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Effect of Textured Soy Protein on Quality Characteristics of Low Fat Cooked Kofte (Turkish Meatball)

[1]Birol Kilic, [1]Tolga Kankaya, [1]Yasar Kemal Ekici and [2]Hikmet Orhan
[1]Department of Food Engineering, Faculty of Engineering,
[2]Department of Animal Science, Faculty of Agriculture,
Suleyman Demirel University, 32260 Isparta, Turkey

Abstract: This study reports the effects of Textured Soy Protein (TSP) incorporation at different concentrations (0, 5, 10 and 20% of total mass) on physicochemical properties of pan-fried beef Kofte (traditional Turkish meatball). The results indicated that the incorporation of TSP increased pH, a* values and total Unsaturated Fatty Acid (UFA) contents and decreased L* values, cooking loss and lipid oxidation in meatball samples ($p<0.05$). Addition of TSP also significantly affected some of the sensory attributes of meatballs ($p<0.05$). It was concluded that addition of TSP up to 10% into meatball formulation may be applied to improve the quality of meatballs without any adverse effects on the final product.

Key words: Textured soy protein, meatballs, oxidation, quality, final product, physiocochemical

INTRODUCTION

Recently, consumer demands for healthier meat products have increased. Meeting consumer demands is stimulating the development of meat products formulated with various amounts and types of healthier bioactive compounds. In this regards, several plants such as oat, soy, wheat, sunflower and rosemary and plant origin ingredients are commonly used in meat products formulations to provide beneficial components such as phytochemicals, to improve product quality such as enhanced binding properties and to reduce manufacturing cost (Pennington, 2002). Plant-based proteins are used as non-meat ingredients for bringing bioactive components into meat products (Jimenez-Colmenero, 2007).

Soy proteins have an important role in human health since they are a good source of essential amino acids. Soy proteins also play important role for production of foods with health-enhancing activity. When soy proteins are combined with other protein source such as meat, the food with the higher nutrious value can be formed. In addition, soy proteins are effective for preventing cardiovascular disease cancer and osteoporosis.

Thus, soy proteins are becoming one of the most commonly used non-meat ingredient in the meat industry (Feiner, 2006). Soy based ingredients also contain another group of bioactive components such as isoflavones which is thought to be effective for reducing risk of cancer in women by binding estrogen receptors (Hasler, 1998; Arihara, 2006; Messina and Wood, 2008). Soy-based ingredients contain a range of vitamins and minerals including vitamin A, vitamin B12, vitamin B2 (riboflavin) and vitamin D, as well as calcium, phosphorus and magnesium (Das *et al*., 2008).

Soy proteins can be obtained from several types of soy-based ingrediens such as soy flour, soy concentrate and soy isolate. There have been several studies about the effects of soy protein incorparation on quality of different types of meat products (Sofos and Allen, 1977; Dexter *et al*., 1993; Matulis *et al*., 1995; Feng *et al*., 2003; Lin and Mei, 2000).

It was reported that the addition of soy proteins improve texture and moisture retention in meat products and provide a juicy and meaty mouth-feeling (Feiner, 2006). Interaction between myofibrillar and soy proteins is occured by heat application and this interaction encourages the formation of a gel matrix which has a role for improving the quality charecteristics of meat products (Haga and Ohashi, 1984; Nagano *et al*., 1996; Feng and Xiong, 2002; Ramirez-Suarez and Xiong, 2003).

One of the most important and widely consumed traditional meat dishes in Middle East is Kofte. Kofte is a traditional Turkish meatball made of ground meat. Beef or lamb are the main meat source for kofte manufacture. Skofte may also contain parsley, crumbled bread, egg yolk and a range of spices such as cumin, oregano, mint

Corresponding Author: Birol Kilic, Department of Food Engineering, Faculty of Engineering, Suleyman Demirel University, 32260 Isparta, Turkey

powder, red or black pepper powder, onion and garlic. Many places in Turkey have a nationwide reputation for their kofte, such as Edirne, Inegol, Tekirdag, Sultanahmet in Istanbul, Adapazari, Sanliurfa, Akcaabat and Adana.

Therefore, the word kofte is sometimes preceded by the name of a town which refers to the technique for cooking it or the ingredients or spices specifically used in that region (http://en.wikipedia.org/wiki/Turkish_cuisine. Turkish cuisine). Kofte is traditionally kichen-made food and a part of traditional Turkish cuise. Now a days, kofte is also manufactured commercially and sold in supermarkets as packaged and refrigerated or frozen forms as ready-to cook meat product. The objective of this study was to investigate the effect of TSP incorparation on some quality characteristics of pan-fried beef meatballs.

MATERIALS AND METHODS

Source of meat: A 24 h post mortem fresh bovine muscle (Musculus longissimus dorsi) was purchased from a big local market in Isparta, Turkey (Migros Turk T.A.[a].) for each of 3 replications on separate production days. The meat materials were transported on ice to the laboratory. Raw meat was trimmed off visible fat and connective tissue and then ground through a 0.94 cm plate in a meat grinder in a 4°C cold room. pH values were determined. Raw ground meat was used in meatball manufacture on the same day it was received and stored at 4°C for approximately one h until use.

Texturized soy protein was obtained from Ulker Soyet (Istanbul, Turkey). Spices were provided by Arifoglu Baharat ve Gida San. Ltd (Istanbul, Turkey) and Pinar Foods (Izmir, Turkey), respectively.

Manufacture of meatballs: Ground meat was randomly divided into four equal batches. The ground meat contained 4±0.6% fat as determined by the modified Babcock test (Salwin *et al*., 1955). The formulations of meatballs are shown in Table 1. Ingredients used in kofte manufacture for each treatment group were expressed as a percentage of the total amount of TSP and meat combination. Each ground meat batch was formulated by adding various levels of texturized soy protein (0, 5, 10 and 20% of total mass) and kneaded for approximately 20 min by hand to obtain a uniform meatball dough.

Then, the dough was shaped manually into approximately 1 cm thick and 6 cm diameter circular shaped meatballs (25±2 g each). Meatballs were placed on tray, wrapped tightly with strech film and stored at 4°C until cooking. Cooking was carried out under exhaust fan and the temperature of the heating source was controlled

Table 1: Meat and nonmeat ingredients used in formulations of meatball groups (%)

	Groups			
Ingredients	C	TSP5	TSP10	TSP20
Ground beef	100.0	95.0	90.0	80.0
TSP	0.0	5.0	10.0	20.0
Red pepper	1.8	1.8	1.8	1.8
Black pepper	1.8	1.8	1.8	1.8
Cummin	0.9	0.9	0.9	0.9
Salt	2.0	2.0	2.0	2.0
Garlic powder	2.0	2.0	2.0	2.0
Onion powder	1.2	1.2	1.2	1.2

by gas valve. Meatballs were cooked on a gas stove in a frying pan until reaching the final internal temperature of 71°C measured with a thermocouple. Meatballs were flipped and rotated every 3 min in a frying pan during approximately 9 min of the total cooking time. After removing the excess oil on study towels and cooling down to room temperature, samples were vacuum packaged and stored at 4°C for 15 days. Meatball samples were weighed before and after cooking to measure cooking losses.

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 five (14 males and 11 females, aged between 23 and 55 years old) non-smoker panelists experienced in the sensory evaluation of foods, using procedures described in the IFT. Sensory Evaluation Division (1981).

Each panelist was seated in individual booth with white illumination and water was provided for rinsing the mouth between samples. Meatball sample from each treatment was randomly chosen, presented in dishes coded with random three-digit numbers, reheated 20 sec 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 meatballs. Meatball attribute intensities were rated on 9 point scale (Lawless and Heymann, 1999) (Table 2).

pH, color, protein and fat determination: A 10 g meatball sample was blended with 90 mL distilled water. After filtering, pH measurements were taken with spear tip electrode (Chouliara *et al*., 2007). CIE color values (L*, a*, b*) of the cooked cooled meatball were determined by Minolta colorimeter (Luo, 2006; Wiegand and Waloszek, 2009). The colorimeter was calibrated using a standard white plate. Color was measured at three positions at interior parts of meatball samples. The fat and protein levels in cooked meatball samples were determined according to the AOAC (1995).

Table 2: Attributes used to characterize the properties of reheated cooked meatball samples

	Point scale	
Attributes	0	9
Integrity	Too much fracture	No fracture
Color	Not desirable	Very desirable
Color intensity	Light	Dark
Firmness[a]	Soft	Firm
Juiciness	Dry	Juicy
Greasiness	Not greasy	Extremely greasy
Ease of fracture[b]	Very easy to fracture	Very difficult to fracture
Flavor	Not desirable	Very desirable
Off-flavor	Not exist	Too much
Meat flavor intensity	Not exist	Intense
Odor	Not desirable	Very desirable
The overall acceptability	Not acceptable	Extremely acceptable

[a]Expressed by the force needed by teeth to cut the sample, [b]Expressed by the force needed by hand to pull apart the samples

Cooking loss: Cooking loss of meatballs was calculated by using formula described by Barbut (2006). It was expressed as a percentage.

Measurement of lipid oxidation: Lipid oxidation of meatballs was assessed on 0, 1, 3, 7 and 15 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 addition of EDTA and propyl gallate to the Trichloroacetic Acid (TCA) extraction solution to prevent the development of TBARS during the analytic procedure. About 1 g meatball sample was blended into 6 mL of extraction solution.

The samples were homogenized with a Polytron type PT 10/35 (Brinkmann Instruments, Westbury, N.Y., U.S.A.) for 15 sec. The homogenate was filtered through Whatman nr 1 filter study (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 g 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^{-1} meat. A standard curve was prepared using tetraethoxypropane.

Measurement of fatty acid composition: A fatty acid composition was determined in both a raw and cooked meatball samples. To determine the fatty acid composition, lipids were extracted from a ten g of meatball samples by homogenizing them with 30 mL of chloroform and methanol (2:1 v/v) mixture. The chloroform extract was evaporated. Following the extraction of lipids, 1.5 M methanolic hydrogen chloride was applied for the preparation of fatty acid derivatives. After addition of hexane, analysis of fatty acid composition was performed on a QP 5050 GC/MS (Shimadzu, Japan), equipped with an Electron Impact (EI) ionisation detector. A column, Cp WAX 52 CB 50 m* 0.32 mm, 1.2 μm was used. The operating conditions were as follows: column temperature, 240°C; injector temperature, 250°C; detector temperature, 250°C. The carrier gas used was helium, at a flow rate of 10 psi. The column was operated at 60°C for 4 min, then the temperature was increased to 175°C at a rate of 4°C min^{-1}. After 27 min at 175°C, the temperature was increased to 215°C at the rate of 4°C min^{-1}. After 5 min at 215°C, the temperature was increased to 240°C at a rate of 4°C min^{-1} and left at this point until the end of analyses. Fatty acids were identified by comparison of their retention time with appropriate standards. The results were expressed in weight percent of the total amount of fatty acids.

Statistical analysis: The entire experiment was replicated three times on separate production days. Data collected for chemical composition, physicochemical properties and sensory attributes were analyzed by the statistical analysis system (SAS, 1998). The generated data were Analyzed by Analysis Of Variance (ANOVA). Differences among mean values were established using the Least Significant Difference test (LSD) and were considered significant when $p<0.05$.

RESULTS AND DISCUSSION

Sensory evaluation: Meatball 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. Sensory evaluation of four meatball groups showed that addition of TSP significantly affected some of the sensory attributes compared to control group (Table 3). Panelist indicated that all meatball samples kept their integrity well but meatballs with 20% TSP were beter than other groups ($p<0.05$). Panelists rated color of all meatball samples as desirable and were unable to detect any differences among tested four meatball groups. Hovewer, meatballs with 20% TSP were found to be darker in color compared the other groups ($p<0.05$). It was shown that firmness values were decreased and juiciness values were increased with addition of TSP in meatball formulation ($p<0.05$). Even though the panelist did not report high greasiness scores for tested meatball samples, meatball samples produced with 20% TSP were rated as the most greasy meatball group ($p<0.05$). The panelist rated meatball samples produced with 20% TSP as the easiest to fructure by hand ($p<0.05$). Meatball samples produced with 10% TSP were chosen as meatballs with the most desirable flavor ($p<0.05$). This group was followed by meatball samples with 5% TSP, control and meatball

Table 3: The results of sensory evaluation reheated cooked meatballs

TBARS values	Integrity	Color	Color intensity	Firmness	Juiciness	Greasiness
C	6.43 ± 1.96^{a}	5.63 ± 1.92^{a}	5.07 ± 1.93^{a}	6.67 ± 1.49^{a}	3.20 ± 1.83^{a}	3.47 ± 1.96^{a}
TSP5	6.40 ± 1.94^{a}	5.69 ± 2.09^{a}	5.40 ± 1.59^{ab}	5.47 ± 2.05^{b}	4.67 ± 1.88^{b}	4.27 ± 1.82^{ab}
TSP10	6.87 ± 2.03^{ab}	5.43 ± 2.21^{a}	5.43 ± 2.03^{ab}	4.87 ± 1.79^{b}	4.80 ± 1.86^{b}	4.30 ± 1.82^{ab}
TSP20	7.50 ± 1.53^{b}	5.47 ± 2.01^{a}	6.37 ± 1.71^{b}	5.00 ± 1.98^{b}	5.00 ± 1.86^{b}	4.60 ± 1.73^{b}

	Ease of fracture	Flavor	Off-flavor	Meat flavor	Odor	The overall acceptability
C	5.87 ± 1.98^{a}	4.87 ± 1.66^{ab}	2.43 ± 1.87^{a}	6.13 ± 2.16^{a}	5.80 ± 1.52^{a}	5.00 ± 1.90^{b}
TSP5	5.50 ± 2.00^{ab}	5.40 ± 2.16^{b}	2.33 ± 1.92^{a}	5.17 ± 2.21^{ab}	5.40 ± 1.87^{a}	5.67 ± 2.20^{c}
TSP10	5.37 ± 2.21^{ab}	6.33 ± 2.22^{c}	2.00 ± 1.74^{a}	5.47 ± 2.01^{ab}	5.53 ± 2.46^{a}	5.83 ± 2.29^{c}
TSP20	$4.63^{b}\pm1.97$	4.17 ± 2.29^{a}	3.93 ± 2.90^{b}	4.13 ± 2.35^{b}	5.27 ± 2.23^{a}	$4.07^{a}\pm2.19^{a}$

*Means with different letters in the same column are significantly different ($p<0.05$)

Table 4: The results of pH, fat, protein and cooking loss values of meatballs

	pH				
TBARS values	Raw	Cooked	Fat (%)	Protein (%)	Cooking loss (%)
C	5.75 ± 0.05^{a}	6.10 ± 0.05^{a}	5.05 ± 0.05^{a}	18.9 ± 0.55^{a}	40.25 ± 0.57^{a}
TSP5	5.89 ± 0.04^{b}	6.17 ± 0.03^{b}	5.23 ± 0.10^{a}	19.1 ± 0.80^{a}	38.11 ± 0.69^{ab}
TSP10	5.92 ± 0.02^{b}	6.20 ± 0.07^{b}	5.25 ± 0.09^{a}	19.3 ± 0.40^{a}	34.50 ± 0.20^{b}
TSP20	5.94 ± 0.02^{b}	6.20 ± 0.06^{b}	5.38 ± 0.12^{a}	19.8 ± 0.60^{a}	30.27 ± 0.27^{b}

*Means with different letters in the same column are significantly different ($p<0.05$)

Table 5: The results of color values of raw and cooked meatballs

	Raw			Cooked		
TBARS values	L^*	a^*	b^*	L^*	a^*	b^*
C	40.32 ± 1.29^{a}	5.56 ± 0.96^{a}	7.75 ± 1.12^{a}	39.66 ± 2.16^{a}	3.89 ± 0.38^{a}	5.47 ± 1.23^{a}
TSP5	40.46 ± 1.15^{a}	5.76 ± 1.04^{a}	7.41 ± 1.21^{a}	36.56 ± 3.84^{b}	4.84 ± 0.81^{b}	5.83 ± 0.66^{a}
TSP10	40.66 ± 4.36^{a}	5.66 ± 1.01^{a}	7.48 ± 0.90^{a}	36.83 ± 3.42^{b}	4.35 ± 0.49^{b}	5.91 ± 1.80^{a}
TSP20	39.21 ± 1.27^{b}	5.47 ± 0.64^{a}	7.66 ± 1.05^{a}	35.60 ± 2.00^{b}	4.39 ± 0.96^{b}	5.48 ± 1.51^{a}

*Means with different letters in the same column are significantly different ($p<0.05$)

samples with 20% TSP, respectively. Even though the panelist did not report high off-flavor scores, meatball samples produced with 20% TSP were received higher off-flavor scores compared to other groups ($p<0.05$). As addition of TSP reached to the level of 20%, the perception of meat flavor intensity decreased ($p<0.05$).

The odor acceptance of the four meatball samples was not different among groups. In the study, results indicated that meatballs contained 5 and 10% TSP were highly desired for the overall acceptability by panelists ($p<0.05$) and there was no statistical differences among these groups. The overall acceptability scores of control were lower than that of groups written above but still significantly higher than that of meatball samples contained 20% TSP ($p<0.05$). There are several studies in agreement with our results. It was reported that addition of TSP at various levels in baked patties gradually decreased the sensory quality and 20% TSP caused a significant decrease in overall acceptability (Gujral *et al*., 2002). Another study reported that up to 10% TSP can be used in meat product manufacture without affecting consumer acceptability (Rao *et al*., 1984).

pH, color, protein and fat: pH values of meatballs are shown in Table 4. In this study, the average pH value of raw meat was 5.75 ± 0.35. It was determined that pH increased with addition of TSP into meat batter ($p<0.05$). Hovewer, pH differences among meatball groups containing various levels of TSP were statistically not significant. An increase in pH due to TSP addition into meat product formulation was reported previously (Rao *et al*., 1984). As expected, there was a strong correlation between raw meat pH and cooking loss. In general, pH of raw meat was significantly and positively correlated with moisture retention in the product.

These results agree with the findings of Das *et al.* (2008). Cooking also increased pH in all treatment groups ($p<0.05$). Although, cooked meatball samples with TSP had a higher pH than control group ($p<0.05$), the differences among cooked meatballs containing different amounts of TSP were not statistically important. The instrumental color measurement results of raw and cooked meatballs are shown in Table 5. There were non-significant differences among raw meatball groups for color axcept meatballs with 20% TSP which was lower in L^* value compared to other groups.

After cooking, L^* a^* b^* color values decreased in all meatball groups. The results indicated that addition of TSP in meatball formulation decreased L^* and increased a^* values in cooked meatballs compared to control ($p<0.05$). The higher a^* might be the result of higher pH values in cooked meatballs compared to control

Table 6: TBARS values of cooked meatballs during storage at 4°C. Expressed as mmol TBARS per kg tissue

Storage time at 4°C (days)	C	TSP5	TSP10	TSP20
0	1.39±0.20	1.4±0.160	1.39±0.24	1.38±0.25
1	1.95±0.08[a]	1.64±0.11[b]	1.54±0.09[b]	1.56±0.10[b]
3	3.15±0.20[a]	2.27±0.15[b]	2.12±0.30[b]	2.11±0.19[b]
7	5.93±0.11[a]	3.7±0.210[b]	3.02±0.62[b]	2.9±0.120[b]
15	10.56±1.25[a]	6.14±0.11[b]	4.5±0.980[c]	3.19±0.48[d]

*Means with different letters in the same row are significantly different ($p<0.05$)

Table 7: The results of fatty acid composition of raw and cooked meatballs

	Raw				Cooked			
Fatty acids	C	TSP5	TSP10	TSP20	C	TSP5	TSP10	TSP20
C14:0	4.38±0.100	3.95±0.070	3.92±0.08	4.15±0.200	3.53±0.09	3.47±0.10	3.45±0.10	3.10±0.08
C16:0	32.89±0.500	31.45±0.600	32.80±0.50	31.69±0.700	32.07±0.40	28.75±0.60	30.10±0.50	28.77±0.40
C16:1	2.31±0.060	2.95±0.050	2.93±0.06	2.49±0.090	1.70±0.04	2.34±0.06	2.12±0.10	1.61±0.09
C17:0	1.35±0.050	1.40±0.040	1.48±0.05	1.63±0.060	1.41±0.03	1.44±0.05	1.32±0.07	1.33±0.03
C18:0	18.19±0.700	19.05±0.600	18.20±0.30	18.69±0.800	18.77±0.50	18.55±0.90	17.38±0.40	16.48±0.40
C18:1	37.99±0.400	36.35±0.600	35.40±0.60	35.69±0.700	35.67±0.60	34.34±1000	34.84±0.60	35.32±0.70
C18:2	1.85±0.200[a]	3.40±0.100[b]	3.84±0.09[b]	4.30±0.100[b]	5.79±0.30[a]	8.25±0.50[b]	9.16±0.40[b]	12.04±0.50[c]
C18:3	0.39±0.030	0.70±0.090	0.62±0.02	0.73±0.060	0.53±0.03	1.20±0.08	1.07±0.04	1.16±0.03
SFA	56.81±0.500	55.85±0.400	56.40±0.40	56.16±0.600	55.30±0.20	52.21±0.40	52.25±0.50	49.68±0.30
MUFA	40.30±0.200	39.30±0.400	38.33±0.30	38.18±0.400	37.37±0.30	36.68±0.60	36.96±0.40	36.93±0.40
PUFA	2.24±0.050[a]	4.10±0.100[b]	4.46±0.04[b]	5.03±0.070[b]	6.32±0.09[a]	9.45±0.20[b]	10.23±0.20[b]	13.20±0.20[c]
SFA/UFA	1.34±0.200	1.29±0.300	1.32±0.20	1.30±0.400	1.27±0.10	1.13±0.30	1.11±0.30	0.99±0.20
PUFA/SFA	0.04±0.010[a]	0.07±0.030[b]	0.08±0.03[b]	0.09±0.020[b]	0.11±0.05[a]	0.18±0.09[ab]	0.20±0.10[b]	0.27±0.10[b]

*Means with different letters in the same row are significantly different ($p<0.05$). SFA: Saturated Fatty Acids, MUFA: Monounsaturated Fatty Acids, PUFA: Polyunsaturated Fatty Acids

(Brewer *et al*., 2006). A non-significant differences were observed in the fat and protein contents of cooked meatball samples (Table 4).

Cooking loss: Protein sources such as soy proteins have been used in manufacture of meat products to enhance the products' functional characteristics like improving cooking yield and slicability. In the present study, the results indicated that 10 and 20% TSP addition in meatball formulation significantly reduced meatballs' cooking loss ($p<0.05$) (Table 4).

Increased water holding capacity and reduced cooking loss were reported previously with increasing TSP in meat patties (Kassama *et al*., 2003). The lower cooking loss in meatballs produced with 10 and 20% TSP 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 (Pena-Ramos and Xiong, 2003).

Lipid oxidation: Table 6 shows the effect of TSP incorparation on TBARS values of cooked meatballs stored at 4°C during 15 days of storage time. TBARS values of cooked meatballs ranged from 1.38-10.56 mmol TBARS per kg during 15 day of storage. In general, lipid oxidation in all cooked meatball samples increased during storage based on TBARS ($p<0.05$).

Hovever, TBARS values of cooked meatballs with TSP were significantly lower than that of control during storage ($p<0.05$). The ability of TSP to inhibit lipid oxidation was increased with increasing the amount of added TSP in meatball formulation ($p<0.05$). Pena-Ramos and Xiong (2003) reported that Soy Protein Isolate (SPI) hydrolysates were effective in inhibiting lipid oxidation in cooked pork patties.

This result was explained by the effects of the antioxidative phenolic compounds that were present in SPI. Ulu (2004) also reported that Whey Protein Consantrate (WPC) and SPI improved the textural properties of meatballs and suppressed lipid oxidation. The results of the study demonstrated that TSP addition was effective in reducing lipid oxidation in cooked meatballs during storage.

Fatty acid composition: Fatty acid composition of raw and cooked meatballs is shown in Table 7. In general, non-significant differences were observed for fatty acid composition among meatball groups. Addition of TSP increased the linoleic acid and polyunsaturated fatty acids to saturated fatty acids (PUFA/SFA) ratios ($p<0.05$).

In addition, sunflower oil used in this study might has contributed to increase in the level of linoleic acid because of its high linoleic acid content. Slight reduction in SFA to Unsaturated Fatty Acids (SFA/UFA) ratio due to incorporation of TSP and sunflower oil indicated an improvement in nutritional content of products (Tsanev *et al*., 1998). The ratio of PUFA/SFA in meatballs increased, as the level of TSP was increased in meatball formulation ($p<0.05$).

CONCLUSION

The results showed that TSP incorporation into meatball increased pH and UFA contents and decreased cooking loss. The addition of TSP changed color charecteristics of the cooked meatballs by decreasing L* and increasing a* values. Test panel results indicated that meatballs manufactured with TSP upto 10% were well accepted. In addition, lipid oxidation was retarded in cooked meatballs during storage by TSP. The results of this study concluded that up to 10% TSP addition into meatball formulation may be applied to improve the quality of meatballs without any adverse effects on the final product.

REFERENCES

AOAC, 1995. Official Methods of Analysis. 16th Edn., Association of Official Analytical Chemists, Washington, DC., USA.

Arihara, K., 2006. Strategies for designing novel functional meat products. Meat Sci., 74: 219-229.

Barbut, S., 2006. Effects of caseinate, whey and milk powders on the texture and microstructure of emulsified chicken meat batters. LWT Food Sci. Technol., 39: 660-664.

Brewer, M.S., J. Novakofski and K. Freise, 2006. Instrumental evaluation of pH effects on ability of pork chops to bloom. Meat Sci., 72: 596-602.

Chouliara, E., A. Karatapanis, I.N. Savvaidis and M.G. Kontominas, 2007. Combined effect of oregano essential oil and modified atmosphere packaging on shelf-life extension of fresh chicken breast meat, stored at 4°C. Food Microbiol., 24: 607-617.

Das, A.K., A.S.R. Anjaneyulu, Y.P. Gadekar, R.P. Singh and P. Hazarika, 2008. Effect of full-fat soy paste and textured soy granules on quality and shelf-life of goat meat nuggets in frozen storage. Meat Sci., 80: 607-614.

Dexter, D.R., J.N. Sofos and G.R. Schmidt, 1993. Quality characteristics of turkey bologna formulated with carrageenan, starch, milk and soy protein. J. Muscle. Foods, 4: 207-223.

Feiner, G., 2006. Additives: Proteins, Carbohydrates, fillers and Other. In: Meat Products Handbook: Practical Science and Technology, Feiner, G. (Ed.). CRC Press, Washington, DC, Boca Raton, Boston, New York, pp: 89-139.

Feng, J. and Y.L. Xiong, 2002. Interaction of myofibrillar and preheated soy proteins. J. Food Sci., 67: 2851-2856.

Feng, J., Y.L. Xiong and W.B. Mikel, 2003. Textural properties of pork frankfurters Containing thermally/enzymatically modified soy proteins. J. Food Sci., 68: 1221-1224.

Gujral, H.S., A. Kaur, N. Singh and S.N. Sodhi, 2002. Effect of liquid whole egg, fat and textured soy protein on the textural and cooking properties of raw and baked patties from goat meat. J. Food Eng., 53: 377-385.

Haga, S. and T. Ohashi, 1984. Heat-induced gelation of a mixture of myosin B and soybean protein. Agr. Biol. Chem., 48: 1001-1007.

Hasler, C.M., 1998. Functional foods: Their role in disease prevention and health promotion. Food Technol., 52: 63-70.

IFT. Sensory Evaluation Division, 1981. Sensory evaluation guide for the testing of food and beverage products. Food Technol., 35: 50-59.

Jimenez-Colmenero, F., 2007. Meat Based Functional Foods. In: Handbook of Food Products Manufacturing, Hui, Y.H. (Ed.). John Wiley and Son Inc., Hoboken, New Jersey, pp: 989-1015.

Kassama, L.S., M.O. Ngadi and G.S.V. Raghavan, 2003. Structural and instrumental textural properties of meat patties containing soy protein. Int. J. Food Prop., 6: 519-529.

Kilic, B. and M.P. Richards, 2003. Lipid oxidation in poultry doner kebab: Pro-oxidative and anti-oxidative factors. J. Food Sci., 68: 886-889.

Lawless, H.T. and H. Heymann, 1999. Sensory Evaluation of Food: Principles and Practices. 1st Edn., Aspen Publishers, New York, ISBN-10: 083421752X.

Lemon, D.W., 1975. An Improved TBA Test for Rancidity. Halifax Laboratory, Canada Canada.

Lin, K.W. and M.Y. Mei, 2000. Influences of gums, soy protein isolate and heating temperatures on reduced-fat meat batters in a model system. J. Food Sci., 65: 48-52.

Luo, M.R., 2006. Applying colour science in colour design. Opt. Laser Technol., 38: 392-398.

Matulis, R.J., F.K. McKeith, J.W. Sutherland and M.S. Brewer, 1995. Sensory characteristics of frankfurters as affected by salt, f at, soy protein and carrageenan. J. Food Sci., 60: 48-54.

Messina, M.J. and C.E. Wood, 2008. Soy isoflavones, estrogen therapy and breast cancer risk: Analysis and commentary. Nutr. J., 7: 17-17.

Nagano, T., Y. Fukuda and T. Akasaka, 1996. Dynamic viscoelastic study on the gelation properties of b-conglycinin-rich and glycinin-rich soybean protein isolates. J. Agr. Food Chem., 44: 3484-3488.

Pena-Ramos, E.A. and Y.L. Xiong, 2003. Whey and soy protein hydrolysates inhibit lipid oxidation in cooked pork patties. Meat Sci., 64: 259-263.

Pennington, A.T., 2002. Food composition databases for bioactive food components. J. Food Compost Anal., 15: 419-434.

Ramirez-Suarez, J.C. and Y.L. Xiong, 2003. Effect of transglutaminase-induced cross-linking on gelation of myofibrillar/soy protein mixtures. Meat Sci., 65: 899-907.

Rao, L.O., F.A. Draughon and C.C. Melton, 1984. Sensory characters of thuringer sausage extended with textured soy protein. J. Food Sci., 49: 334-336.

SAS, 1998. SAS User's Guide: Statistics. 8th Edn., SAS Institute Inc., Cary, NC.

Salwin, H., I.K. Bloch and J.H. Jr. Mitchell, 1955. Rapid determination of fat in meat products. J. Agr. Food Chem., 3: 588-593.

Sofos, J.N. and C.E. Allen, 1977. Effects of lean meat source and levels of fat and soy protein on the properties of wiener-type products. J. Food Sci., 42: 875-878.

Tsanev, R., A. Russeva, T. Rizov and I. Dontcheva, 1998. Content of trans-fatty acids in edible margarines. J. Am. Oil Chem. Soc., 75: 143-145.

Ulu, H., 2004. Effect of wheat flour, whey protein concentrate and soya protein isolate on oxidative processes and textural properties of cooked meatballs. Food Chem., 87: 523-529.

Wiegand, C. and G. Waloszek, 2009. Color glossary A-C. Version 1.0, 03/18/2003. http://www. sapdesignguild. org/resources/glossary_color/index1.html#norm_cs.