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Effect of tomato powder on quality of Chinese sausage

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Abstract Tomato powder is a major source of lycopene, a red coloured pigment with an antioxidant property. It is used for a natural coloring agent in reduced nitrite Chinese sausage. Nevertheless, the levels of tomato powder (0-1.4% w/w) affected the product quality in terms of colour, a_w, pH, texture and sensory attributes. Sensory results showed that appearance, taste, texture and overall liking scores of Chinese sausage with 0.2% tomato powder and control treatment were not significantly different ($p>0.05$). However, residual nitrite of the Chinese sausage with 0.2% tomato powder was less than the control. Product shelf-life was affected by packaging systems (vacuum and non-vacuum packaging) and storage temperatures [ambient (30-32 ℃) and chilling (4 ℃) temperature]. The best storage condition of the Chinese sausage with 0.2% tomato powder was performed by vacuum packaging and storage at 4 ℃ that could preserve the Chinese sausage for 12 days.

Keywords: Natural colouring agent, Tomato powder, Chinese sausage

Introduction

Tomato (*Lycopersicon esculentum*) is a great source of vitamin A, B, C, E, iron and potassium. It is also high fiber but low fat and calories. Ripen tomatoes become red or orange, which are the major source of antioxidant lycopene and provide many health benefits. Lycopene in tomato can reduce uterus cancer and lung cancer. It helps to reduce prostate cancer and digestive tract cancer, too. Addition tomato products could provide meat products with health benefits (Østerlie and Lerfall, 2005).

Application of tomato and tomato products in meat products in order to reduce nitrite which caused a potential health risk for cancer, improve product colour and enhance antioxidant activity were reported. Deda *et al*. (2007) reported that addition of 12% tomato paste could reduce added nitrite in frankfurters from 150 mg/kg to 100 mg/kg without any negative effect on the product quality. The treatments with 50 and 100 mg/kg sodium nitrite in a

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combination with 12% tomato paste had lower pH values and residual nitrites, but higher thiobarbituric acid values, lightness, redness and yellowness than those of control (with only 150 mg/kg sodium nitrite). Calvo *et al*. (2008) found that dry fermented sausages enriched with lycopene could be produced by addition of tomato peel. After 21 days storage, lycopene content of dry fermented sausages enriched with lycopene from tomato peel decreased, but redness, yellowness, hardness and adhesiveness of the sausages significantly increased ($p > 0.05$) as dry tomato peel concentration increased from 0 to 1.2 % w/w. Eyiler and Oztan (2011) stated that tomato powder retarded oxidation reaction and improved consumer acceptance of frankfurters. The TBA value of sample with 2g/100g tomato powder slightly decreased, but it was not significantly different from the control treatment ($p>0.05$). Wei-dong *et al.* (2013) revealed that tomato powder could be a potential solution for nitrite substitute in red sausage (Chinese-style sausage). The sample with 2% tomato powder and 100 mg/kg nitrite received the highest score of overall acceptability and had lower residual nitrite and TBARS value than control (with only 150 mg/kg nitrite).

Therefore, the research finding was aimed to investigate the effect of tomato powder on the quality of Chinese sausage in order to reduce nitrite in traditional formulation and created a higher quality product to meet consumer demand. The shelf life of the Chinese sausage with tomato powder at different storage conditions were evaluated.

Materials and Methods

Preparation of tomato powder

Fresh Tomatoes powder were procured from local market, Phatumthani, Thailand. The tomatoes were washed, blended, filtered and dried at 75 ℃ for 15 hours. Then, dried tomato was ground with a mill (0.075 mm particle size). This tomato powder had moisture content of 12.50%, water activity (a_w) of 0.349, pH of 4.48, lycopene content of 1.18 mg/100g, and the following color values: lightness (L*) of 54.42, redness (a*) of 23.79 and yellowness (b*) of 31.64.

Preparation of Chinese sausage

Chinese sausage was prepared with a traditional formulation of 55.4% lean pork, 27.7% pork backfat, 15.5% sugar, 1.2% sodium nitrite, 0.08% sodium erythrobate and 0.06% Chinese five spices powder. Lean pork and backfat was ground, mixed with other ingredients, stuffed in collagen casing and dried at 60 ℃ for 15 hours.

Five treatments of Chinese sausage were produced with four levels of tomato powder (0.2, 0.6, 1.0 and 1.4% w/w) in a combination with 0.6% sodium nitrite and control treatment with only 1.22% sodium nitrite without tomato powder.

Measurement of colour, a_w and pH

Colour (L*, a*, b*), a_w and pH values were measured according to the method described by Liu *et al.* (2010) using colorimeter (HunterLab, CX2687, USA), water activity meter (Aqualab, CX2, USA) and pH meter (Sartorius, PB-20, Germany), repectively.

Texture analysis

Texture was evaluated according to the method of Calvo *et al.* (2008). Texture parameters including hardness, springiness and cohesiveness were determined using texture analyzer (Stable Micro System, TA-XT2i, UK).

Sensory evaluation

Samples were evaluated by 30 untrained panels. Sensory attributes in term of appearance, texture, taste and overall liking were conducted using a 9 point hedonic scale test (9 = extremely like, 1 = extremely dislike).

Determination of proximate composition and residual nitrite

Proximate composition of Chinese sausage including moisture, lipid, protein, fiber and ash contents were analyzed by using the method of AOAC (1995). Residual nitrite was determined according to the method of Liu *et al.* (2010).

Evaluation of the shelf life of Chinese sausages

Chinese sausages with 0.2% tomato powder were packed in nylon plastic bag using different packaging systems (vacuum and non-vacuum) and stored at ambient temperature (30-32 ^{o}C) and chilling temperature (4 ^{o}C) for 4 weeks. Total bacteria count, total yeast and mold count, water activity (a_w) and pH value of the sausages were analyzed every 3 days except Thiobarbituric acid

(TBA) value was analyzed every 7 days. Microbial qualities and TBA values were determined according to the method described by Liu *et al.* (2010).

Statistical analysis

A completely randomized design (CRD) was considered in experiments. An analysis of variance (ANOVA) was conducted to determine the significance of the main factors. Significant differences ($p<0.05$) among the means were compared using Duncan's new multiple range test.

Results

Effect of tomato powder on quality of Chinese sausages

The redness and yellowness of sausage increased with the increased concentrations of tomato powder while the lightness decreased (Table 1). The Chinese sausage with 0.2% w/w of tomato powder was significantly higher in redness than control treatment, but yellowness and lightness of both samples were not significantly different ($p>0.05$). Water activity (a_w) and pH values of the sausage with tomato powder decreased when tomato powder levels increased (Table 2).

Springiness and cohesiveness of all treatments were significantly different ($p<0.05$), but there was no significant difference in hardness (Table 3). The hardness and cohesiveness of the Chinese sausage with 0.2% tomato powder and the control were not significantly different ($p>0.05$).

Sensory scores of Chinese sausage in all attributes decreased with the increased concentration of tomato powder (Table 4). The Chinese sausage with 0.2% of tomato powder received higher sensory scores than those of other treatments, but the scores in all attributes were not significantly different from the control ($p>0.05$). Therefore, it was concluded that levels of tomato powder affected consumer acceptance.

According to the results of product quality and sensory evaluation, the Chinese sausage with 0.2% tomato powder and the control were selected for chemical analysis. The results of proximate composition are presented in Table 5. Residual nitrite of the Chinese sausage with 0.2% tomato powder was less than that of the control formulation.

Table 1. Colour values of Chinese sausage with different levels of tomato powder

Tomato powder (% w/w)	Mean ± Standard Error		
	L*	a*	b*
0 (Control)	24.44^{a} ± 0.49	4.68^{c} ± 0.19	4.07^{c} ± 0.17
0.2	24.34^{a} ± 0.27	5.83^{ab} ± 0.04	5.24^{b} ± 0.02
0.6	22.17^{b} ± 0.21	5.55^{b} ± 0.12	5.43^{b} ± 0.14
1.0	21.90^{b} ± 0.21	6.37^{a} ± 0.13	6.55^{a} ± 0.36
1.4	20.69^{c} ± 0.14	5.40^{b} ± 0.13	4.33^{c} ± 0.14

[a-c] Means within the same column with different superscripts are significantly different ($p<0.05$).

Table 2. Water activity (a_w) and pH values of Chinese sausage with different levels of tomato powder

Tomato powder (% w/w)	Mean ± Standard Error	
	a_w	pH
0 (Control)	0.84^{a} ± 0.01	6.49^{d} ± 0.03
0.2	0.79^{c} ± 0.01	6.42^{c} ± 0.01
0.6	0.81^{b} ± 0.01	6.25^{b} ± 0.03
1.0	0.79^{c} ± 0.01	S 6.21^{ab} ± 0.02
1.4	0.77^{d} ± 0.01	6.16^{a} ± 0.01

[a-d] Means within the same column with different superscripts are significantly different ($p<0.05$).

Table 3. Texture of Chinese sausage with different levels of tomato powder

Tomato powder (% w/w)	Mean ± Standard Error		
	Hardness[ns] (N)	Springiness (mm)	Cohesiveness
0 (Control)	178.13 ± 5.02	0.80^{c} ± 0.02	0.39^{a} ± 0.01
0.2	217.48 ± 8.38	0.97^{a} ± 0.01	0.39^{a} ± 0.01
0.6	185.07 ± 8.69	0.95^{a} ± 0.03	0.34^{b} ± 0.00
1.0	229.86 ± 15.31	f0.92^{ab} ± 0.03	0.39^{a} ± 0.02
1.4	187.50 ± 10.56	f0.84^{bc} ± 0.03	0.35^{b} ± 0.01

[a-c] Means within the same column with different superscripts are significantly different ($p<0.05$).

Table 4. Sensory evaluation of Chinese sausage with different levels of tomato powder

Tomato powder (% w/w)	Mean ± Standard Error				
	Appearance	Colour	Texture	Taste	Overall Liking
0 (Control)	6.98^{a} ± 1.24	7.38^{a} ±0.94	6.88^{a} ±1.29	7.08^{a} ±1.09	7.15^{a} ±1.02
0.2	6.65^{a} ± 1.10	6.73^{b} ±1.25	6.81^{a} ±1.20	6.87^{a} ±1.34	7.00^{a} ±1.10
0.6	6.18^{b} ± 1.36	6.07^{c} ±1.49	6.18^{b} ±1.35	5.78^{b} ±1.53	5.88^{b} ±1.41
1.0	6.01^{b} ± 1.23	5.70^{c} ±1.52	6.00^{bc} ±1.37	5.57^{b} ±1.49	5.73^{b} ±1.19
1.4	5.59^{b} ± 1.33	5.68^{c} ±1.53	5.57^{c} ±1.53	4.92^{c} ±1.62	4.97^{c} ±1.67

$^{a-c}$ Means within the same column with different superscripts are significantly different ($p<0.05$).

Table 5. Proximate composition and residual nitrite of Chinese sausage with tomato powder and control (without tomato powder)

Proximate composition	Chinese sausage	
	control	0.2% tomato powder
Protein (%)	28.88 ±1.23	28.35 ±0.48
Lipid (%)	23.95 ±0.09	23.72 ±1.53
Ash (%)	3.12 ± 0.02	3.17 ± 0.03
Fiber (%)	1.63 ± 0.23	1.86 ± 0.14
Carbohydrate (%)	18.88 ± 1.07	18.95 ± 1.61
Moisture (%)	23.53 ± 0.31	23.95 ± 0.23
Residual nitrite (mg/ml)	0.0269 ±0.00	0.0186 ±0.00

Evaluation of the shelf life of Chinese sausages

The total bacteria, yeast and mold counts of Chinese sausage with 0.2% tomato powder and the control treatment increased as the storage time increased (Figure 1-4). During storage at ambient temperature (30-32 ℃), the total bacteria counts of Chinese sausage with tomato powder packed in non-vacuum packaging were higher than those of the control. The Chinese sausage with tomato powder could be kept for 6 days while the control treatment could be kept for 9 days until the product was spoiled. However, it was found that both samples stored at 4 ℃ (chilled storage) in vacuum package were preserved over 15 days. The results obtained from determination of total yeast and mold showed a similar trend with the results of total bacteria counts. The Chinese sausage with tomato powder in non-vacuum package could be kept for 6 days whereas the control treatment could be kept for 9 days during storage at ambient temperature. However, both samples packed in vacuum package could be kept for 12 days at ambient temperature. During storage at 4 ℃, the sausage packed in vacuum and non-vacuum package could be preserved for 12 days. The TBA values of Chinese sausage stored at ambient and chilling (4 ℃) condition in vacuum and non-vacuum package increased when storage time increased (Figure 5-6).

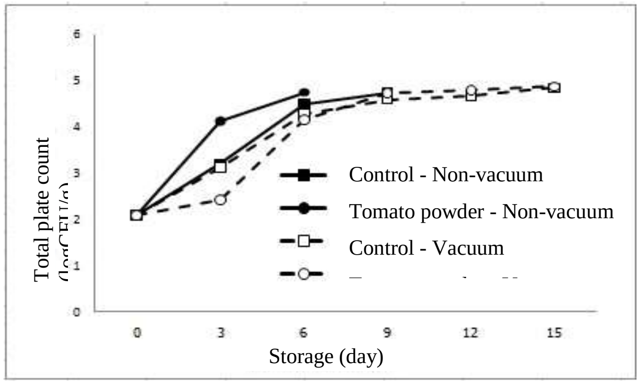

Figure 1. Total bacteria count of Chinese sausage during storage at ambient temperature

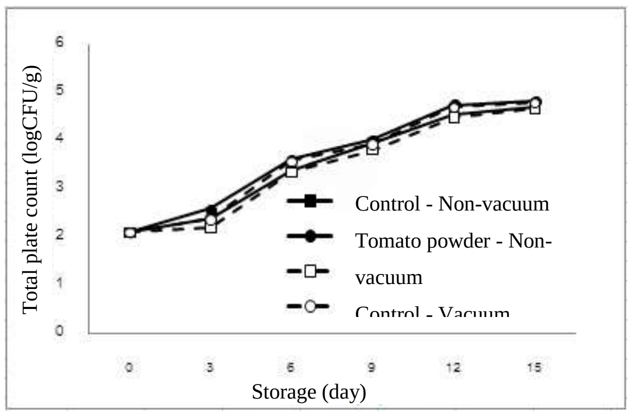

Figure 2. Total bacteria count in Chinese sausage during storage at 4 ℃

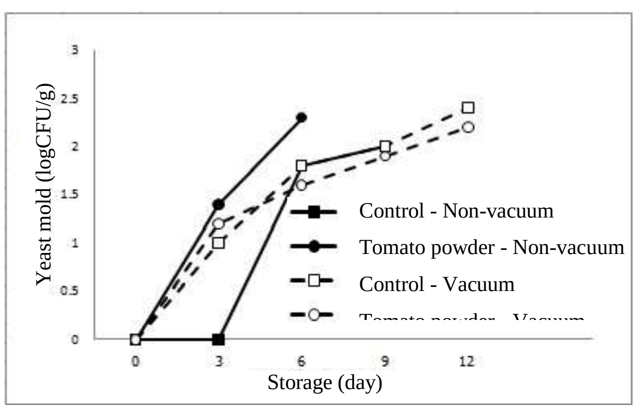

Figure 3. Total yeast and mold count in Chinese sausage during storage at ambient temperature

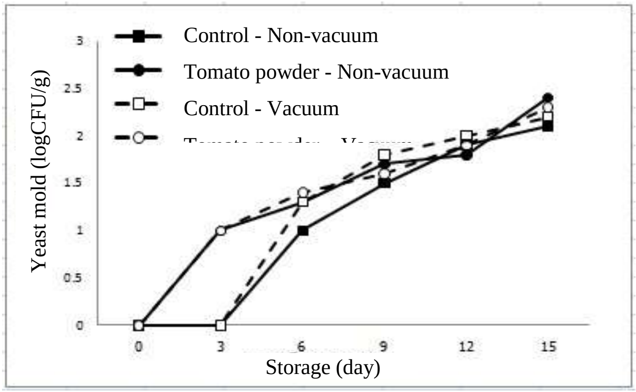

Figure 4. Total yeast and mold count in Chinese sausage during storage at 4 ℃

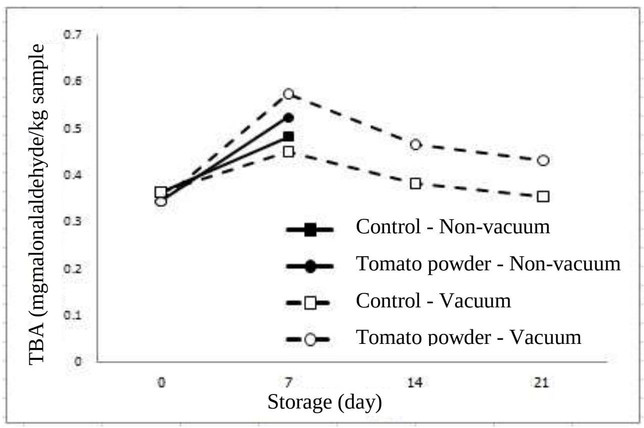

Figure 5. TBA Value of Chinese sausage during storage at ambient temperature

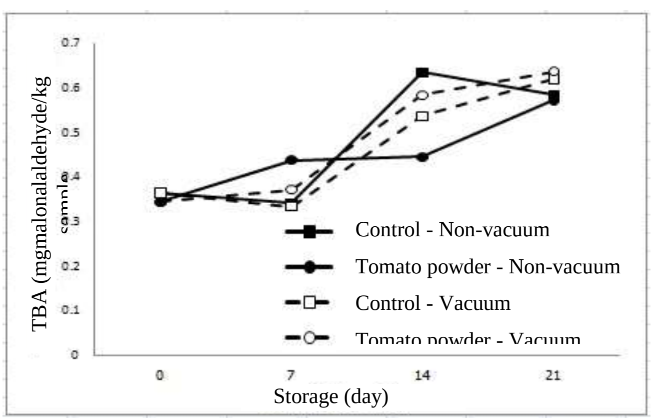

Figure 6. TBA Value of Chinese sausage during storage at 4 ℃

Discussion

The levels of tomato powder affected colour values of Chinese sausage. The lightness (L*) significantly decreased ($p< 0.05$) while the redness (a*) and yellowness (b*) had an increasing trend as the levels of tomato powder increased. Similar results were reported by Calvo *et al*. (2008) that L* values of dry fermented sausage decreased and a* and b* values increased as the levels of dry tomato peel increased from 0 to 1.2% w/w. It could be due to the tomato powder contained a natural colouring compound of carotenoids especially lycopene, a red-orange coloured pigment.

The pH and a_w values of the Chinese sausage decreased with the increased concentration of tomato powder. It could be due to the lower pH value (4.48) and a_w (0.039) of tomato powder. Similar result was reported by Deda *et al*. (2007) that frankfurters with 12% tomato paste had lower pH value than the control treatment.

When the concentration of tomato powder increased, springiness and cohesiveness of the Chinese sausage were slightly different. However, no significant difference ($p\geq0.05$) was observed in hardness, indicating tomato powder did not affect the hardness of the Chinese sausage. These results were agreed with the previous report of Calvo *et al*. (2008) that there were no significant difference ($p\geq0.05$) among springiness, cohesiveness and hardness of dry fermented sausage enriched with dry tomato peel.

Sensory scores of all attributes including appearance, colour, texture, taste and overall liking were significantly decreased ($p<0.05$) as the tomato powder level was increased. It could be explained by the colour and acidic characteristics of tomato powder which affected the product acceptability as revealed by Eyiler and Oztan (2011). However, no significant difference ($p\geq0.05$) was found between the control and the reduced nitrite Chinese sausage with 0.2% tomato powder. Therefore, Chinese sausage with 0.2% tomato powder was selected for chemical analysis and shelf-life study.

The nitrite residue of Chinese sausage with 0.2% tomato powder was reduced approximately by 30% as compared to the control treatment. The fiber content was also increased by approximately 14%. It might due to the lower content of added nitrite, which was in agreement with results of Wei-dong *et al*. (2013). This could be an alternative for consumers who concern about their health.

Total plate count and yeast and mold count increased as the storage time increased. The shelf life of the Chinese sausage with 0.2% tomato powder and the control could be extended from 6-9 days to 12 days by using vacuum package and chilled storage (4 ℃). The growth of bacteria, yeast and mold could be retarded under vacuum packaging and refrigerated condition, which prolonged the product shelf life. The TBA values increased with both ambient and refrigerated storage time, indicating lipid oxidation occurred during storage. This similar results for Chinese sausage made from PSE pork was reported by Kuo and Chu (2003).

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