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ARTICLE

Changes in Quality Characteristics of Fresh Pork Patties Added with Tomato Powder during Storage

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Abstract

This study was carried out to determine the effects of olive oil prepared tomato powder (OPTP) used as lycopene source on fresh pork patties. OPTP was not added (0%; C), or was added at 0.25% (T1), 0.5% (T2), 0.75% (T3) and 1.0% (T4) in a basic pork patty formula and patties were stored for 7 days at 5°C. pH values of T3 and T4 were lower (p<0.05) than those of control until storage day 3. However, pH values of treated samples were dramatically increased (p<0.05) after 7 d of storage. Cooking loss values of treatments were lower (p<0.05) than those of control at day 1 of storage. Thiobarbituric acid reacting substances values were lower (p<0.05) in all treatments than in untreated samples during storage. All treated samples had lower values (p<0.05) for lightness (L*) but significantly higher values (p<0.05) for redness (a*) and yellowness (b*) than the untreated samples during storage. Total plate counts of T4 were lower (p<0.05) than others during storage. In sensory evaluation, the scores of color, aroma and overall acceptability in T3 and T4 scored higher (p<0.05) than those of control at days 1 and 3 of storage, however, statistical significance was not found (p>0.05) among the samples after 7 days of storage. In conclusion, tomato powder-treated groups were significantly higher in redness (a*) and yellowness (b*), and lipid oxidation was inhibited, as compared with control during storage. Therefore, as a natural additive, tomato powder could be used to extend the self-life of meat products, providing the consumer with food containing natural additives, which might be seen more healthful than those of synthetic origin.

Key words: tomato powder, lycopene, non-cooked pork patty, meat quality

Introduction

In these days consumers have demanded meat products that are safe, nutritious, convenient, rich in variety, attractive (in appearance, texture, odor, and taste) and innovative. The consumer preference for naturally derived colorants is associated with their image of being healthy and of good quality. In addition, some synthetic colorants are considered to be responsible for allergenic and intolerance reactions (Østerlie and Lerfall, 2005). This stimulates interest in manufacturing meat products by using new technologies and formulations, using different types of meat and reducing levels of sodium or potassium nitrite, phosphate, salt and fat, all of which lead to beneficial effects on health (Arun *et al*., 2010; Lin and Lin, 2002).

Tomatoes are an integral part of the human diet worldwide. Although they are frequently consumed fresh, over 80% of tomato consumption comes from processed products such as tomato juice, paste, pure, ketchup and sauce (Gould, 1992). Recent studies have indicated the potential health benefits of a diet rich in tomatoes and tomato products (Tapiero *et al*., 2004). Tomato and tomato products are the major sources of lycopene and are considered to be important contributors of carotenoids in human diet (Goula and Adamopoulos, 2005; Tapiero *et al*., 2004). Tomato and tomato products are rich in lycopene and other carotenoids such as β-carotene, phytoene, phytofluene and lutein (Choski and Joshi, 2007; Kavanaugh *et al*., 2007). The ability of lycopene to act as a potent antioxidant is thought to be responsible for protecting cells against oxidative damage and thereby decreasing the risk of chronic diseases (Kavanaugh *et al*., 2007; Omoni and Aluko, 2005). Adding tomato, tomato products or lycopene to meat could lead to products with health benefits. However, few studies have been reported regarding the use of tomato products or lycopene in meat and meat products (Candogan, 2002; Deda *et al*., 2007; Østerlie

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and Lerfall, 2005; Sánchez-Escalante *et al*., 2003; Yilmaz *et al*., 2002). The present study addresses the utilization of different level of tomato powder as antioxidant treatments in fresh pork patties. Our objective was to evaluate the effectiveness of different levels of tomato powder for inhibiting lipid oxidation and color stability as well as microbial growth in fresh pork patties packaged with oxygen-permeable bag during refrigerated storage at 5°C for 7 d.

Materials and Methods

Preparation of dried tomato powder

Fresh tomato harvested in August 2007 was obtained from an agricultural products wholesale market in Jinju, Korea. After washing and dicing, hot-air drying method was used. Tomato paste (5 kg) was mixed with olive oil (140 mL), and dried at 80°C for 2 h and 60°C for 72 h using a hot-air drying oven (DMC-122SP, Daeil Eng. Co., Korea) to 3-5% moisture content. The dried tomato was then pulverized using a blender (3030, Hsign Feng Enterprise Factory, Taiwan) and sieved through a No. 40 stainless sieve (40 mesh). The resulting tomato powder prepared with olive oil (TPPO) were then sealed and kept at -40°C. The powder prepared by this way had color values in lightness (CIE L*) 46.24, redness (CIE a*) 8.26 and yellowness (CIE b*) 6.26.

Meat patty manufacture

Fresh pork loin and backfat were obtained from a local meat market. Fresh pork meats were trimmed of separable fat to provide very lean meats. The lean meat and the pork backfat were separately ground through a 10 mm plate and then through a 5 mm plate. Ground meat was thoroughly mixed with salt, seasoning, ice and ground back fat using a mixer (5K5SS, KitchenAid®, USA). Used seasonings and additives were obtained from MSC Co., Ltd. (Seongnam, Korea). Pork meat patties were formulated according to the experimental design with a base formula containing ground pork, ground fat, salt, pepper, ice as well as four levels of TPPO [0% (C), 0.25% (T1), 0.25% (T2), 0.5% (T3) and 0.75% (T4)] (Table 1). The selected adding concentrations of TPPO were decided mainly by preliminary experiments of sensory evaluation. All treatments, about 5 kg each, were replicated three times from separate meat sources at three different time periods. Pork meat patties were hand linked at 2 cm thickness, and weighed approximate 50 g. The fresh pork patties were packed with a thin polyethylene film of high oxygen permeability (equal to aerobic package) and were stored in the dark room at 5°C (±1°C) until subsequent analysis.

Table 1. Formula of fresh pork patties added with different levels (%) of TPPO[1)]

Ingredients	Treatments				
	C	T1	T2	T3	T4
Pork loin	80.0	80.0	80.0	80.0	80.0
Pork Fat	10.0	10.0	10.0	10.0	10.0
NaCl	1.2	1.2	1.2	1.2	1.2
B-pepper	0.3	0.3	0.3	0.3	0.3
Ice/wate	8.5	8.5	8.5	8.5	8.5
TPPO	0.00	0.25	0.50	0.75	1.00

[1)]TPPO: tomato powder prepared with olive oil.

pH value

The pH values were measured by blending 10 g of samples with 90 mL distilled water for 30 s (T25B, IKA, Malaysia). Readings were taken with a pH meter (8603, Metrohm, Switzerland).

Cooking loss

The packages were heated in a water bath at 75°C for 1 h and then cooled at room temperature for 30 min. The cooking-loss percentage was determined by the sample weight differences between before and after cooking.

TBARS

The 2-thiobarbituric acid reactive substances (TBARS) test according to Tarladgis *et al.* (1960) was used to determine the extent of oxidative rancidity. A 5 g sample was homogenized in a 50 mL centrifuge tube with a 50 uL of BHA (7.2% in ethanol) and 15 mL of distilled water by using a homogenizer (T-25B, IKA, Malaysia). Two mL of the homogenate was mixed with 4 mL of a thiobarbituric acid (TBA/trichloroacetic acid (TCA) solution (20 mM TBA in 15% TCA), heated at 90°C in water bath. After heating the samples were cooled in ice and centrifuged for 15 min at 2,000 rpm by using a centrifuge (UNION 5KR, Hanil Science Industrial, Korea). The absorbance of the supernant was measured at 532 nm by using a spectrophotometer (Spectronic Genesys 5, Thermo Fisher Scentific, USA). The concentration (mg MA (malonaldehyde))/kg sample on the basis of wet weight) was calculated using a standard curve.

Volatile basic nitrogen (VBN) values

A micro-diffusion method described by Pearson (1968)

was modified for the determination of VBN. One 10 g homogenized sample was mixed with 90 mL distilled water and blended for 30 seconds at low speed (T-25Basic, IKA, Malaysia). The prepared mixture was filtered (Whatman No. 2 filter paper). One milliliter of filtrate was pipetted to the Conway dish containing 1 mL saturated K_2CO_3 solution and allowed for reaction at 37°C for 120 min. Boric acid solution containing indicator (methyl red and bromocresol green) was used to absorb volatile nitrogen. The solution was titrated with 0.01 N HCl and VBN value was expressed as mg VBN/100 g of the sample.

Color measurement

Color was measured instrumentally using a spectrocolorimeter (CR 400, Minolta Co., Japan) (λ: 400-700 nm, Δλ: 10 nm, D65, 10°) calibrated with a white plate and light trap supplied by the manufacturer. Color was expressed using the CIE $L^*a^*b^*$ color system (CIE, 1976). The instrument was standardized each time with a white ceramic plate (L_0 = 89.2, a_0 = 0.921, and b_0 = 0.783). The three fundamental color coordinates are CIE L^*, a^* and b^*. The CIE L^* measures the lightness and is a measure of the light reflected (100 = white; 0 = black); CIE a^* measures positive red, negative green and CIE b^* measures positive yellow, negative blue (CIE, 1976).

Total plate count (TPC)

Two duplicate 25 g samples were taken aseptically from each treatment, transferred to sterile plastic pouches and homogenized for 2 min at room temperature with 225 mL sterile 0.88% (w/v) ringer solution using a stomacher Lab-Blender (78860 ST-Nom, Interscience, France). Appropriate dilutions of samples were prepared in 0.88% Ringer solution blank and plated in duplicates onto plate count agar (PCA, Difco Lab, USA) for total bacteria and incubated at 32°C for 48 h under anaerobic conditions.

Sensory evaluation

The samples were served to 12 experienced panel members. Panelists were presented with randomly coded samples. The color, aroma (1 = extremely undesirable, 9 = extremely desirable), juiciness (1 = extremely dry, 9 = extremely juicy) and overall acceptability (1 = extremely undesirable, 9 = extremely desirable) of the samples were evaluated using 9-point descriptive scale. Panelists were required to cleanse their palate between samples with water.

Statistical analysis

An analysis of variance were performed on all the variables measured using the general linear model (GLM) procedure of the SAS statistical package (SAS Institute, 1999). The Duncan's multiple range test (p<0.05) was used to determine differences between treatment means.

Results and Discussion

pH value

Table 2 shows the results for pH values of fresh pork patties added with TPPO during storage. The addition with 0.5%, 0.75% and 1.0% TPPO had lower (p<0.05) pH values in fresh pork patties than the control on day 1 and 3 of storage. A decrease in the pH value of meat products containing tomato paste have been reported by Candogan (2002), Hoe *et al.* (2006) and Deda *et al.* (2007). Similar results have been reported by Yilmaz *et al.* (2002) for Turkish sausages produced with tomato juice. This is due to the low pH value of tomato powder (pH 3.48). After 7 days of storage, the pH values of T1, T2, T3 and T4 samples dramatically increased by 0.07, 0.06, 0.15 and 0.20 unit of initial pH values, respectively. The increments of pH in treated samples were significant at p<0.05 and was somewhat more intensive than that the control under the same conditions. In agreement with findings by other authors, pH values higher than 5.8 favored microbial growth (Drosinos and Board, 1995;

Table 2. Changes in pH and cooking loss value of fresh pork patties added with TPPO during storage at 5°C

	Treatments[1)]	Storage days			
		1	3	7	SEM[2)]
pH	C	5.52^{a}	5.53^{a}	5.54^{e}	0.01
	T1	5.52^{Ba}	5.50^{Ba}	5.59^{Ac}	0.01
	T2	5.50^{Bb}	5.49^{Bb}	5.56^{Ad}	0.01
	T3	5.48^{Bc}	5.48^{Bb}	5.63^{Ab}	0.03
	T4	5.46^{Bd}	5.46^{Bb}	5.66^{Aa}	0.03
	SEM[2)]	0.01	0.01	0.01	
Cooking loss	C	9.55^{Ca}	11.67^{B}	13.66^{A}	0.66
	T1	9.33^{Cab}	11.30^{B}	14.07^{A}	0.84
	T2	9.12^{Cab}	11.78^{B}	13.34^{A}	0.62
	T3	9.17^{Cab}	11.36^{B}	14.21^{A}	0.69
	T4	8.36^{Bb}	13.32^{AB}	14.34^{A}	1.10
	SEM[2)]	0.16	0.47	0.16	

[1)]Treatments are the same as described in Table 1.

[2)]Pooled standard errors of the mean.

[a-e]Means with different superscripts in the same column significant differences at p<0.05.

[A-C]Means with different superscripts in the same row significant different at p<0.05.

Kennedy *et al*., 2005; Vergara and Gallego, 2001), however, our results showed that higher pH values of T3 and T4 samples (5.63 and 5.66, respectively) resulted in lower total plate counts (5.68 and 5.77 log CFU/g) compared to the control (TPC 6.98 log CFU/g) of non-cooked pork meat patties on day 7 of storage (Table 2).

Cooking loss

Table 2 shows the results for cooking loss values of fresh pork patties added with TPPO during storage. The high addition of TPPO group (T4) significantly decreased (p<0.05) the cooking loss on day 1 of storage. Among the treatments, cooking loss of T4 had the lowest values on day 1 of storage. However, on day 3 and 7 of storage, no differences (p>0.05) in cooking loss were found among the samples. Storage time increased (p<0.05) the cooking loss in all treatments. Razminowicz *et al.* (2006) determined cooking loss to estimate water-holding capacity (WHC) of meat. WHC is a factor that determines the juiciness of meat and is defined as the ability of meat to retain its water during application of external forces, such as cutting, heating, grinding or pressing (Zhang *et al*., 2005). According to our results, these low levels of adding tomato powder in fresh pork patties may not affect cooking loss.

Table 3. Changes in TBARS and VBN value and total plate counts (TPC) (log CFU/g) of fresh pork patties added with TPPO during storage at 5°C

	Treatments[1)]	Storage days			
		1	3	7	SEM[2)]
TBARS (mg MA/kg)	C	0.44^{Ba}	0.50^{Ba}	0.74^{Aa}	0.04
	T1	0.32^{Cb}	0.37^{Bb}	0.58^{Ab}	0.05
	T2	0.29^{Bbc}	0.31^{Bbc}	0.50^{Ac}	0.03
	T3	0.26^{Bc}	0.26^{Bc}	0.43^{Acd}	0.28
	T4	0.25^{Bc}	0.25^{Bc}	0.42^{Ad}	0.03
	SEM[2)]	0.02	0.03	0.03	
VBN (mg/100 g)	C	3.40	4.39	4.54	0.27
	T1	4.08	4.39	4.94	0.36
	T2	4.04	4.55	5.33	0.37
	T3	3.55	4.11	4.78	0.34
	T4	4.23	4.97	5.49	0.32
	SEM[2)]	0.28	0.20	0.28	
TPC (log CFU/g)	C	4.05^{Ca}	5.89^{Ba}	6.98^{Aa}	0.43
	T1	4.13^{Ba}	5.75^{Aab}	6.65^{Aa}	0.29
	T2	4.14^{Ca}	5.79^{Aab}	5.98^{Bb}	0.25
	T3	4.12^{Ca}	5.52^{Bb}	5.68^{Ac}	0.36
	T4	3.11^{Cb}	4.87^{Bc}	5.77^{Ac}	0.65
	SEM[2)]	0.21	0.10	0.15	

[1)]Treatments are the same as described in Table 1.
[2)]Pooled standard errors of the mean.
[a-d]Means with different superscripts in the same column significant differences at p<0.05.
[A,B]Means with different superscripts in the same row significant differences at p<0.05.

Lipid oxidation

Table 3 shows the results for TBARS values of fresh pork patties added with TPPO during storage. In fresh pork patties containing TPPO significantly lower of TBARS values compared to control were observed. The higher concentration of TPPO in pork patties, the lower (p<0.05) TBARS values were shown. Candogan (2002) who found that in beef patties, produced without the use of sodium nitrite, the treatments added with 5%, 10% and 15% tomato paste had lower (p<0.05) TBA values than the control, due to the antioxidative activity of lycopene present in tomato paste. TBA value of all fresh pork patties increased during storage (p<0.05).

In general, the effect of a certain lipid oxidation might vary considerably depending on a complex interaction between various factors, involving the type and concentration of active compound(s) and the nature of the food system (Madsen and Bertelsen, 1995; Schwarz *et al*., 2001). The addition of NaCl at 0.5-2.5% was claimed to be prooxidative and therefore to promote lipid oxidation (Rhee and Ziprin, 2001). Dzudie *et al.* (2004) reported that the TBA values of pork fat were higher than those of beef fat in beef patties during storage. In this study, increased TBARS values were significantly decreased with adding TPPO at the initial time of storage. At day 7 of storage, TBARS value of C, T1, T2, T3 and T4 was 0.74, 0.58, 0.50, 0.43 and 0.42 mg malonaldehyde/kg, respectively. The TBARS values of TPPO treated samples were significantly lower than the control (p<0.05). However, even after 7 days of storage, the TBARS values in TPPO treated samples remained lower than 0.60 mg malonaldehyde/kg and lower than the minimum detectable level in raw ground meat for oxidized flavor by an inexperienced panel (Greene and Cumuze, 1982). The TBARS values in cooked beef between 0.5-1.0 were perceived by trained panelist, which are determined to be the threshold values being characterized as an oxidized flavor (Tarladgis *et al.,* 1960). The TBARS values between 0.6-2.0 were perceived by inexperienced panelists (Greene and Cummuze, 1982).

VBN values

VBN is related to protein breakdown (Ahn *et al*., 2000; Egan *et al*., 1981), which is associated with the amino acid decarboxylase activity of microorganisms during

storage and generally could be used as a quality indicator for fish products (Lin *et al*., 1995; Ohasi *et al*., 1991). Changes in VBN value during storage are shown in Table 3. The VBN values of tested samples slightly increased, but not significantly increased as expected when storage time increased in fresh pork patties. Results from our studies were not confirmed with the several researchers (Lin *et al*., 1995 Ohasi *et al*., 1991), who reported that higher VBN values for meat products were associated with the higher microbial counts among treatments. These disagreed results of fresh pork patties may be due to the incomplete degradation of protein comparing to the cooked samples (Collins and Charles, 1987; Wang, 2000), who suggested that samples that had more antioxidant materials added had significantly lower VBN values (p<0.05). All the samples in this study did not exceed 20 mg/100 g, which is the value that often described as the level of meat spoilage (Su and Lin, 1988).

Total plate count

TPC of T4 sample was significantly lower than other samples, however, no significant differences among C, T1, T2, and T3 samples were found on day 1 of storage (Table 3). And on day 3 and 7, the TPCs of treated samples added with TPPO were lower than those of control sample. The TPCs of samples increased steadily during storage, reaching 6.98 log CFU/g in control samples after 7 days. And the TPC of treated fresh pork patties pork added with TPPO decreased 0.33, 1.00, 1.30 and 1.21 logs in T1, T2, T3 and T4 samples, respectively, after 7 days compared to control (p<0.05). This confirms the results found by researchers studying the antimicrobial effects of tomato (Yilmaz *et al*., 2002). These low bacterial counts of treated groups added with TPPO seemed to have antimicrobial materials just like lycopene in tomato powder.

Surface color

Table 4 shows the results for surface color values of fresh pork patties added with TPPO during storage. Meat color is the most important factor affecting consumer acceptance, purchasing decisions and satisfaction of meat products. The changes observed in color parameters (Table 4) were mainly related to the concentration of TPPO. Fresh pork patties added with TPPO had lower values (p<0.05) for lightness (CIE L^*) but higher (p<0.05) for redness (CIE a^*) and yellowness (CIE b^*) than the patties without tomato powder during storage. The lightness values of all tested samples were not changed, however, redness and yellowness of all samples were significantly decreased over the storage (p<0.05). All treated samples added with tomato powder had lower (p<0.05) lightness than the control. These products had improved red color. According to Candogan (2002), this color improving effect of tomato paste can be attributed to the pigment, lycopene, which is present in tomato paste, due to its red color and antioxidant effect. Similar results have been reported by Calvo *et al.* (2008). Furthermore, Østerlie and Lerfall (2005) indicated that mixing minced meat with a lycopene-containing product could reduce or replace the use of nitrite.

Table 4. Changes in meat color of fresh pork patties added with TPPO during storage at 5°C

	Treatments[1)]	Storage days			
		1	3	7	SEM[2)]
L^*	C	65.00^{a}	64.92^{a}	65.56^{a}	0.52
	T1	64.66^{ab}	63.91^{a}	65.01^{a}	0.39
	T2	64.87^{ab}	63.11^{b}	63.80^{ab}	0.41
	T3	62.90^{ab}	62.59^{b}	63.11^{ab}	0.40
	T4	62.20^{b}	62.68^{b}	62.07^{b}	0.58
	SEM[2)]	0.43	0.37	0.36	
a^*	C	12.76^{Ac}	10.80^{Bc}	7.50^{Cd}	0.77
	T1	13.21^{Ac}	10.92^{Bc}	8.89^{Cc}	0.63
	T2	14.64^{Ab}	10.99^{Bc}	10.92^{Bb}	0.63
	T3	14.89^{Ab}	12.65^{Bb}	10.47^{Cb}	0.65
	T4	15.74^{Aa}	14.15^{Ba}	12.19^{Ca}	0.52
	SEM[2)]	0.31	0.37	0.44	
b^*	C	9.69^{Ae}	8.52^{Be}	7.94^{Be}	0.28
	T1	12.95^{Ad}	11.77^{Bd}	12.02^{Bd}	0.22
	T2	15.83^{Ac}	14.35^{Bc}	14.17^{Bc}	0.28
	T3	18.15^{Ab}	16.50^{Bb}	16.86^{Bb}	0.37
	T4	19.99^{Aa}	18.99^{Ba}	18.65^{Ba}	0.25
	SEM[2)]	0.99	0	1.01	

[1)]Treatments are the same as described in Table 1. [2)]Pooled standard errors of the mean.
[a-d]Means with different superscripts in the same column significant differences at p<0.05.
[A-C]Means with different superscripts in the same row significant differences at p<0.05.

Change of sensory evaluation

Table 5 shows the results for sensory scores of fresh pork patties added with TPPO during storage. On day 1 and 3 of storage, the pork patties of T3 and T4 added with TPPO scored higher in color-like scores than the control, but statistical significance was not found (p>0.05) in color-like scores after 7 days of storage. These high color-like scores are maybe caused by significantly higher redness and yellowness in treated patties compared to con-

Table 5. Changes in sensory scores[1)] of non-cooked pork meat patties added with TPPO during storage at 5°C

Items	Treatments[2)]	Storage days			
		1	3	7	SEM[3)]
Color	C	6.33^{Ab}	6.00^{Ab}	5.33^{B}	0.14
	T1	6.33^{Ab}	6.25^{Ab}	5.17^{B}	0.16
	T2	6.83^{Aa}	6.25^{Bb}	5.17^{C}	0.18
	T3	7.17^{Aa}	6.75^{Aa}	5.67^{B}	0.19
	T4	7.17^{Aa}	6.75^{Aa}	5.50^{B}	0.22
	SEM[3)]	0.10	0.07	0.12	
Aroma	C	6.33^{Ab}	6.00^{Ab}	4.67^{B}	0.21
	T1	6.33^{Ab}	6.00^{Ab}	4.75^{B}	0.21
	T2	6.50^{Ab}	6.00^{Ab}	4.92^{B}	0.23
	T3	7.17^{Aa}	6.50^{Aa}	4.67^{B}	0.28
	T4	7.17^{Aa}	6.50^{Aa}	4.83^{B}	0.29
	SEM[3)]	0.1	0.07	0.16	
Juiciness	C	6.83^{Aa}	6.00^{B}	6.17^{B}	0.10
	T1	6.83^{Aa}	6.00^{B}	6.17^{B}	0.10
	T2	7.00^{Aa}	6.00^{C}	6.25^{B}	0.11
	T3	6.50^{Ab}	6.00^{A}	6.67^{B}	0.10
	T4	6.50^{Ab}	6.00^{B}	6.67^{A}	0.11
	SEM[3)]	0.06	0.00	0.08	
Overall acceptability	C	6.50^{Ab}	6.00^{Ab}	5.00^{B}	0.18
	T1	6.83^{Aab}	6.25^{Bb}	5.00^{C}	0.20
	T2	6.83^{Aab}	6.25^{Bb}	5.00^{C}	0.20
	T3	7.17^{Aa}	7.00^{Aa}	5.42^{B}	0.22
	T4	7.00^{Aa}	7.25^{Aa}	5.33^{B}	0.24
	SEM[3)]	0.07	0.10	0.12	

[1)]Sensory scores were assessed on 9 point scale where 1 = extremely bad, 9 = extremely good.
[2)]Treatments are the same as described in Table 1.
[3)]Pooled standard errors of the mean.
[a,b]Means with different superscripts in the same column significant differences at $p<0.05$.
[A-C]Means with different superscripts in the same row significant differences at $p<0.05$.

trol (Table 4). The meat patties of T3 and T4 added with TPPO scored higher in aroma-like scores than the control at day 1 and 3 of storage, but statistical significance was not found ($p>0.05$) in aroma scores after 7 days of storage. These high aroma-like scores in high level of tomato powder suggested that TPPO addition is an effective antioxidant in cooked meat patties (Table 3) and could be acted for the attributes against warmed over flavor in pork meat patties. These results disagreed with those of Hoe *et al.* (2006) who found that the 0.5% tomato powder did not change the sensory characteristics of emulsion sausages. On day 1 of storage, juiciness scores of T3 and T4 samples were lower than those of control, however, no significant differences were observed among the tested samples on day 3 and 7 of storage. These findings disagreed with those of Desmond *et al.* (1998) who found that the oat fiber aided in water retention, produced juicy low-fat beef patties. At day 1 and 3 of storage, the pork meat patties of T3 and T4 in overall acceptability marked higher scores compared to other samples, but statistical significance was not found after 7 days of storage ($p>0.05$). Storage time decrease the sensory scores of color, aroma, flavor, juiciness and overall acceptance in all samples.

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