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Supplementation of combined tomato powder and bacterial cellulose in chicken chinese sausage

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Abstract - Meat products with low synthetic antioxidants are getting attention for consumers. We expected to extend the findings to produce the product with low synthetic antioxidants. The objective of this study was to compare the effect of natural compounds (combination of bacterial cellulose, BC and tomato powder, TP) and synthetic antioxidants (buthylated hydroxytoluene, BHT) on the physico-chemical properties and sensory attributes of chicken Chinese sausage (CCS). The determination of DPPH scavenging activity, peroxide value (PV), color, pH, texture properties and sensory characteristics were studied. We found that DPPH radical scavenging activity, a*, b*, hardness, gumminess and chewiness were increased with increased levels of TP. In contrast, CCSs with increased level of TP showed the reduction in PV and sensory attributes. This study revealed a potential application of BC and TP as ingredient to produce the meat product with low synthetic antioxidants. Overall, our results indicated that incorporation of 2% (w/w) BC and 6% (w/w) TP in CCS was high effective DPPH scavenging activity and peroxide value.

Keywords: Chinese sausage, meat product, natural antioxidant, BHT, peroxide value

1. Introduction

Sausages are the processed meat products consumed worldwide in various cultures (Savadkoohi *et al.*, 2014). They can be made from pork, beef, fish, chicken, etc. with different kind seasonings. Chicken Chinese sausage (CCS) or in Thai called *Kunchiang kai* is a dry sausage types. According to Thai community product standard (2012), CCS is characterized as chicken meat and chicken skin coarsely ground and mixed with seasoning such as sugar, salt and other suitable ingredients before put into stuffing and then was dried using hot air or other suitable method. They are characterized as it must be firm, form-fitting, and have adequate softness. There must be a natural good color of the components used and consistent throughout the piece. It must be not abnormal color, such as pale, dark green, black, or burnt. There should be a good natural smell and taste of the ingredients used, free from other unpleasant odors and flavors such as musty, rancid, fishy smell, bitter and sour (Thai community product standard, 2012). However, CCS products usually spoil because of two major causes; microbial growth and chemical deterioration. Oxidative rancidity is the main chemical deterioration of fat containing product and that can vary significantly, ranging from extensive color losses, flavor changes and structural damage leading to unacceptable sensory and discourages repeat purchases by consumers (Sebranek *et al.*, 2005).

Antioxidant is used for preventing lipid oxidation and may be effective in controlling and reducing the oxidation in meat products (Lorenzo *et al.*, 2013). It has long been known that synthetic antioxidants such as buthylated hydroxyanisole (BHA), buthylated hydroxytoluene (BHT), tert-butylhydroquinone (TBHQ) may form a potential health hazard for consumers (Lorenzo *et al.*, 2013). Moreover, the use of some synthetic antioxidants at high levels may concern carcinogenic and /or toxicological implications (Mercadante *et al.*, 2010). The consumer's interest in natural antioxidants with biological activity has increased significantly. Many publications have reported the antioxidant potential of natural ingredients such as apple (Yu *et al.*, 2015), rosemary (Sebranek *et al.*, 2005), grape seed and chestnut (Lorenzo *et al.*, 2013), and natural pigment (norbixin, lycopene, zeaxanthin and beta-carotene) (Mercadante *et al.*, 2010) in meat products. Based on literature reports, food companies are trying to replace synthetic additives with natural compounds, thus improving an image of their products (Mercadante *et al.*, 2010).

Tomato (*Lycopersicon esculentum* Mill.) is food plant that has various positive health benefits to human. Dietary intake of tomatoes can help to prevent the heart diseases and the formation of cancer such as prostate cancer, digestive-tract cancer, and lung cancer (Gann *et al.*, 1999; (Toor & Savage, 2006) Toor & Savage, 2006; Eyiler & Oztan, 2011). Tomato is the main source of carotenoids, particularly beta-carotene and lycopene. Moreover, tomato has high level of dietary fiber, vitamin, and various phenolic compounds with high antioxidant activities (Tan *et al.*, 2021). Addition of tomato in minced meat probably effect on a meat product with different color, taste and with a great health benefit (Østerlie & Lerfall, 2005). Some studies reported that the addition tomato powder (Eyiler & Oztan, 2011) and tomato pomace (Savadkoohi *et al.*, 2014) as a natural food additive could improve the consumer perception and increase color scores in meat products.

Bacterial cellulose (BC) is a dietary fiber and regulatory is defined as generally recognized as safe (GRAS) (Shi *et al.*, 2014). Textural properties of BC are chewy, soft and smooth surface (Esa *et al.*, 2014). BC contains low fat, low calories and no cholesterol (Esa *et al.*, 2014). Mesomya *et al.* (2008) reported that health food from mixture of nata de coco and cereal able to reduce the serum lipid level in human. In additional, BC can assist to reduce the risk of non-communicable diseases (NCDs) such as diabetes, obesity, cardiovascular disease, and diverticulitis (Cho & Almeida, 2012; Shi *et al.*, 2014). BC is traditionally use coconut water as carbon source for *Acetobacter xylinum* (Esa *et al.*, 2014). Industrial production of BC has focused on a new cost-effective carbon source from agriculture by-product and industrial waste such as waste beer yeast (Lin *et al.*, 2014) soybean whey (Lu *et al.*, 2004).

The objective of this study was to compare the effect of natural compounds (combination of BC and TP) and synthetic antioxidants (BHT) on the physicochemical properties and sensory acceptance of chicken Chinese sausage. The determination of DPPH radical scavenging activity, peroxide value, color, pH, texture properties and sensory evaluation were studied.

2. Materials and methods

2.1. Preparation of tomato powder

Tomato (*Lypersicon esculentum* mill.), *Srida* variety, were purchased from local market in Mahasarakham province, Thailand. Tomato powder was prepared by using the method of Savadkoohi *et al.* (2014). Tomatoes were washed with tap water several times and cut into quarters before drying in a hot air oven at temperature of 60±2 °C for 64 h until a moisture content of 4-5% (wet-weight). Dried tomato was milled using a laboratory mill and sieved through a mesh no. 80 to contain fine particles. The tomato powder was immediately placed in polypropylene bags and stored at refrigerator temperature (5 °C) for further experiments.

2.2. Determination of lycopene content in tomato powder

The amount of lycopene in the tomato powder was determined following the method of Fish *et al.* (2002) with slight modifications. In brief, 1 g of tomato powder was added 10 mL of 0.05% (w/v) butylated hydroxytoluene (BHT) in acetone, 10 mL of 95% ethanol, and 20 mL hexane. The solution was mixed well and then left to separate layers. The hexane (upper) layer was collected and measured at 503 nm on a spectrophotometer using hexane as a blank.

2.3. Preparation of bacterial cellulose

2.3.1. Preparation of Acetobacter xylinum

A. xylinum was cultivated in 20 mL of Glucose Yeast Extract Broth (GYEB) (100 g Glucose, 10 g Yeast Extract and 1 L distilled water), shaken under 30^{o}C for 24 hr.

2.3.2. Starter culture preparation

The liquid in coconut fruit is also called coconut juice. Coconut juice purchased from Mahasarakham province, Thailand. Five hundred milliliters of coconut juice were added 5% sugar (w/v) and mixed evenly.

The juice was autoclaved at 121°C for 15 min. Ethyl alcohol (2% v/v), acetic acid (1% v/v) and 20 mL of *A. xylinum* (from 2.3.1.) were added in sterile coconut juice and then placed at room temperature for 7-10 days until bacterial cellulose membrane was formed.

2.3.3. Bacterial cellulose preparation

Water residues from boiling sweet corn, the by-product, were often discarded. The residue was obtained from local market (Mahasarakham University, Thailand) and used to produce the bacterial cellulose. The bacterial cellulose (BC) was prepared by using the modified method of Jagannath *et at.* (2008). The residue was filtered and added with 5% sugar (w/v). They were sterilized at 121°C for 15 min. Set aside until cool and added with 2% ethyl alcohol (v/v), 1% acetic acid (v/v), 0.5% ammonium dihydrogen phosphate (w/v) and 10% starter culture (*A. xylinum)* from 2.3.2. They were placed at room temperature for 7-10 days to produce BC membrane with thickness about 1 cm. The BC membrane was washed with tap water and then boiled to removal acidity. The BC was cut into small pieces and then was grounded using an electric blender. The BC paste were removed water using the manual juicer before were used as food ingredient in next study.

2.4. Chinese chicken sausage formulation and processing

Fresh chicken thigh and skin, sugar, salt, vegetable oil and fresh sausage casing were purchased from local market. The Chinese chicken sausages were produced in food processing laboratory at Mahasarakham University, Thailand. Firstly, chicken thigh (67.19% w/w) and skin (8.06% w/w) were cut into small size before ground with meat grinder. The ground meat was mixed with sugar (23.50% w/w), salt (0.50% w/w), vegetable oil (1.00% w/w), bacterial cellulose (BC) (2.00% w/w), and different levels of tomato powder (TP) by using mixer for 5 min. The meat batter was kept at refrigerator temperature (5°C) for 30 min. The fresh sausage casing was prepared for filling the meat batter. The sausages were dried at 60°C for 72 h in a hot air oven. All sausages were packed in polyethylene bags and stored at refrigerator temperature (5°C). Each treatment was produced in duplicate for analyses. Bacterial cellulose (BC) was added as dietary fiber source in Chinese chicken sausage. Amount of BC was previous studied by sensory evaluation of 20 untrained panels. Chinese chicken sausage with 2% BC (w/w) was the highest likeness on overall acceptability. Six different treatments of CCS showed in Table 1.

Table 1. Chicken Chinese sausages (CCS) formulations.

Ingredients	Amount (g/100 g)						
	Control	TP0: BHT 0	TP2: BHT 0	TP4: BHT 0	TP6: BHT 0	TP0: BHT 0.015	TP2: BHT 0.015
Chicken tight	67.0	67.0	67.0	67.0	67.0	67.0	67.0
Chicken skin	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Vegetable oil	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sugar	23.5	23.5	23.5	23.5	23.5	23.5	23.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Bacterial cellulose (BC)	-	2.0	2.0	2.0	2.0	2.0	2.0
Tomato powder (TP)	-	-	2	4	6	-	2
Butylated hydroxytoluene (BHT)	-	-	-	-	-	0.015	0.015

2.5. Determination of DPPH radical scavenging activity

Antioxidant activity of CCS was measured by DPPH free radical scavenging activity assay. The stock 0.05 mM DPPH solution was prepared by dissolving 1 mg DPPH with 50 mL ethanol. Five grams of ground CCS sample was homogenized in 50 mL of 80% ethanol and then mixed for 3 hrs. Two milliliters of sample were mixed with 3 mL of DPPH solution before left in the dark for 30 min. The remaining DPPH absorbance was measured at 517 nm. The results were expressed as percentage inhibition of DPPH radical scavenging activity.

DPPH radical scavenging activity was calculated as follows:

$$\% \text{ inhibition} = \frac{(A_{blank} - A_{sample}) \times 100}{A_{blank}}$$

2.6. Evaluation of peroxide value

Peroxide value (PV) of CCS was measured by a titration method according to the method of Tseng & Zhao (2013) with some modification. Briefly, 5 g of sausage was extracted with 25 ml of acetic acid:chroloform (3:2 v/v). The mixture was added with 1 ml of 2% saturated potassium iodide solution and shaken in a vortex for 1 min before left in dark at room temperature for 5 min. The mixture was then filtrated through Whatman No.1 filter paper. The mixture was added with 75 mL of distilled water and 2-3 drops of starch solution then titrated with 0.01 N sodium thiosulphate solution to a transparent endpoint. The results were expressed as milliequivalent peroxide/kg product.

Peroxide value was calculated as follows:

$$PV = \frac{(S - B) \times N \times 1000}{\text{Sample weight (g)} \times 1000}$$

Where

S = Titration volume of sample

B = Titration volume of blank

N = Normality of sodium thiosulphate solution

2.7. Color measurements

Color of each sausage was measured in the form of *L**, *a**, and *b** using a color reader (Model CR-400, Minolta Camera Company, Japan). The equipment was calibrated with a standard white plate, a 10° visual angle and a D-65 illuminate. The method described by Savadkoohi *et al.* (2014). For each treatment, five cylindrical samples were cut into 15 mm-thick pieces (approximately 22 g) to measure on five different areas of the surface.

2.8. pH measurements

10 g of ground sausage and 90 ml of distilled water were homogenized with homogenizer at 5000 rpm for 5 min. The mixture was filtered through a filter paper (0.45 µm) to remove residual. The supernatant was directly measured using a pH meter (model LE435pH, Mettler Toledo, Switzerland).

2.9. Texture analysis

The texture profile analysis (TPA) was measured using texture analyzer (model TA- XTplus, Stable Micro systems, UK), followed the method of Choi *et al.* (2010). The five cylindrical samples of each sausage sample were 12 mm height and 10 mm diameter. The texture profile parameters of were as follow: pre-test speed 2.0 mm/s, post-test speed 5.0 mm/s, maximum load 2 kg, head speed 2.0 mm/s, distance 8.0 mm, force 5 g. The value for hardness (N) and chewiness (N mm) were calculated from the peak force required for first compression and from the hardness x cohesiveness x springiness, respectively.

2.10. Sensory evaluation

Sixty untrained panels consisting of students and staffs from Faculty of Technology at Mahasarakham University in Thailand participated to evaluate the CCS samples. Panelists evaluated the liking of cooked CCS in terms of general acceptance, color, odor, taste and texture. The cooked CCSs with a randomly three digit number coded were served in the booths and under the fluorescence lighting. A 7-point hedonic scale (7 = Very much like, 1 = Very much dislike) was used for evaluate sensory attributes of CCS.

2.11. Statistical analysis

All data were analyzed using SPSS (SPSS Corporation, Chicago, IL) version 12.0 for windows. Data were reported as means ± standard error of means of three replicates conducted by ANOVA. Duncan's Multiple Range test compared differences among the means.

3. Results and discussion

3.1. DPPH radical scavenging activity

Figure 1 presented the DPPH radical scavenging activity of CCS containing BC, TP and BHT. CCS with the combination of BC and TP was the higher the DPPH radical scavenging activity than control. Significant ($p < 0.05$) differences of antioxidant activity were increased with increased levels of TP added. The highest scavenging effect on DPPH radicals was TP6:BHT0 treatment (37.24%), follow by TP2:BHT0.015 treatment (32.61%). There were no significant ($p > 0.05$) differences between treatment of TP4:BHT0 (31.47%) and TP2:BHT0.015 (32.61%).

It is maybe related to the high antioxidant compound in tomato such as lycopene. We found lycopene content of *Srida* tomato powder was 32.12 mg/100g dry basic. Several researchers reported the lycopene contents in tomatoes. Tan *et al*. (2021) revealed the lycopene content in fresh tomato was range from 16.11 – 29.39 mg/g of dry matter and in dried tomato using oven drying method showed significantly increase level. Additionally, Nochai, K. and Pongjanta, J. (2013) presented the lycopene contents of *Eepuea* and *Srida* tomato varieties were 67.61 and 42.39 mg/100g dry basic, respectively.

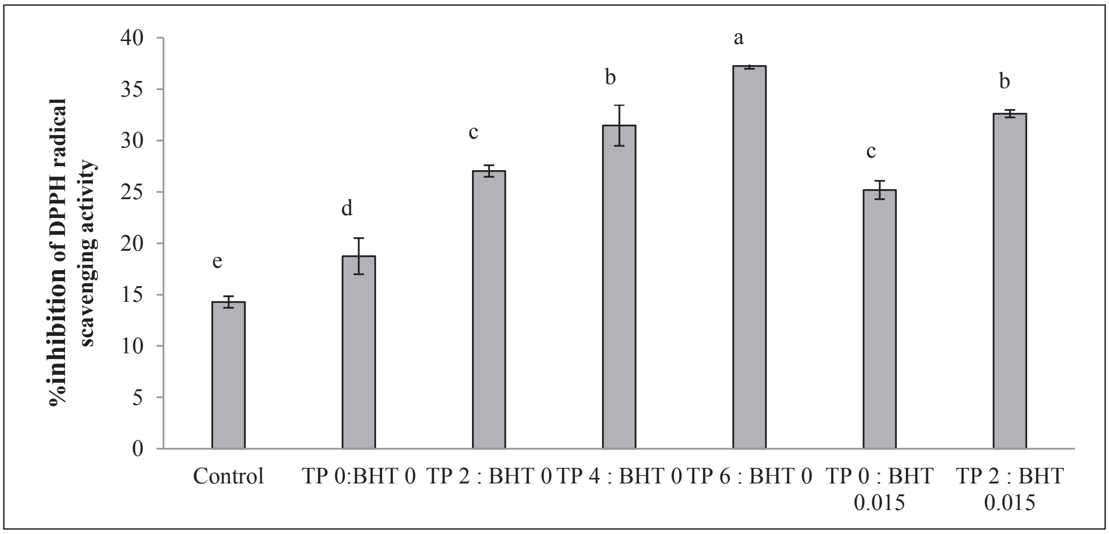

Figure 1 DPPH scavenging activity of chicken Chinese sausages (CCS) containing bacterial cellulose (BC), tomato powder (TP) and butylated hydroxytoluene (BHT). Bars with different letters (a-e) indicate significant difference ($p < 0.05$; Duncan's Multiple Range test).

3.2. Peroxide value (PV)

Figure 2 shows the PV value of CCS treatments. The BC2:TP0:BHT0 treatment had a maxiimum PV of 8.29 mequiv./kg product which was higher the control. This result may be associated to the fat content in BC. Mesomya *et al.* (2008) reported fat content in BC was 1.55 % / 100 g wet weight. We found that increasing the TP level from 0% (w/w) to 6% (w/w) significantly decrease the PV of all CCS treatments. The PV of TP0:BHT0 and TP6:BHT0 treatment were 8.29 and 0.83 mequiv./kg product, respectively. There was not significantly ($p > 0.05$) different between TP0:BHT0.015 treatment and control. The TP2:BHT0.015 treatment had a minimum PV of 0.44 mequiv./kg product. It has long been known that PV is the precursor of the initial stage of lipid oxidation that causes the rancidity of food products (Tseng & Zhao, 2013). Lipid oxidation control is the most important to maintain the meat products quality. Østerlie & Lerfall (2005) reported that the tomato addition in meat products could prevent rancidity. TP has been evaluated as natural antioxidant and safe for consumption. Thus, TP may be used as a functional food ingredient for delay the lipid oxidation.

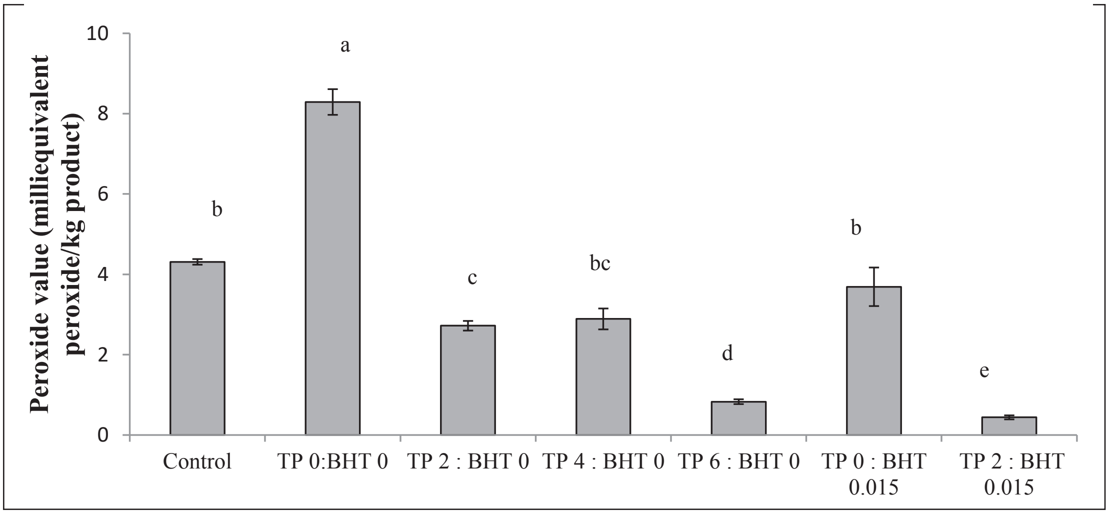

Figure 2. Peroxide value of chicken Chinese sausages (CCS) containing bacterial cellulose (BC), tomato powder (TP) and butylated hydroxytoluene (BHT). Bars with different letters (a-e) indicate significant difference ($p < 0.05$; Duncan's Multiple Range test).

3.3. Color, pH and water activity (Aw) of chicken Chinese sausage (CCS)

Table 2 shows the L*, a*,b*, pH and Aw values of CCS prepared with and without the combination of BC, TP and BHT. In the color parameter, lightness values were not different among treatments ($p > 0.05$). CCS with TP all treatments were the higher a* and b* values than CCS without TP. TP6:BHT0 treatment was the highest of a* and b* values (8.06 and 4.13, respectively). Addition of TP affected redness of CCS. Similarly with Savadkoohi *et al.* (2014), they found the high a* and b* values of beef frankfurters containing tomato pomace. It is maybe related to beta-carotene and cryptoxanthine coming from the color of lycopene in tomato (Savadkoohi *et al.*, 2014). For total color difference (DE) value, a significant difference ($p < 0.05$) was observed for CCS with and without TP all treatments. The color change in the CCS containing TP was visible. The DE values are higher than 2 was considered as noticeable visual changes (Savadkoohi *et al.*, 2014).

For pH parameter, the significant difference was found among all treatments. The pH of BC2:TP6:BHT0 treatment was the lowest. The pH of CCS with TP reduced due to acidic nature of TP. Valenzuela-Melendres *et al.* (2014) reported a pH of tomato paste was 4.2 acidity. They also reported a decrease in pH by adding tomato paste in pork frankfurter. Moreover, the researcher presented adding TP in formulations effect on the pH value of meat products (Eyiler & Oztan, 2011; Østerlie & Lerfall, 2005).

The water activity values (Aw) in food effect on germination, spore formation, and toxin production by microorganisms (Rahman & Labuza, 2007). These effects associated with food safety. According to Thai community product standard (2012), the Aw value of CCS must be less than 0.86. It is a critical water activity value which pathogenic bacteria cannot grow and produce toxin. In this study, the Aw value of CCS was lower than this value. Addition the BC and TP in formulation did not affect the Aw value of CCS. There was no significant difference among treatments ($p > 0.05$).

Table 2. Color, pH and water activity of chicken Chinese sausages (CCS) containing bacterial cellulose (BC), tomato powder (TP) and butylated hydroxytoluene (BHT)

Treatment	L* ns	a*	b*	DE	pH	Aw ns
Control	37.19±0.94	5.26±0.30[e]	1.55±0.44[c]	0	6.33±0.08[bc]	0.79±0.03
TP 0:BHT 0	37.55±1.66	5.29±0.70[e]	1.85±0.58[c]	1.88±0.95[c]	6.47 ± 0.06[a]	0.81 ± 0.03
TP 2:BHT 0	37.84±1.59	7.16±0.92[c]	3.25±0.73[b]	3.21±1.18[b]	6.40 ± 0.07[ab]	0.80 ± 0.02
TP 4:BHT 0	37.29±1.22	7.77±0.52[ab]	3.87±0.64[a]	3.79±0.66[ab]	6.23 ± 0.04[d]	0.79 ± 0.02
TP 6:BHT 0	37.11±1.93	8.06±0.53[a]	4.13±0.82[a]	4.31±0.69[a]	6.15 ± 0.02[e]	0.77 ± 0.02
TP 0:BHT 0.015	36.96±0.87	5.88±0.56[d]	1.85±0.66[c]	1.59±0.74[c]	6.30 ± 0.01[c]	0.80 ± 0.01
TP 2:BHT 0.015	38.54±1.57	7.36±0.52[bc]	3.06±0.65[b]	3.27±0.91[b]	6.35 ± 0.02[b]	0.78 ± 0.00

Mean ± standard deviation values in the same column with different letters are significant difference ($p < 0.05$; Duncan's Multiple Range test). ns is not significant difference.

3.4. Texture profile analysis

Textural properties of CCS with and without 2%BC and 0.015%BHT as well as different levels of TP (2%, 4%, and 6%) are shown in Table 3. For all parameters of textural properties, TP0:BHT0 and TP0:BHT0.015 were not significant ($p > 0.05$) differences with control sample. Addition of 0.015% BHT had no effect on textural properties of CCS. Significant ($p < 0.05$) differences of hardness, gumminess and chewiness values were increased with increased levels of TP added. This occurrence was similar to the report of Savadkoohi *et al.* (2014) that the increasing the gelling properties and hardness of the beef frankfurter containing tomato pomace was related to seed protein presented in tomato pomace.

Table 3. Texture profile analysis means of chicken Chinese sausages (CCS) containing bacterial cellulose (BC), tomato powder (TP) and butylated hydroxytoluene (BHT)

Treatments	Hardness (N)	Cohesiveness ns	Gumminess (N)	Chewiness (N.mm)
Control	168.77±6.92[c]	0.74±0.02	126.75±6.61[b]	126.66±6.63[b]
TP 0 :BHT 0	179.97±15.79[c]	0.72±0.07	130.86±21.96[b]	130.77±22.02[b]
TP 2:BHT 0	218.25±11.23[b]	0.75±0.01	162.62±9.57[a]	162.54±9.58[a]
TP 4:BHT 0	226.64±11.61[b]	0.74±0.02	166.88±9.47[a]	166.51±9.30[a]
TP 6:BHT 0	257.42±6.31[a]	0.67±0.08	172.28±17.39[a]	172.15±17.39[a]
TP 0:BHT 0.015	171.98±7.51[c]	0.76±0.03	128.43±1.00[b]	128.36±1.02[b]
TP 2:BHT 0.015	214.85±17.63[b]	0.75±0.02	159.87±10.26[a]	159.83±10.32[a]

Mean ± standard deviation values in the same column with different letters are significant difference ($p < 0.05$; Duncan's Multiple Range test). ns is not significant difference.

3.5. Sensory evaluation

Sensory evaluation results are shown in Table 4. TP0:BHT0 and TP2:BHT0 treatments had high sensory attribute score and were not significant difference ($p > 0.05$) with control. TP6:BHT0 treatment had the lowest evaluation by the panelists. We found that panelist provided the low liking score when the addition of TP increased in the CCS treatment. These results may be associated to the fresh green flavor in tomatoes. (Mirondo & Barringer, 2015) reported that the fresh green flavor in tomatoes can change the intensity and sensory profile. Texture and color of meat products are the important elements for the quality, acceptability and also influencing purchasing decisions (Wang *et al.*, 2022).

Table 4. Sensory attributes of chicken Chinese sausages (CCS) (7-point hedonic scale, N=60)

Treatments	General acceptance	Color	Odor	Taste	Texture
Control	5.10±0.93^{ab}	5.44±1.01^{a}	5.02±1.55^{abc}	4.50±1.25^{bc}	4.68±1.46^{abcd}
TP 0:BHT 0	5.66±1.17^{a}	5.52±1.25^{a}	5.64±1.51^{a}	5.34±1.19^{a}	5.24±1.29^{ab}
TP 2:BHT 0	5.16±1.09^{ab}	4.94±1.43^{a}	5.34±1.61^{ab}	4.86±1.54^{ab}	5.46±1.09^{a}
TP 4:BHT 0	4.22±1.45^{c}	4.00±1.49^{b}	4.54±1.78^{c}	4.04±1.43^{cd}	4.36±1.55^{cd}
TP 6:BHT 0	3.78±1.53^{c}	3.04±1.41^{c}	3.68±1.88^{d}	3.64±1.55^{d}	3.76±1.33^{de}
TP 0:BHT 0.015	5.00±1.21^{b}	5.16±1.18^{a}	5.68±1.38^{a}	4.84±1.39^{a}	4.94±1.20^{abc}
TP 2:BHT 0.015	4.26±1.47^{c}	4.22±1.56^{b}	4.90±1.86^{bc}	4.40±1.55^{bc}	4.22±1.46^{cde}

Mean ± standard deviation values in the same column with different letters are significant difference ($p < 0.05$; Duncan's Multiple Range test).

4. Conclusion

The effect of natural compounds (combination BC and TP) on the physico-chemical properties and sensory attributes of CCS were investigated. The results of this study revealed that addition of BC and TP in CCS can increased antioxidant capacity and reduce peroxide value. Incorporation of BC and TP help to reduce the BHT level addition in meat products. BC and TP can be used as ingredient to improve the safety and to be an alternative to consumers looking for the low synthetic compound in meat products. We expected to extend the findings to produce the product with low synthetic antioxidants. Although the consumer's perception of CCS with BC and TP showed moderately liking score, it should be to further study the optimization of added BC and TP in meat products formulation for consumer's acceptance and shelf life.

5. Acknowledgement

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6. References

Cho, S., & Almeida, N. (2012). *Dietary fiber and health*. CRC Press.

Choi, Y.-S., Choi, J.-H., Han, D.-J., Kim, H.-Y., Lee, M.-A., Kim, H.-W., Lee, J.-W., Chung, H.-J., & Kim, C.-J. (2010). Optimization of replacing pork back fat with grape seed oil and rice bran fiber for reduced-fat meat emulsion systems. *Meat Science, 84*(1), 212-218.

Esa, F., Tasirin, S. M., & Abd Rahman, N. (2014). Overview of bacterial cellulose production and application. *Agriculture and Agricultural Science Procedia, 2*, 113-119.

Eyiler, E., & Oztan, A. (2011). Production of frankfurters with tomato powder as a natural additive. *LWT - Food Science and Technology, 44*(1), 307-311.

Fish, W., Perkins-VeazieJulie, P. & Collins, K. (2002). A Quantitative Assay for Lycopene That Utilizes Reduced Volumes of Organic Solvents. *Journal of Food Composition and Analysis, 15*(3), 309-317

Gann, P. H., Ma, J., Giovannucci, E., Willett, W., Sacks, F. M., Hennekens, C. H., & Stampfer, M. J. (1999). Lower prostate cancer risk in men with elevated plasma lycopene levels: results of a prospective analysis. *Cancer research, 59*(6), 1225-1230.

Jagannath, A., Kalaiselvan, A., Manjunatha, S., Raju, P., & Bawa, A. (2008). The effect of pH, sucrose and ammonium sulphate concentrations on the production of bacterial cellulose (Nata-de-coco) by Acetobacter xylinum. *World Journal of Microbiology and Biotechnology, 24*(11), 2593-2599.

Lin, D., Lopez-Sanchez, P., Li, R., & Li, Z. (2014). Production of bacterial cellulose by Gluconacetobacter hansenii CGMCC 3917 using only waste beer yeast as nutrient source. *Bioresource Technology, 151*, 113-119.

Lorenzo, J. M., González-Rodríguez, R. M., Sánchez, M., Amado, I. R., & Franco, D. (2013). Effects of natural (grape seed and chestnut extract) and synthetic antioxidants (buthylatedhydroxytoluene, BHT) on the physical, chemical, microbiological and sensory characteristics of dry cured sausage “chorizo”. *Food Research International, 54*(1), 611-620.

Lu, X., Qian, Y., & Yan, T. (2004). Bacterial cellulose production by soybean whey based medium. *Current Applied Science and Technology, 4*(1), 100-107.

Mercadante, A. Z., Capitani, C. D., Decker, E., & Castro, I. A. (2010). Effect of natural pigments on the oxidative stability of sausages stored under refrigeration. *Meat Science, 84*(4), 718-726.

Mesomya, W., Komindr, S., Leelahakul, P., Cuptapun, Y., Hengsawadi, D., Tammarate, P., & Tangkanakul, P. (2008). *Effects of health food from cereal and nata de coco on serum lipids in human*. Institute of Food Research and Product Development, Kasetsart University.

Mirondo, R., & Barringer, S. (2015). Improvement of flavor and viscosity in hot and cold break tomato juice and sauce by peel removal. *Journal of Food Science, 80*(1), S171-S179.

Nochai, K., & Pongjanta, J. (2013). Effects of tomato variety and lycopene extraction methods on physicochemical properties of tomato powder. *KMUTT Research and Development Journal, 36*(4), 409-421.

Østerlie, M., & Lerfall, J. (2005). Lycopene from tomato products added minced meat: Effect on storage quality and colour. *Food Research International, 38*(8-9), 925-929.

Rahman, M.S. & Labuza, T. P. (2007). Water activity and food preservation. In Rahman, M.S. (Ed.), *Handbook of food preservation* (pp. 447-476).

Savadkoohi, S., Hoogenkamp, H., Shamsi, K., & Farahnaky, A. (2014). Color, sensory and textural attributes of beef frankfurter, beef ham and meat-free sausage containing tomato pomace. *Meat Science, 97*(4), 410-418.

Sebranek, J., Sewalt, V., Robbins, K., & Houser, T. (2005). Comparison of a natural rosemary extract and BHA/BHT for relative antioxidant effectiveness in pork sausage. *Meat Science, 69*(2), 289-296.

Shi, Z., Zhang, Y., Phillips, G. O., & Yang, G. (2014). Utilization of bacterial cellulose in food. *Food hydrocolloids, 35*, 539-545.

Tan, S., Ke, Z., Chai, D., Miao, Y., Luo, K., & Li, W. (2021). Lycopene, polyphenols and antioxidant activities of three characteristic tomato cultivars subjected to two drying methods. *Food Chemistry, 338*, 128062.

Thai community product standard. (2021). Dried chicken sausages, Kunchiana kai (reference number 105/2555). https://tcps.tisi.go.th

Toor, R. K., & Savage, G. P. (2006). Effect of semi-drying on the antioxidant components of tomatoes. *Food Chemistry, 94*(1), 90-97.

Tseng, A., & Zhao, Y. (2013). Wine grape pomace as antioxidant dietary fibre for enhancing nutritional value and improving storability of yogurt and salad dressing. *Food Chemistry, 138*(1), 356-365.

Valenzuela-Melendres, M., Torrentera-Olivera, N.G., González-Aguilar, G., Villegas-Ochoa, M., Cumplido-Barbeitia, L. G., & Camou, J. P. (2014). Use of avocado and tomato paste as ingredients to improve nutritional quality of pork frankfurter. *J Food Res, 3*, 132-143.

Wang, X., Zhou, P., Cheng, J., Yang, H., Zou, J., & Liu, X. (2022). The role of endogenous enzyme from straw mushroom (Volvariella volvacea) in improving taste and volatile flavor characteristics of Cantonese sausage. *LWT, 154*, 112627.

Yu, H., Qin, C., Zhang, P., Ge, Q., Wu, M., Wu, J., Wang, M., & Wang, Z. (2015). Antioxidant effect of apple phenolic on lipid peroxidation in Chinese-style sausage. *Journal of food science and technology, 52*(2), 1032-1039.