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ORIGINAL ARTICLE

Quality of low-fat pork sausages with tomato powder as colour and functional additive during refrigerated storage

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Abstract Low fat pork sausages were formulated with tomato powder at 0% (C), 0.8% (T1), 1.2% (T2) and 1.5% (T3) levels in basic formula. With the increase in tomato powder concentration the lightness of the sausage decreased but the redness and yellowness increased significantly ($p<0.05$). The pH values of T2 and T3 were significantly ($p<0.05$) lower than the others, whereas, water holding capacity of T2 and T3 was significantly ($p<0.05$) higher. Thiobarbituric acid reactive substances, cohesiveness and springiness values of treated groups were significantly ($p<0.05$) lower than those of control samples, however, hardness values of sausages with tomato powder were significantly ($p<0.05$) higher. The scores of overall acceptability in tested groups were significantly ($p<0.05$) higher than those of control samples after 30 days of storage. The low fat pork sausage with tomato powder up to 1.5% was found to be well acceptable up to 30 days at refrigerated storage. This new product will have special value due to the functional additive lycopene in tomato powder.

Keywords Pork sausages · Tomato powder · Refrigerated storage · Colour · Quality

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Introduction

Demand for nutritious, convenient and healthy meat products with functional value is increasing. The colour of meat product is one of the important attributes for product preference. Nitrite is one of the commonly used additives in meat product mainly for imparting attractive colour and as antibacterial. However, the modern consumers are increasingly aware about the toxic effect of nitrite in meat procucts. Therefore, there is increasing demand for alternative to nitrite preferably of natural origin. The naturally derived colorants are more preferred by consumers because of their healthy quality. In addition, some synthetic colorants are considered to be responsible for allergenic and intolerant reactions (Østerlie and Lerfall 2005). These factors stimulated interest in manufacturing sausages by using new technologies and formulations using different types of meat and reduced levels of nitrite, phosphate, salt and fat, all of which are beneficial to health (Desmond and Kenny 2005).

Tomatoes are an integral part of the human diet worldwide. Although they are frequently consumed fresh, over 80% of tomatoes are consumed as 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 (Tapiero et al. 2004; Goula and Adamopoulos 2005). They 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 (Omoni and Aluko 2005; Kavanaugh et al. 2007).

Adding tomato and tomato products or lycopene to meat could lead to products with health benefits. A few studies have been reported regarding the use of tomato products or lycopene in meat and meat products (Candogan 2002; Yilmaz et al. 2002; Sánchez-Escalante et al. 2003; Østerlie and Lerfall 2005; Deda et al. 2007). The present study was done for incorporation of different level of lycopene-rich tomato powder as antioxidant and functional additive in pork sausages. Our objective was to evaluate the effectiveness of different levels tomato powder in inhibiting lipid oxidation, microbial growth and color stability as well as to enhance the sensory characteristics of low-fat and low-salt sausages during refrigerated storage.

Materials and methods

Preparation of tomato powder Fresh tomatoes were procured from local Agricultural Products Wholesale Market, Jinju, Korea. After washing and dicing tomato paste was prepared. Tomato paste (5 kg) was mixed with olive oil (140 ml) and dried at 80°C for 2 h followed by 60°C for 72 h using a hot-air drying oven (DMC-122SP; Daeil Engr. Co., Korea) to the moisture level of 3–5%. The dried tomato was then pulverized using a blender (3030, Hsign Feng Enterprise, Taiwan) and sieved through 40 mesh stainless steel sieve. The resulting tomato powder prepared in olive oil was then sealed and kept at -40°C. The colour values of tomato powder was: lightness (L*) 46.2, redness (a*) 8.3, yellowness (b*) 6.3

Sausage manufacture Commercial fresh pork loin was obtained from a local meat market and trimmed of separable fat to get lean meats. The lean meat was ground first through a 10 mm plate and then through a 5 mm plate in a meat grinder (PM-98, MANCA Industries INC, Spain). A fat replacer was prepared by mixing soy protein isolate (SPI EX-33, Dupon Protein Technologies International, St. Louis, USA), carrageenan (MSC Co., Ltd., Seongnam, Korea), malto dextrin (MD-1520; Corn Products Korea Inc., Seoul, Korea) and water in the ratio of 1: 0.5: 0.5:10, respectively. The proportion of the components in fat replacer was standardized through several trials for optimum quality (data not shown). The hydrated mixture of fat replacer was added in meat emulsion to compensate the reduced fat content. Other seasonings and additives were obtained from MSC Co., Ltd. (Seongnam, Korea). Sausages were manufactured according to a standardized procedure and formula containing lean pork (72%), fat replacer (15%), olive oil (1%), SPN (NaCl : $NaNO_2$=99:1) (1.3%), phosphate (0.2%), sugar (0.5%), MSG (0.05%), spice (0.5%) and ice (9.45%) and tomato powder at 0% (C), 0.8% (T1), 1.2% (T2), and 1.5% (T3) levels. Sausages were hand linked at 15 cm intervals, weighed, heat processed in a single truck smokehouse (AC-7FM-SMK, YUSUNG Industries INC, Korea) according to the following processing cycle: drying for 20 min at 45°C and 50% (RH), reddening for 20 min at 52°C and 20% RH and steam cooking to an internal temperature of 72°C. The sausages were then showered for 15 min, removed from the smokehouse and chilled at 2°C for 2 h. After chilling the samples were aerobically packed and stored at 4°C until subsequent analysis. All treatments, about 5 kg each, were replicated three times from separate meat sources at three different time periods.

Moisture, protein, fat and ash contents (AOAC 1995) of each sausage samples were determined. pH measurements were determined by blending 10 g of samples with 90 ml distilled water for 30 s (T25B, IKA Sdn. Bhd., Malaysia) then readings were taken with pH meter (8603, Metrohm, Swiss).

Determination of water holding capacity (WHC) Five samples per batch were analyzed. Approx 10 g per sample were weighed into a glass jar. The jars were heated in a water bath for 30 min at 70°C. After heating, each sample was carefully removed from the jar using forceps and wrapped in cheesecloth and placed into a 30 ml centrifuge tube (Model 3118-0030, Nalgene Brand Products, NY, USA) each containing cotton wool in the bottom. The samples were centrifuged (UNION 5KR; Hanil Science Industrial, Co., Ltd., Incheon, Korea) for 10 min at 1,000 rpm at 4°C. Then samples were taken out of the centrifuge, the cheesecloth removed and the samples reweighed. The percent WHC was calculated using following formula (Jin et al. 2008).

$$\text{WHC\%} = \frac{\text{wt of sample before heating} - \text{wt of sample after heating and centrifugal} \times 100}{\text{Total water content in sample}}$$

Color measurement Color was measured instrumentally using a spectrocolorimeter (CR 400, Minolta Co., Japan) 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) together with hue angle (H) and chroma (C). The hue and the chroma were also calculated using the equalizations H=tan (b*/a*) and C= $[(a^*)^2+(b^*)^2]^{1/2}$, respectively. A total of six spectral readings were taken for each sample using different instrument orientations.

Lipid oxidation determination The 2-thiobarbituric acid reactive substances (TBARS) test according to Tarladgis et al. (1960) were used to determine the extent of oxidative rancidity. A 5 g sample was homogenized in a 50 ml centrifuge tube with a 50 µl of BHA (7.2% in ethanol) and 15 ml of distilled water by using a homogenizer (IKA model T-25 Basic, Malaysia). Two ml of the homogenate were mixed with 4 ml of a thiobarbituric acid (TBA) in trichloroacetic acid (TCA) solution (20 mM TBA in 15% TCA), heated at 90° for 15 min 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, Co., Ltd., Incheon, Korea). The absorbance of the supernant was measured at 532 nm by using a spectrophotometer (Spectronic model Genesys-5, U.S.A.). The concentration of malonaldehyde (mg/kg) on the basis of wet weight was calculated using a standard curve.

Microbiological analysis 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 1% (w/v) ringer solution using a stomacher Lab-Blender (78860 ST-Nom, Interscience, France). Appropriate dilutions of samples were prepared in 1% Ringer solution and plated in duplicates onto plate count agar (Difco Lab) and incubated at 35° for 48 h under aerobic conditions for taking total bacterial count.

Texture profile analysis (TPA) Texture profile analysis (TPA) was performed as described by Bourne (1978), Szczceniak (1963) and Texture Technologies (2003). Texture profile analysis of eight samples (2×2×2 cm) cut from each treatment was determined using an Instron Texture Analyser (3343 US/MX50, A&D Co., USA) equipped with a standard cylindrical plate of diameter 0.25 cm. After peeling off the casing, the sausages were equilibrated to room temperature and compressed twice to 50% of their original thickness at a constant speed of 60 mm/min. Texture profile parameters were calculated from the force–deformation curves, as follows: hardness (kg f: force necessary to attain a given deformation, maximum force); cohesiveness (dimensionl: ratio of the positive force area during the second compression to that during the first compression excluding the areas under the decompression portion of each cycle); gumminess (kg f: simulated energy required to disintegrate a semisolid food to a steady state, hardness×cohesiveness); springiness (ratio of distances that the samples recover after the first compression) and chewiness (kg f: hardness × cohesiveness×springiness).

Sensory evaluation The samples were served to 12 experienced panel members. Panelists were presented with randomly coded samples. The colour, aroma and flavour (1 = extremely undesirable, 9 = extremely desirable), juiciness (1 = extremely dry, 9 = extremely juicy), tenderness (1 = extremely tough, 9 = extremely tender), 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 with water between samples.

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

Results and discussion

Proximate analysis Moisture, protein and fat content of freshly prepared sausages ranged between 73.7–76.4%; 18.6–20.6%; 23.5–23.9% and 1.71–1.88%, respectively (Table 1). Therefore, the sausages manufactured in the present study had slightly lower fat and similar moisture contents compared to the commercially available common pork sausages in Korea. There were no significant differences among samples in moisture and fat contents. However, protein contents of T2 and T3 were significantly higher ($p<0.05$) than the control and T1 samples. This higher protein contents might be due to the added tomato powder in the sausages. The dry tomato powder has crude protein content of 10.3% with a crude fibre content of 41.0% (Chung et al. 1987), which might also improve the fibre content in sausages.

pH The pH of the fresh sausages reduced significantly ($p>0.05$) with the higher (T2 and T3) level of tomato powder ranging from 5.8-5.7 (Table 2). However, during storage the pH of the sausages reduced on 15th day and then

Table 1 Proximate composition (%) of low fat pork sausage with tomato powder

Treatments	Moisture	Crude protein	Crude fat	Crude ash
C	76.4	18.7^{C}	1.17	2.51
T1	74.7	18.6^{C}	1.18	2.44
T2	73.6	19.6^{B}	1.18	2.45
T3	73.7	20.6^{A}	1.18	2.74
SEM	0.40	0.10	0.00	0.05

SEM: Standard error of mean (pooled) ($n=3$)

^{A,B} Means with different superscripts in the same column differ significantly ($p<0.05$)

Tomato powder: 0% (C), 0.8% (T1), 1.2% (T2), 1.5% (T3)

Table 2 Physico-chemical and microbiological changes in low fat pork sausages with tomato powder during refrigerated storage (4°C)

Treatments	Storage, period, day			
	1	15	30	SEM
pH				
C	5.8^{Ab}	5.8^{Ab}	6.0^{Aa}	0.03
T1	5.8^{Ab}	5.8^{Bc}	5.9^{Ba}	0.02
T2	5.7^{Bb}	5.7^{Cb}	5.7^{Da}	0.01
T3	5.7^{Bb}	5.7^{Cb}	5.8^{Ca}	0.01
SEM	0.02	0.02	0.03	
Water holding capacity %				
C	72.6^{Ba}	62.9^{Bb}	71.9^{Ca}	1.77
T1	76.4^{Aa}	69.1^{Ab}	72.3^{Bb}	2.73
T2	77.1^{Aa}	70.4^{Ab}	74.3^{Ab}	1.77
T3	75.9^{Aa}	65.4^{Bb}	75.0^{ABa}	3.34
SEM	0.78	2.71	6.67	
Thiobarbituric and reactive substances, mg MA/kg				
C	1.4^{Ab}	1.5^{Ab}	1.8^{Aa}	0.06
T1	1.2^{Bb}	1.2^{Bb}	1.6^{Ba}	0.07
T2	1.1^{Cb}	0.96^{Cc}	1.7^{Ba}	0.08
T3	1.3^{Bb}	1.3^{Bc}	1.3^{Ca}	0.09
SEM	0.04	0.05	0.07	
Total plate counts, log cfu/g				
C	2.09^{c}	5.96^{Ab}	6.37^{Aa}	0.68
T1	1.46^{c}	5.93^{Aa}	5.40^{Cb}	0.71
T2	1.93^{c}	5.81^{Ba}	4.77^{Db}	0.58
T3	2.20^{c}	5.06^{Cb}	5.71^{Ba}	0.63
SEM	0.08	0.11	0.19	

SEM: Standard error of mean (pooled) (n=3)

^{a,b,c} Means with different superscripts in the same row differ significantly (p<0.05)

^{A,B,C,D} Means with different superscripts in the same column differ significantly (p<0.05)

Treatments: See Table 1

increased significantly (p<0.05) on 30th day of storage. A decrease in the pH value of meat products containing tomato paste have also been reported by Candogan (2002) and Deda et al. (2007). The decrease in pH of fresh sausages with higher level of tomato powder could be due to the low pH value (3.5) of tomato powder. The decrease in pH on 15th day might be due to the growth of lactic bacteria, however, the significant increase on 30th day is a normal pattern of deterioration in meat products during storage due to increasing load of spoilage bacteria (Jay 1996).

Water holding capacity WHC was significantly (p<0.05) higher in fresh sausages with tomato powder compared to the control, however, there was no significant difference in WHC between the levels of tomato powder added (Table 2). During storage the WHC reduced significantly at 15th day and then increased significantly (p<0.05) on 30th day. The reason for decrease in WHC on 15th day might be due to the decrease in pH at this time, however, the increase on 30th day might be due to increase in pH and protein breakdown by incipient deterioration of meat product. Hermansson (1986) stated that WHC referred to the ability of a given structure to prevent water from being released from it, thus, a lower amount of released water reflected a greater WHC.

Lipid oxidation TBARS values in sausages with tomato powder reduced significantly (p<0.05) particularly at higher level compared to controls (Table 2). After 15 days of storage, significant decrease (p<0.05) of TBARS values were observed in T2 and T3, but no significant changes (p> 0.05) were shown in C and T1 samples. When the mean values were compared within the tomato powder added samples, it was observed that the TBARS values decreased significantly (p<0.05) as the tomato powder level increased. Similar results have been reported by Candogan (2002). He observed that beef patties, prepared with tomato paste had lower (p<0.05) TBARS values than the control, due to the antioxidative activity of lycopene present in tomato paste. Tomato and tomato products are rich in lycopene and other carotenoids (Tapiero et al. 2004; Goula and Adamopoulos 2005). Lycopene, a major carotenoid is considered responsible for their beneficial effects (Clinton 1998). 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 (Rao and Agarwal 1998) hence becoming useful as a functional additive.

Microbiological quality The total microbial load in the fresh sausages was 1.5–2.2 log cfu/g (Table 2). However, the total plate counts of T2 and T3 samples were significantly (p<0.05) lower than those of control after 15 days of storage. Similarly microbial load of T1, T2 and T3 were significantly lower (p<0.05) than that of control sausages after 30 days of storage. This observation is in agreement with the findings reported earlier (Drosinos and Board 1995; Vergara and Gallego 2001; Kennedy et al. 2005). Our results suggest that lower pH values of T1, T2 and T3 (5.8, 5.7 and 5.7, respectively) reduced total plate counts (5.4, 4.8 and 5.7 log cfu/g) compared to the control (pH 5.8, TPC 6.4 log cfu/g) sausages at day 30 of storage (Table 2). This confirms the results reported by many researchers studying the antimicrobial effects of tomato (Yilmaz et al. 2002; Østerlie and Lerfall 2005; Calvo et al. 2007). These low bacterial counts of tomato powder added groups seemed to be due to lower pH and antimicrobial activity of tomato powder, which can replace the use of nitrate in meat products.

Color changes Sausages with 1.2 and 1.5% tomato powder had significantly ($p<0.05$) lower values for lightness but values for redness, yellowness, chroma and hue were significantly ($p<0.05$) higher than sausages without tomato powder during storage (Table 3). The changes observed in colour parameters were mainly related to the added concentration of tomato powder. Sausages with high quantities (1.5%) of tomato powder were found to be unstable during storage although, no significant differences were observed in control, T1 and T2 during storage. These products have improved red colour and are more attractive to consumers than the control sausages. According to Candogan (2002) this colour improving effect of tomato paste can be attributed to red colour and antioxidant effect of lycopene present in tomato. Similar results have been reported by Calvo et al. (2008). All tomato powder added sausages had a hue angle index between 46.76 and 56.32 indicating an orange colour ($p<0.05$). Further, Østerlie and Lerfall (2005) indicated that mixing minced meat with lycopene-containing product could reduce or replace the use of nitrite.

Table 3 Change of color in low fat pork sausage with tomato powder during refrigerated storage (4°C)

Treatments	Storage, period, days			
	1	15	30	SEM
L* (lightness)				
C	75.3^{A}	75.3^{A}	75.1^{A}	0.10
T1	71.3^{B}	70.9^{B}	70.6^{B}	0.15
T2	68.6^{C}	68.2^{D}	67.7^{C}	0.20
T3	68.7^{Cb}	69.7^{Ca}	68.1^{Cc}	0.23
SEM	0.82	0.81	0.90	
a* (redness)				
C	11.2^{Ca}	11.0^{Da}	10.5^{Cb}	0.10
T1	11.3^{C}	11.4^{C}	11.4^{B}	0.03
T2	12.5^{Aa}	12.3^{Aa}	11.8^{Ab}	0.11
T3	11.9^{B}	12.0^{B}	11.9^{A}	0.04
SEM	0.16	0.16	0.17	
b* (yellowness)				
C	4.2^{C}	4.1^{D}	4.4^{C}	0.06
T1	11.7^{Bb}	12.2^{Cb}	13.0^{Ba}	0.22
T2	17.3^{A}	17.3^{A}	16.8^{A}	0.31
T3	17.5^{Aa}	15.5^{Bb}	17.8^{Aa}	0.42
SEM	1.63	1.52	1.71	
Chroma				
C	11.9^{Ca}	11.6^{Dab}	11.4^{Db}	0.08
T1	16.7^{B}	17.0^{C}	18.0^{C}	0.30
T2	21.2^{A}	21.5^{A}	22.2^{A}	0.19
T3	21.1^{Aa}	19.5^{Bb}	21.0^{Ba}	0.32
SEM	1.18	1.12	1.27	
Hue angle				
C	20.5^{Cb}	19.5^{Db}	20.8^{Ca}	0.80
T1	46.8^{Bb}	47.0^{Cb}	51.0^{Ba}	0.80
T2	54.0^{Ab}	55.8^{Aab}	58.0^{Aa}	0.70
T3	56.3^{A}	52.8^{B}	55.8^{A}	0.77
SEM	4.31	4.33	4.08	

SEM: Standard error of mean (pooled) (n=3)

^{a,b,c} Means with different superscripts in the same row differ significantly ($p<0.05$). ^{A,B,C,D} Means with different superscripts in the same column differ significantly ($p<0.05$)

C-T_3 : See Table 1

Texture profile analysis Significant ($p<0.05$) differences were found in hardness, cohesiveness and springiness values within the tested samples during storage (Table 4). In all cases hardness values increased when tomato powder was added. Similar results have been reported by Calvo et al. (2007). The increase of hardness could be explained by the presence of fiber in tomato peel. It has been reported by Knoblich et al. (2005) that this by-product has an acid detergent fibre content close to 30 g/100 g of dry matter. This is composed mainly of cellulose and lignin, which could modify the textural properties yielding a harder sausage. Similar results have been obtained by García et al. (2002, 2007) by adding cereals and fruit fibre to dry and cooked sausages. García et al. (2007) reported a marked increase in hardness when wheat or oat fibres were added to fermented sausages as consequence of their insoluble dietary fibre content. However, in the case of cohesiveness values, the fibre could cause a difference in the opposite direction since the components of this type of fibre have a complex structure, even crystalline making it easier to break into small pieces in the mouth favoring mastication. Springiness has reduced significantly ($p<0.05$) in tomato powder added sausages when fresh and on day 15 of storage, however, on day 30 there was no differences between control and treated groups. Similarly addition of tomato powder did not make any significant differences in gumminess and chewiness. From the texture profile analysis we observed that addition of tomato powder did not cause any negative effect in the texture properties of sausages and it partially improved the hardness.

Sensory quality There were no significant differences for color, aroma, flavour, tenderness and juiciness values during the entire storage period, but the flavour scores were higher in tomato powder added sausages at every stages of storage (Table 5). The scores for colour, aroma, tenderness and juiciness were mostly comparable to the control or sometimes even better. In general the score of overall acceptability

Table 4 Changes in texture profile in low fat pork sausages with tomato powder during refrigerated storage (4°C)

Treatments	Storage, period, days			
	1	15	30	SEM
Hardness, kg f				
C	0.42^{B}	0.42^{C}	0.41^{B}	0.01
T1	0.49^{A}	0.49^{B}	0.47^{A}	0.01
T2	0.48^{Ab}	0.53^{Aa}	0.46^{Ab}	0.01
T3	0.51^{Aa}	0.52^{Aa}	0.47^{Ab}	0.01
SEM	0.01	0.01	0.01	
Cohesiveness, ratio				
C	0.66^{A}	0.64^{A}	0.60^{AB}	0.02
T1	0.58^{Bb}	0.55^{Bb}	0.67^{Aa}	0.02
T2	0.57^{B}	0.55^{B}	0.56^{B}	0.01
T3	0.59^{Ba}	0.62^{Aa}	0.55^{Bb}	0.01
SEM	0.01	0.01	0.02	
Springiness, ratio				
C	1.08^{Aa}	1.05^{Aa}	1.01^{b}	0.01
T1	1.01^{B}	1.00^{B}	1.05	0.02
T2	1.04^{AB}	1.00^{B}	1.00	0.01
T3	1.01^{B}	1.00^{B}	1.00	0.00
SEM	0.01	0.01	0.01	
Gumminess, kg f				
C	0.28	0.26	0.25	0.01
T1	0.29	0.27	0.31	0.01
T2	0.26	0.29	0.29	0.01
T3	0.29^{a}	0.30^{a}	0.26^{c}	0.01
SEM	0.01	0.01	0.01	
Chewiness, kg f				
C	0.30	0.27	0.25	0.01
T1	0.30	0.27	0.27	0.01
T2	0.27	0.29	0.26	0.01
T3	0.30^{a}	0.30^{a}	0.26^{b}	0.01
SEM	0.01	0.01	0.01	

SEM: Standard error of mean (pooled) (n=3)

^{a,b,c} Means with different superscripts in the same row differ significantly (p<0.05)

^{A,B} Means with different superscripts in the same column differ significantly (p<0.05)

C-T_3: See Table 1

in tomato powder added sausages were higher and in T1 it was significantly higher (p<0.05) than others on day 30 of storage. Our results on sensory scores reveal that addition of tomato powder up to 1.5% did not have any negative effect on the acceptability of the sausages rather it has partially improved the flavour of the product. These results agreed with those of Hoe et al. (2006) who found that 0.5% tomato powder addition did not change the sensory characteristics of emulsion type sausages.

Table 5 Changes in sensory scores of low fat pork sausages with tomato powder during refrigerated storage (4°C)

Treatments	Storage, period, day			
	1	15	30	SEM
Colour				
C	6.8	6.0	6.5	0.25
T1	7.2	6.2	7.2	0.25
T2	6.4	6.0	6.2	0.22
T3	6.2	6.0	6.2	0.21
SEM	0.20	0.13	0.25	
Aroma				
C	6.6	6.1	5.7	0.22
T1	6.0	6.5	6.5	0.20
T2	6.0	6.5	6.3	0.20
T3	5.8	6.5	6.7	0.20
SEM	0.19	0.12	0.18	
Flavour				
C	6.3	5.6	5.8	0.24
T1	6.8	6.5	6.5	0.21
T2	6.5	6.0	6.3	0.27
T3	6.8	6.0	6.3	0.28
SEM	0.20	0.22	0.20	
Tenderness				
C	6.3	6.4	6.7	0.19
T1	6.3	6.2	6.5	0.17
T2	6.1	5.7	4.8	0.36
T3	6.2	5.5	6.2	0.22
SEM	0.16	0.19	0.38	
Juiciness				
C	6.3	6.1	6.3	0.19
T1	6.7	6.0	6.5	0.26
T2	6.3	6.1	6.7	0.23
T3	6.2	5.6	6.7	0.24
SEM	0.20	0.17	0.16	
Overall acceptability				
C	6.6	6.4	6.0^{B}	0.15
T1	7.3	6.6	7.2^{A}	0.20
T2	6.6	6.6	6.3^{AB}	0.22
T3	6.6	6.6	6.3^{AB}	0.22
SEM	0.18	0.14	0.17	

SEM: Standard error of mean (pooled) (n=12 panelists)

Sensory scores were assessed on 9 point Hedonic scale where 1 = extremely undesirable, and 9 = extremely desirable

^{a,b,c} Means with different superscripts in the same row differ significantly (p<0.05)

^{A,B,C} Means with different superscripts in the same column differ significantly (p<0.05)

C-T_3: See Table 1

Conclusions

The low-fat pork sausage with added tomato powder developed showed lower ($p<0.05$) lipid oxidation, lightness, pH, hardness values and higher redness, yellowness, chroma, hue angle and water holding capacity values compared to control during refrigerated storage. This new meat product with added tomato powder could also be a source of lycopene which acts as a functional additive in human diet.

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