computer running Nexygen™ MT software was used to measure the texture of döner kebab. This method involved compressing döner kebab samples. Samples were

taken from the cooler and placed at room temperature for 30 min. Döner kebab samples were cut as 3 cm wide, 5 cm long, 5 mm thick. Then samples were taken place under plunger. The test was performed using a 5 mm cylindrical stainless steel plunger attached to a 50 N cell connected to the crosshead (crosshead speed of 50 mm/min) of texture analyzer. Analysis of force-times curves led to the identification of measured textural parameters. Firmness was the maximum peak force during compression (Perera et al., 2003; Claus, 1995).

Cooking loss

Cooking loss of döner samples was assessed after cooking process. Cooking loss of döner samples was calculated by the using formula shown below (Barbut, 2006). It was expressed as a percentage;

$$\% \text{ cooking loss} = \frac{(\text{Weight of the uncooked donernsamples} - \text{weight of the cooked doner samples})}{\text{Weight of the uncooked doner samples}} \times 100$$

Color determination

CIE color values (L*, a*, b*) of the cooked cooled döner kebab were determined by Minolta colorimeter (AOAC, 1995). The colorimeter was calibrated using a standard white plate. Color was measured at three positions at interior parts of döner samples.

pH determination

Ten gram (10 g) of döner sample were blended with 90 ml distilled water. After filtering, pH measurements were taken with spear tip electrode (Chouliara et al., 2007).

Measurement of lipid oxidation

Lipid oxidation of the cooked döner samples was assessed on 0, 7, 15 and 30 days of storage. Evaluation of oxidative stability was performed by measuring the formation of thiobarbituric acid reactive substances (TBARS). TBARS were determined in triplicate from each group using the muscle extraction procedure of Lemon (1975) with some modifications (Kilic and Richards, 2003). This method requires the addition of EDTA and propyl gallate to the trichloroacetic acid (TCA) extraction solution to prevent the development of TBARS during the analytic procedure. One gram (1 g) döner kebab sample was blended into 6 mL of extraction solution. The samples were homogenized with a laboratory blender. The homogenate was filtered through Whatman No. 1 filter paper (Maidstone, England). Filtrate (1 mL) was mixed with 1 mL of thiobarbituric acid (TBA) and vortexed. The mixture was heated at 100°C for 40 min in heating block. After cooling, the sample was centrifuged at 2000 rpm for 5 min. Absorbance was determined at 532 nm against blank containing 1 mL TCA extraction solution and 1 mL TBA solution. The TBARS values were expressed as mmol TBARS per kg meat. A standard curve was prepared using tetraethoxypropane.

Microbiological analysis

Samples (10 g) of ground meat were aseptically weighed, added to sterile buffered peptone water (90 ml) and homogenized in a stomacher at room temperature. Decimal dilutions in buffered peptone water were prepared and duplicate 0.1 ml samples of appropriate dilutions were spread on the following media: Plate Count Agar (PCA; Merck, Darmstadt, Germany) for total viable aerobic count (TVAC), incubated at 30°C for 48 h; Potato Dextrose Agar (PDA; Merck, Darmstadt, Germany) for yeast and moulds, incubated at 25°C for 72 h; Eosin Metilen Blue Agar (EMB; Merck, Darmstadt, Germany) for coliforms, incubated at 37°C for 48 h.

Statistical analysis

The entire experiments were replicated three times. Data collected for chemical composition, physicochemical properties and sensory attributes were analyzed by the statistical analysis system. The generated data were analyzed by analysis of variance (ANOVA). Differences among mean values were established using the Duncan test and were considered significant when $p < 0.05$. Differences among mean values obtained from sensory observations were established using the Kruskal-Wallis test which is non-parametric tests. In this test, Bonferroni-Dunn method was used to determine differences between group means.

RESULT AND DISCUSSION

Sensory evaluation

Döner kebab samples were evaluated for integrity, color, color intensity, firmness, juiciness, greasiness, ease of fracture, flavor, off-flavor, meat flavor intensity, odor and the overall acceptability. Tenderness, juiciness, flavor and color of meat products are the eating quality characteristics and these properties influence the consumers' overall decision. They can be influenced by several production factors such as addition of some additives and processing techniques.

Sensory evaluation of döner kebab groups showed that addition of textured soy protein and tomato pulp affected some of the sensory attributes such as color intensity, firmness, juiciness and flavor properties compared to the control group (Table 2). Sensory analysis revealed that T1 and T2 groups have statistically lower color intensity compared to ST4 group ($p < 0.05$). S2, ST2, ST3 and ST4 groups received the highest color intensity scores ($p < 0.05$).

Panelists rated juiciness of all döner samples as moderately dry and they reported that ST3 group has lower juiciness compared to T1 group ($p < 0.05$). Taste panel results indicated that addition of 15% TSP and 2.5% TP in döner formulation resulted in softer texture ($p < 0.05$). According to the results of sensory analysis, T_1 group has more desirable flavor than S_2 group ($p < 0.05$). Even though there were no differences among groups, all treatment groups received high overall acceptability scores from panelists. No significant differences were reported among treatment groups for color, integrity, ease of fracture, greasiness, off flavor, flavor intensity and odor.

Texture analysis

Texture analysis was conducted after cooking process

Table 2. The results of sensory evaluation in döner kebab groups.

Group	Color	Color intensity	Integrity	Firmness	Ease of fracture	Juiciness
Control	5.6 ± 1,9^{a}	4.7 ± 1.6^{cd}	6.5 ± 2.1^{a}	5.8 ± 1.4^{a}	5.4 ± 1.9^{a}	4.4 ± 1.7^{ab}
S1	5.5 ± 2,1^{a}	5.4 ±1.7^{bc}	6.7 ± 2.3^{a}	5.0 ± 1.6^{ab}	5.2 ± 1.9^{a}	4.6 ± 1.9^{ab}
S2	4.7 ± 2,3^{a}	6.0 ± 2.0^{ab}	5.5 ± 2.3^{a}	4.6± 1.8^{ab}	5.7 ± 1.9^{a}	4.6 ± 1.8^{ab}
T1	5.7 ± 2,0^{a}	3.5 ± 1.8^{d}	6.7 ± 1.6^{a}	5.0 ± 2.0^{ab}	5.5 ± 1.8^{a}	4.7 ± 1.8^{a}
T2	5.65 ± 2,1^{a}	4.1 ± 1.6^{d}	5.6 ± 1.6^{a}	5.0 ± 1.9^{ab}	5.6 ± 2.0^{a}	4.4 ± 1.9^{ab}
ST1	5.2 ± 1,9^{a}	4.7 ± 1.7^{cd}	5.9 ± 1.8^{a}	4.4 ± 1.7^{b}	5.9 ± 1.8^{a}	4.2 ± 2.0^{ab}
ST2	5.0 ± 2,0^{a}	5.9 ± 2.3^{abc}	5.8 ± 1.8^{a}	5.4 ± 2.5^{ab}	5.3 ± 2.0^{a}	3.8 ± 2.0^{abc}
ST3	5.5 ± 2,3^{a}	6.6 ± 2.0^{ab}	6.5 ± 2.1^{a}	5.3 ± 2.2^{ab}	5.2 ± 1.8^{a}	3.0 ± 1.9^{c}
ST4	5.5 ± 1,9^{a}	6.9 ± 1.9^{a}	6.4 ± 1.7^{a}	5.4 ± 1.9^{ab}	5.4 ± 1.5^{a}	3.4 ± 1.5^{bc}

	Greasiness	Flavor	Off-Flavor	Flavor Intensity	Odor	Overall acceptability
Control	3..8 ± 1.7^{a}	5.8 ± 1.5^{ab}	0.1 ± 1.8^{a}	4.4 ± 2.2^{a}	5.9 ± 1.9^{a}	6.3 ± 1.4^{a}
S1	3.8 ± 1.6^{a}	5.4 ± 1.9^{ab}	1.6 ± 2.2^{a}	5.6 ± 1.8^{a}	5.7 ± 2.2^{a}	5.8 ± 2.1^{a}
S2	4.4 ± 1.9^{a}	5.0 ± 1.2^{b}	1.7 ± 1.6^{a}	4.4 ± 2.0^{a}	5.7 ± 1.8^{a}	5.5 ±1.8^{a}
T1	4.1 ± 1.3^{a}	6.5 ± 0.9^{a}	0.8 ± 2.1^{a}	4.7 ± 1.7^{a}	6.2 ± 1.6^{a}	6.3 ± 1.6^{a}
T2	4.0 ± 1.7^{a}	5.6 ± 1.4^{ab}	1.2 ± 1.5^{a}	4.9 ± 1.8^{a}	5.4 ± 2.0^{a}	5.6 ± 2.0^{a}
ST1	4.1 ± 2.0^{a}	5.0 ± 1.6^{b}	1.5 ± 1.8^{a}	4.9 ± 2.0^{a}	6.2 ± 2.3^{a}	5.5 ± 2.3^{a}
ST2	3.6 ± 1.9^{a}	5.7 ± 1.7^{ab}	1.1 ± 1.6^{a}	4.7 ± 2.4^{a}	5.7 ± 2.2^{a}	5.7 ± 2.2^{a}
ST3	3.4 ± 2.3^{a}	5.1 ± 2.2^{b}	1.5 ± 2.1^{a}	5.0 ± 2.2^{a}	5.3 ± 2.5^{a}	5.1 ± 2.5^{a}
ST4	3.7 ± 2.3^{a}	5.4 ± 2.5^{ab}	1.9 ± 1.2^{a}	5.2 ± 2.6^{a}	5.6 ± 2.4^{a}	5.6 ± 2.4^{a}

*Means with different letters in the same column are significantly different ($p<0.05$). S1: 15% Textured soy protein; S2: 30% Textured soy protein, T1: 2.5 % tomato pulp, T2: 5% tomato pulp, ST1: 15% Textured Soy Protein and 2.5% Tomato Pulp, ST2: 15% Textured Soy Protein and 5% Tomato Pulp, ST3: 30% Textured Soy Protein and 2.5% Tomato Pulp, ST4: 30% Textured Soy Protein and 5% Tomato Pulp

Table 3. The results of texture analyses in döner kebab groups.

Group	Firmness (N/m)	
	Manufacturing Day	30 days storage
Control	9.88±2.75^{abc}	12.80±2.41^{a}
S1	6.99±3.59^{c}	6.80±0.31^{b}
S2	11.59±494^{ab}	13.57±471^{a}
T1	9.35±3.15^{bc}	7.10±0.65^{b}
T2	6.49±1.97^{c}	6.32±0.96^{b}
ST1	8.14±1.18^{c}	8.02±2.33^{b}
ST2	8.57±0.67^{bc}	7.63±1.50^{b}
ST3	9.21±0.72^{bc}	8.04±2.52^{b}
ST4	12.83±0.58^{a}	9.17±2.19^{b}

*Means with different letters in the same column are significantly different ($p<0.05$). S1: 15% Textured Soy Protein; S2: 30% Textured Soy Protein, T1: 2.5 % Tomato Pulp, T2: 5% Tomato Pulp, ST1: 15% Textured Soy Protein and 2.5% Tomato Pulp, ST2: 15% Textured Soy Protein and 5% Tomato Pulp, ST3: 30% Textured Soy Protein and 2.5% Tomato Pulp, ST4: 30% Textured Soy Protein and 5% Tomato Pulp.

and at the end of 30 days storage period. Texture analysis results are shown in Table 3.

Research findings showed that TSP, TP and their combination affect firmness properties of döner kebab. ST4 group which is containing 30% TSP and 15% TP have the highest firmness values after the cooking process ($p < 0.05$). The increase of firmness could be explained by the presence of fiber in the TP and TSP. Knoblich et al. (2005) reported that tomato pulp has acid detergent fiber content close to 30 g/100 g of dry matter. Similarly, Ahn et al. (1999) has shown that addition of soy proteins resulted in better binding and texturization of sausages. On the other hand, the highest firmness values were determined in the control and S_2 group at the end of 30

Table 4. The results of cooking loss in döner kebab groups.

Group	Cooking Loss (%)
Control	35.68±4.57^{a}
S1	32.04±4.11^{ab}
S2	29.58±0.65^{abc}
T1	28.57±3.66^{abc}
T2	31.89±3.24^{ab}
ST1	25.48±3.31^{bc}
ST2	32.09±0.66^{ab}
ST3	21.07±7.04^{c}
ST4	26.67±1.90^{bc}

*Means with different letters in the same column are significantly different ($p<0.05$). S1: 15% Textured Soy Protein; S2: 30% Textured Soy Protein, T1: 2.5 % Tomato Pulp, T2: 5% Tomato Pulp, ST1: 15% Textured Soy Protein and 2.5% Tomato Pulp, ST2: 15% Textured Soy Protein and 5% Tomato Pulp, ST3: 30% Textured Soy Protein and 2.5% Tomato Pulp, ST4: 30% Textured Soy Protein and 5% Tomato Pulp.

days of storage ($p < 0.05$).

Cooking loss

Protein sources such as soy proteins have been used in the manufacture of meat products to enhance the products' functional characteristics like improving cooking yield and slicability. In the present study, the results indicated that döner kebab samples containing TSP and TP have less cooking loss compared to the control group ($p<0.05$). Especially, when a combination of 30% TSP and 2.5% TP was used, cooking loss of döner kebab samples significantly decreased ($p < 0.05$). Similarly, Aida and Youling (2003) reported that soy protein treatments significantly increased water holding capacity and reduced patties' cooking loss with increasing soy protein in meat patties. The lower cooking loss in döner kebabs produced with 30% TSP and 2.5% TP may be the result of an increased number of charged polar amino and carboxylic groups due to peptide cleavage which led to a stronger protein–water interaction (Aida and Youling, 2003). (Table 4)

Color analysis

Color analyses were performed on döner dough and cooked döner kebab at 1 and 30 day of storage period (Table 6). Lightness values increased and redness values decreased with cooking process ($p < 0.05$). Moreover, this changes in L* and a* values continued in the same trend during storage period ($p<0.05$). Reduction in redness values for all groups during the storage period may be explained with oxidation during the storage period.

The addition of TP, TSP and their combinations resulted in decrease on L* values of döner kebab dough ($p < 0.05$). On the other hand, addition of TP and TSP combination caused an increase in a* values compared to the control group ($p < 0.05$). Furthermore, addition of tomato pulp resulted in an increase in b* values ($p<0.05$). This result is in agreement with the results of Østerlie and Lerfall (2005), Eyiler and Oztan (2011) and Deda et al. (2007). According to Candogan (2002), this color improving effect of TP can be attributed to red color and antioxidant effect of lycopene present in tomato. Similar results have been reported by Calvo et al. (2008) for dry fermented sausage.

While ST_4 group significantly increased a* values and decreased L* values, T_2 group signifi-cantly increased only a* values of cooked döner kebab samples ($p < 0.05$). On the other hand, combination of TP and TSP resulted in lower b* values and higher a* values in döner kebab samples at the end of 30 days storage ($p < 0.05$).

pH analysis

Addition of TP and the combination of TP and TSP decreased pH of döner kebab dough compared to other groups ($p < 0.05$). Similarly, Candogan (2002), Deda et al. (2007) and Eyiler and Oztan (2011) have been reported pH decrease in meat products containing tomato pulp. The authors speculated that the decrease could be possibly related with the acidic charac-teristics of the tomato pulp. (Table 5)

After cooking process and storage, an increase in pH values of all treatment groups was determined ($p < 0.05$). However, there were no significant pH differences among treatment groups.

Table 5. The results of pH analyses of döner kebabs.

Group	pH		
	Döner kebab dough	Manufacturing day	30 days storage
Control	5.85±0.01^{ab}	6.03 ± 0.06^{ab}	6.18 ± 0.07^{a}
S1	5.87 ± 0.02^{a}	6.07 ± 0.03^{a}	6.16 ± 0.06^{a}
S2	5.85 ± 0.02^{ab}	6.02 ± 0.01^{ab}	6.07 ± 0.07^{a}
T1	5.78 ± 0.04^{fg}	6.01 ± 0.05^{b}	6.11 ± 0.14^{a}
T2	5.77 ± 0.05^{g}	5.98 ± 0.07^{b}	6.07 ± 0.08^{a}
ST1	5.79 ± 0.01^{ef}	5.98 ± 0.08^{b}	6.08 ± 0.18^{a}
ST2	5.82 ± 0.03^{cd}	6.01 ± 0.01^{b}	6.08 ± 0.13^{a}
ST3	5.84 ± 0.01^{bc}	5.97 ± 0.09^{b}	6.09 ± 0.13^{a}
ST4	5.81 ± 0.01^{de}	5.98 ± 0.05^{b}	6.13 ± 0.02^{a}

*Means with different letters in the same column are significantly different ($p<0.05$). S1: 15% Textured Soy Protein; S2: 30% Textured Soy Protein, T1: 2.5 % Tomato Pulp, T2: 5% Tomato Pulp, ST1: 15% Textured Soy Protein and 2.5% Tomato Pulp, ST2: 15% Textured Soy Protein and 5% Tomato Pulp, ST3: 30% Textured Soy Protein and 2.5% Tomato Pulp, ST4: 30% Textured Soy Protein and 5% Tomato Pulp.

Table 6. The results of color analysis in döner kebab groups.

Group	Storage time at 4°C (day)								
	L*			a*			b*		
	Döner Dough	Manufacturing day	30 day storage	Döner Dough	Manufacturing day	30 day storage	Döner Dough	Manufacturing day	30 day storage
Control	50.68±7.48^{a}	56.19±5.23^{bc}	61.57±5.23^{a}	6.39±0.62^{c}	5.17±0.53^{cd}	3.35±1.51^{c}	13.45±6.14^{b}	16.42±2.38^{abc}	14.34±2.86^{abc}
S1	41.24±5.11^{bcd}	56.33±1.72^{bc}	59.49±2.68^{ab}	6.66±0.49^{bc}	4.87±0.18^{d}	4.38±0.31^{abc}	15.84±0.08^{ab}	15.42±0.20^{cd}	14.89±1.96^{ab}
S2	40.16±5.46^{cd}	52.40±0.81^{cde}	55.91±6.87^{bc}	6.50±0.02^{bc}	5.01±0.83^{d}	4.38±0.21^{abc}	15.46±2.02^{ab}	13.81±0.19^{d}	12.22±1.47^{c}
T1	45.34±1.56^{b}	61.53±1.92^{a}	64.91±3.84^{a}	7.18±0.2^{bc}	5.06±0.48^{d}	4.89±0.65^{ab}	18.16±0.92^{a}	17.37±0.03^{ab}	16.08±2.85^{a}
T2	44.39±0.65^{bc}	57.32±6.41^{b}	63.58±0.49^{a}	7.16±0.14^{bc}	6.19±0.78^{ab}	3.96±1.24^{bc}	16.77±1.12^{a}	17.81±0.49^{a}	14.46±3.13^{abc}
ST1	43.49±0.22^{bcd}	55.07±0.55^{bc}	60.28±2.39^{ab}	7.83±0.07^{bc}	5.62±0.71^{abcd}	4.78±0.29^{ab}	16.55±1.81^{a}	16.44±1.45^{abc}	15.16±1.22^{ab}
ST2	44.42±2.72^{bc}	54.35±1.87^{bcd}	56.29±0.46^{bc}	8.55±2.33^{a}	6.02±0.05^{abc}	5.42±0.54^{a}	17.06±0.25^{a}	15.56±0.39^{bcd}	15.15±2.17^{ab}
ST3	41.24±1.69^{bcd}	50.72±3.01^{de}	53.10±3.97^{c}	7.67±0.19^{abc}	5.41±1.46^{bcd}	4.42±0.01^{ab}	15.92±1.68^{ab}	14.08±2.74^{d}	12.61±0.77^{bc}
ST4	39.71±3.13^{d}	48.64±0.72^{e}	58.64±6.72^{bc}	8.81±0.46^{a}	6.31±0.96^{a}	4.79±0.32^{ab}	16.57±2.49^{a}	14.22±0.99^{d}	13.11±1.80^{bc}

Means with different letters in the same column are significantly different ($p<0.05$). S1: 15% Textured Soy Protein; S2: 30% Textured Soy Protein, T1: 2.5 % Tomato Pulp, T2: 5% Tomato Pulp, ST1: 15% Textured Soy Protein and 2.5% Tomato Pulp, ST2: 15% Textured Soy Protein and 5% Tomato Pulp, ST3: 30% Textured Soy Protein and 2.5% Tomato Pulp, ST4: 30% Textured Soy Protein and 5% Tomato Pulp. L: Lightness; a*: Redness; b*: Yellowness.

Table 7. TBARS values of cooked döner kebabs during storage at 4 °C. TBARS are expressed as µmol TBARS per kg tissue.

Group	Storage time at 4 °C (days) µmol TBARS/kg tissue					
	Manufacturing day	5th day	10th day	15th day	20th day	30th day
Control	1.47 ± 0.20^{b}	2.44 ± 1.12^{ab}	1.86 ± 0.07^{c}	2.03 ± 0.43^{a}	1.95 ± 0.22^{c}	2.06 ± 0.18^{c}
S1	1.68 ± 0.23^{b}	2.21 ± 0.52^{abc}	2.44 ± 0.24^{b}	2.90 ± 0.89^{a}	2.26 ± 0.25^{bc}	2.51 ± 0.12^{abc}
S2	2.14 ± 0.26^{a}	2.69 ± 0.47^{a}	3.02 ± 0.54^{a}	2.68 ± 0.54^{a}	2.32 ± 0.20^{b}	2.87 ± 0.32^{a}
T1	1.44 ± 0.27^{b}	186 ± 0.17^{bc}	2.10 ± 0.34^{bc}	1.92 ± 0.56^{a}	2.44 ± 0.84^{b}	2.18 ± 0.49^{bc}
T2	1.03 ± 0.12^{c}	1.75 ± 0.25^{c}	1.61 ± 0.17^{d}	2.19 ± 0.89^{a}	2.13 ± 0.38^{bc}	2.44 ± 0.61^{abc}
ST1	1.68 ± 0.09^{b}	1.96 ± 0.27^{bc}	2.31 ± 0.70^{b}	2.03 ± 0.68^{a}	2.31 ± 0.10^{b}	2.30 ± 0.11^{bc}
ST2	1.73 ± 0.26^{b}	1.85 ± 0.29^{bc}	1.96 ± 0.06^{bc}	2.56 ± 0.93^{a}	2.06 ± 0.05^{bc}	2.10 ± 0.40^{c}
ST3	2.11 ± 0.47^{a}	2.47 ± 0.38^{ab}	2.57 ± 0.44^{b}	2.68 ± 0.87^{a}	2.93 ± 0.32^{a}	2.58 ± 0.43^{ab}
ST4	2.31 ± 0.09^{a}	2.49 ± 0.34^{ab}	2.31 ± 0.17^{b}	2.25 ± 0.55^{a}	3.02 ± 0.10^{a}	2.47 ± 0.23^{ab}

*Means with different letters in the same column are significantly different ($p<0.05$). S1: 15% Textured Soy Protein; S2: 30% Textured Soy Protein, T1: 2.5 % Tomato Pulp, T2: 5% Tomato Pulp, ST1: 15% Textured Soy Protein and 2.5% Tomato Pulp, ST2: 15% Textured Soy Protein and 5% Tomato Pulp, ST3: 30% Textured Soy Protein and 2.5% Tomato Pulp, ST4: 30% Textured Soy Protein and 5% Tomato pulp.

Oxidation (TBARS) analysis

Lipid oxidation is one of the main limiting factors for the quality and acceptability of meat and meat products. This process leads to discoloration, drip loss, off-odor and off-flavor development, and the production of potentially toxic compounds (Morrisey et al., 1998).

Table 7 shows the TBARS values which are indicative of lipid oxidation for all samples throughout storage. TBARS values of cooked döner kebabs ranged from 1.03 to 3.02 µmol TBARS per kg during 30 days of storage. Results indicate that TBARS values in all treatment groups gradually increased during storage period ($p < 0.05$). Addition of 5% TP significantly decreased oxidation in döner kebab samples during 10 days of storage compared to the control group ($p < 0.05$). Similarly, Escalante et al. (2003) have been reported that TP showed an antioxidative effect, which was significant only at 8 day of storage. Furthermore, Candogan (2002) observed that beef patties prepared with TP had lower oxidation levels ($p < 0.05$). In this study, antioxidant effect of TP was not determined during the rest of storage period. This may be the results of oxidation occurred in antioxidation components such as lycopene in tomato pulp. Shi et al. (2004) reported that lycopene also can be converted into peroxyl radicals capable of acting as pro-oxidants and of undergoing auto-oxidation themselves.

On the other hand, 30% TSP itself and its combination with TP resulted in higher TBARS values compared to control group during storage period ($p<0.05$). This result may show that level of 30% TSP can act as prooxidant which limited antioxidant effect of 5% TP. This result is an agreement with findings of D'Souza and Skonberg (2011). They reported that the soy protein isolate at both 1000 and 4000 rpm showed a slight pro-oxidant effect in minced trout muscle.

Microbiologic analysis

Microbiological analyses were performed on döner dough and cooked döner kebab on production day and at the end of 30 days of storage period. Results show that TVAC, yeast and mold decreased with cooking process, then increased during storage ($p < 0.05$). (Table 8) No significant differences were determined among treatment groups. Significant reduction was also determined in coliform numbers after cooking process and this reduction continued during storage period ($p<0.05$).

Conclusion

Findings of this study showed that using TSP, TP

Table 8. The results of microbiological analysis in döner kebabs.

Group	Log[10] kob/g - Storage time at 4 °C (day)								
	TVAC			Yeast-Mold			Coliform		
	Döner kebab dough	Manufacturing day	30 day storage	Döner kebab dough	Manufacturing day	30 days storage	Döner kebab dough	Manufacturing day	30 day storage
Control	5.90±0.21^{bc}	2.96±1.16^{a}	5.89±1.02^{a}	2.93±0.59^{c}	0.00±0.00^{a}	2.62±1.87^{a}	4.27±0.43^{a}	0.83±1.28^{b}	1.00±1.09^{a}
S1	6.63±0.48^{abc}	2.99±0.31^{a}	5.69±0.85^{a}	3.03±0.4^{c}	1.52±1.03^{a}	2.88±1.53^{a}	4.59±0.48^{a}	1.48±1.17^{b}	0.34±0.82^{a}
S2	6.05±0.18^{bc}	2.90±0.31^{a}	6.02±0.85^{a}	3.56±0.34^{a}	1.22±0.82^{a}	2.40±1.63^{a}	4.57±0.38^{a}	0.77±1.19^{b}	0.38±0.094^{a}
T1	5.99±0.20^{bc}	2.52±0.94^{a}	5.89±0.72^{a}	3.36±0.36^{abc}	1.22±0.82^{a}	2.85±1.43^{a}	4.58±0.50^{a}	2.15±0.16^{b}	0.67±1.03^{a}
T2	6.69±0.44^{ab}	2.85±0.15^{a}	5.99±0.76^{a}	3.54±0.72^{ab}	1.22±0.82^{a}	2.45±1.68^{a}	4.48±0.32^{a}	2.21±1.11^{a}	0.75±1.17^{a}
ST1	6.73±0.69^{a}	2.67±1.29^{a}	5.90±0.93^{a}	3.19±0.41^{abc}	0.00±0.00^{a}	3.10±1.07^{a}	4.42±0.45^{a}	1.59±1.28^{ab}	1.00±1.09^{a}
ST2	6.56,±0.56^{abc}	2.87±1.09^{a}	6.08±0.72^{a}	3.12±0.48^{bc}	0.00±0.00^{a}	2.34±1.57^{a}	4.66±0.47^{a}	1.69±1.32^{ab}	0.00±0.00^{a}
ST3	5.78±0.06^{c}	3.06±0.74^{a}	6.06±1.15^{a}	3.27±0.18^{abc}	0.34±0.82^{a}	2.79±1.37^{a}	4.66±0.41^{a}	1.00±1.09^{b}	0.34±0.82^{a}
ST4	5.94±0.43^{bc}	2.54±0.69^{a}	5.94±0.84^{a}	2.95±0.23^{c}	0.00±0.00^{a}	2.48±1.72^{a}	4.12±0.22^{a}	1.48±1.17^{b}	0.34±0.82

*Means with different letters in the same column are significantly different ($p<0.05$). S1: 15% Textured Soy Protein; S2: 30% Textured Soy Protein, T1: 2.5 % Tomato Pulp, T2: 5% Tomato Pulp, ST1: 15% Textured Soy Protein and 2.5% Tomato Pulp, ST2: 15% Textured Soy Protein and 5% Tomato Pulp, ST3: 30% Textured Soy Protein and 2.5% Tomato Pulp, ST4: 30% Textured Soy Protein and 5% Tomato Pulp, TVAC: Total viable aerobic count.

and their combinations in döner kebab manufacture may contribute to improve some attributes of döner kebab such as lipid oxidation, pH, cooking loss, color and sensorial properties. Döner kebab with added TSP and TP can be a source of well-balanced amino acids, desirable fatty acids and lycopene which acts as a functional additive in human diet. Additionally, STP, TP and their combination in chicken döner kebabs may be used to reduce manufacture cost of döner kebab.

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