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Effect of Sweet Basil (*Ocimum basilicum* L.) Leaves Powder on Qualities of Pork Emulsion Sausage (Moo Yor)

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Abstract

Effect of sweet basil (*Ocimum basilicum* L.) leaves powder (SBP) (0.25-1.0%) on qualities and lipid oxidation of pork emulsion sausages (Moo Yor) during 21 days of refrigerated storage was investigated. Control sample had lower fiber content than samples added with SBP (p<0.05) at day 0 of storage. Samples treated with SBP (0.25-1.0%) had lower L^* value but higher b^* value, compared to the control samples (p<0.05). With the addition of SBP, peroxide value (PV) and thiobarbituric acid-reactive substances (TBARS) value in the sausages were retarded effectively, compared to the control sample (p<0.05), especially when the SBP at high contents were used. Samples treated with SBP had higher hardness, compared with control sample during storage (p<0.05). SBP had no detrimental effect on the sensory attributes of sausages. Therefore, SBP can be utilized in sausages to enhance shelf life quality.

Keywords: Sweet Basil Leaves; Sausage; Pork; Oxidative Stability

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1. Introduction

Sausages are popular meat products in many Asian and European countries [1]. Sausage is typically made of pork, beef or chicken. Pork meats have recently been used as a raw material for emulsion sausage production [1]. However, pork sausages, especially prepared from pork meat and fat can rapidly develop hydrolytic rancidity or oxidative rancidity flavors under chilled or frozen storage conditions [2]. Pork meat and fat contain high content of saturated fatty acids and is susceptible to lipid oxidation, thereby negatively affecting flavor, odor, color, texture and the nutritional value of meat products [2]. Textural properties changed by biochemical degradation leading to softening of pork meat also considered as an important factor determined pork quality. Normally, pork sausages have a short shelf life at both refrigerated and frozen storage in the absence of preservatives. To retard such a quality loss, synthetic antioxidants have been used to decrease lipid oxidation during the processing and storage of meat and meat products [3]. However, the use of synthetic antioxidants has raised questions regarding safety and toxicity [4]. The applications of natural antioxidants from plants in meat and meat products have been reported [3] Phytochemicals in food materials and their effects on health, especially the suppression of active oxygen species by natural antioxidants from spices, herbs and local plants have been extensively studied [3]. Due to their high content of phenolic compounds, fruits and other plant materials are a good source of natural antioxidants and provide an alternative to currently used conventional antioxidants [5].

Recently, local vegetables and herbs including kaffir lime (*Citrus hystrix* DC.), Indian mulberry (*Morinda citrifolia* Linn.), finger grass (*Limnophila aromatica* Merr.), variegatum (*Piper aurantuacum*), purple velvet plant (*Gynura divaricata* DC.), mulberry (*Morus alba* Linn.), Thai copper pod (*Cassia siamea* Britt.), asiatic pennywort, pak paew (*Polygonum odoratum*), yanag leaves (*Tiliacora triandra* Diels) and sweet basil (*Ocimum basilicum* L.) extracts contain high phenolic compounds that are able to stabilize free radicals and break the oxidation chain have been reported [6]. Sweet basil (*O. basilicum* L.) is a native plant of Southeast Asia and is widespread in Thailand [6]. It is used in many Thai cuisines such as red and green curry. Nevertheless, no information related with the use of natural antioxidants, especially sweet basil leaves in preventing the lipid oxidation and quality maintaining of pork sausages has been reported. Therefore, this research was aimed to evaluate the effect of sweet basil leaves powder (SBP) on the qualities of pork emulsion sausages (Moo Yor) during refrigerated storage.

2. Research Methodology

2.1 Materials and Methods

2.1.1 Chemicals

Sodium chloride, sodium bicarbonate, potassium iodide and trichloroacetic acid were obtained from Merck (Damstadt, Germany). Disodium hydrogen phosphate, sodium tripolyphosphate, 2-thiobarbituric acid, ammonium thiocyanate and ferrous chloride were purchased from Fluka Chemical Co. (Buchs, Switzerland). All chemicals used were of analytical grade.

2.1.2 Collection of sweet basil leaves and preparation of SBP

Sweet basil (*O.basilicum* L.) can be grown throughout the year. A single leaf was selected with width of 2 cm and length of 3–4 cm. The fresh leaves were obtained from three representative markets in the Ubon Ratchathani province during April to June, 2016. At each market, 3 kg samples were sampled from three representative outlets. Single composite samples for each representative market, were prepared by combining about 500 g of homogenized single sample of the same leaves variety from three representative outlets and then homogenizing again to obtain a uniform single composite sample.

All samples were cleaned and dried under hot air oven (Memmert Model UN30, Schwabach, Germany). The samples were placed in sample tray (25x40 cm) and placed between and parallel to the top and bottom heaters and the distance between each set of heaters and a tray was fixed at 15 cm. Drying temperature was set at 50 ºC and velocity at 1.5 m/s (Raksakantong *et al*., 2011) until the moisture content reached 4–5% (wet weight basis). The dried samples were cut into small pieces and ground using a blender (National Model MKK77, Tokyo, Japan) and finally sieved using a stainless steel sieve of 80 mesh size (with the diameter of 0.177 mm). The obtained powders were subjected to chlorophyll removal to lower the green color caused by the chlorophyll. The powder (50 g/L) was mixed with chloroform and the mixture was stirred for 30 min, followed by filtration using Whatman filter paper No.1 [7], [8] SBP with chlorophyll removal were packed in polyethylene bag, sealed and kept at -20ºC until used.

2.1.3 Preparation of pork emulsion sausages containing SBP

Pork meats were obtained from the market in Ubon Ratchathani, Thailand. Pork meat were washed with tap water and minced using a grinder with a hole diameter of 5 mm. Moisture content of the ground pork was adjusted to 75%. Pork emulsion sausages were prepared following the method described by Yang, *et al.* [9] with slight modifications. Ground pork meat (85 g) was added with sodium chloride (2 g), sucrose

(1.5 g), sodium tripolyphosphate (1.0 g), pepper (0.5 g) and pork fat (10 g). The mixture was ground for 3 min using a Panasonic Food Processor (MK, 5087M, Selangor Darul Ehsan, Malaysia).

To study the effect of SBP on lipid oxidation and properties of emulsion sausages, SBP containing 30 mg of phenolic content (gallic acid equivalent/g dry powder) was added to obtain the designated final concentration. SBP (0.25, 0.50, 0.75 and 1.0 % w/w) dissolved in distilled water were added to the mixture along with pork fat (10% w/w). Subsequently, the mixture was further ground thoroughly for 5 min in order to obtain a homogenous paste. The paste was stuffed into a cellophane casing (diameter of 22 mm) and steamed at 100 °C for 40 min. The control samples were prepared in the similar manner but distilled water was added instead of SBP. Samples were cooled for about 30 min in iced water. Samples were cut into cylinders (30 mm height × 20 mm diameter) and place in polythene bags and further stored at 4 °C. Samples were randomly taken at day 0, 7, 14 and 21 of storage for analysis of lipid oxidation products. Textural and sensory analyses were conducted at day 0 and 21. Proximate composition and color of the samples were also analysed at day 0 of storage.

2.1.4 Analyses

Proximate composition determination

The proximate compositions of sausage samples, including moisture, ash, fat, fiber and protein contents were determined. Protein was determined by the Kjeldahl method using a conversion factor of 6.25 [10] Ash and fat contents were determined using a furnace muffle at 600 °C and with the Soxhlet apparatus, respectively, as per the methodof [10]. The contents were expressed on a wet weight basis.

Color determination

Color value of the sausage samples was measured using a colorimeter (Hunter Lab, Model color Flex, Reston, VIRG, USA) with the port size of 0.50 inch. The determination of color was done on ten different samples. Standar dization of the instrument was done using a black and white Minolta calibration plate. The values were reported in the CIE color profile system as L^*-value (lightness), a^*-value (redness / greeness), and b^*value (yellowness/blueness).

Determination of peroxide value

Peroxide value (PV) was determined as per the method of Balange and Benjakul [11] with a slight modification. Samples (1 g) were mixed with 11 mL of chloroform/methanol (2:1, v/v). The mixtures were homogenized at a speed of 12,000 rpm for 2 min, using an IKA homogenizer (Salangor

Malaysia). Homogenates were then filtered using a Whatman No. 1 filter paper. Two milliliters of 0.5% NaCl were then added to 7 mL of the filtrate. The mixtures were vortexed at a moderate speed for 30 s using a Vortex-Genie2 mixer 4 (Bohemia, NY, USA) and then centrifuge using a refrigerated centrifuge (Beckman Coulter, Avanti J-E Centrifuge, Fullerton, CA, USA) at 3,000 ×g for 3 min to separate the sample into two phases. Two millilitres of cold chloroform/methanol (2:1, v/v) were added to 3 mL of the lower phase. Twenty-five microliters of 30 % ammonium thiocyanate and 25 µL of 20 mM iron (II) chloride were added to the mixture (Shantha and Decker, 1993). Reaction mixtures were allowed to stand for 20 min at room temperature and the absorbance was read at 500 nm. A standard curve was prepared using cumene hydroperoxide with the concentration range of 0.5-2 ppm.

Determination of thiobarbituric acid-reactive substances (TBARS)

Thiobarbituric acid-reactive substances (TBARS) were determined as described by Buege and Aust [12]. Samples (0.5 g) were mixed with 2.5 mL of a TBA solution containing 0.375 % thiobarbituric acid, 15 % trichloroacetic acid and 0.25 N HCl.The mixtures were heated in a boiling water for 10 min to develop a pink color, cooled with running tap water and then sonicated for 30 min using an Elma (S 30 H) sonicator (Kolpingstr, Singen, Germany). The mixture was then centrifuged at 5,000 × g at 25 ºC for 10 min. The absorbance of the supernatant was measured at 532 nm. A standard curve was prepared using 1,1,3,3-tetramethoxypropane (MDA) at the concentration ranging from 0 to 10 ppm and TBARS were expressed as mg of MDA equivalents/kg sample.

Textural profile analysis (TPA)

TPA was performed using a TA-XT2i texture analyzer (Stable Micro Systems, Surrey, England) with cylindrical aluminum probe (50 mm diameter). The samples were cut into cylinders (30 mm height × 20 mm diameter) and placed on the instrument's base. The tests were performed with two compression cycles. TPA textural parameters were measured at room temperature with the following testing conditions: crosshead speed 5.0 mm/s, 50% strain, surface sensing force 99.0 g, threshold 30.0 g, and time interval between the first and the second compressions was 1 s. The Texture Expert version 1.0 software (Stable Micro Systems, Surrey, England) was used to collect and process the data. Hardness, springiness, cohesiveness, gumminess and chewiness were calculated from the force–time curves generated for each sample [13].

Sensory analysis

The sensory evaluation of pork emulsion sausages added with and without SBP (0.25-1.0%) at day 0 and 21 of storage was performed by 50 untrained panelists, who were the students in Food Science and Technology program with the age of 20-22 years and were familiar with sausage consumption. The sausage samples were placed in the polythene bags and were dipped in the boiling water for 15 min. Stick water was drained and samples were allowed to cool to room temperature (25–28 ºC) prior to evaluation. Panelists were asked to evaluate for color, odor, taste, texture, appearance and overall likeness of sausage samples using a 9-point hedonic scale [14]. : 1, dislike extremely; 2, dislike very much; 3, dislike moderately; 4, dislike slightly; 5, neither like nor dislike; 6, like slightly; 7, like moderately; 8, like very much; 9, like extremely.

2.1.5 Statistical analysis

All experiments were run in triplicate. The experimental data were subjected to Analysis of Variance (ANOVA) and the differences between means were evaluated by Duncan's New Multiple Range Test [15]. Data analysis was performed using a SPSS package (SPSS 11.0 for Windows, SPSS Inc, Chicago, IL, USA).

3. Results and Discussion

3.1 Proximate composition of pork emulsion sausages added with and without SBP

Proximate compositions of the sausages with and without SBP addition at day 0 of refrigerated storage are shown in **Table 1.** Pork sausages contained moisture, protein, lipid, ash and fiber contents ranging from 70.72-72.15 %, 17.32-17.51 %, 5.89-6.23 %, 1.10-1.35 % and 0.06-1.67 %, respectively. Generally, the addition of SBP did not significantly affect (p>0.05) the moisture, protein and carbohydrate contents. However, pork sausages with SBP addition (0.25-1.0%) have the higher fiber content than control sample.

Table 1 Proximate compositions of pork emulsion sausages added with and without sweet basil leaves powder (SBP) at different levels at day 0 of refrigerated storage

SBP (%)	Content (% wet weight basis)				
	Moisture	Protein	Fat	Ash	Fiber
Control	$72.2±0.1^a$	$17.5±1.1^a$	$6.2±0.2^a$	$1.1±0.0^a$	$0.1±0.0^e$
0.25	$71.6±1.2^a$	$17.5±2.0^a$	$6.1±0.2^a$	$1.2±0.0^a$	$1.2±0.1^d$
0.50	$71.2±0.7^a$	$17.4±1.2^a$	$6.0±1.0^a$	$1.1±0.0^a$	$1.4±0.1^c$
0.75	$71.0±0.5^a$	$17.4±0.9^a$	$6.0±0.5^a$	$1.2±0.0^a$	$1.6±0.01^b$
1.0	$70.7±1.0^a$	$17.3±1.0^a$	$5.9±0.4^a$	$1.4±0.0^a$	$1.7±0.0^a$

* Mean ± SD (*n* = 3).

** Different superscripts in the same column indicate the significant differences (p< 0.05).

It was noted that fiber content (0.06-1.67%) of pork sausages increased with increasing SBP content (0.25-1.0%) ($p<0.05$).

High fiber content in samples added with SBP might be due to the high content of fiber in sweet basil leaves. Sweet basil leaves contain high levels of cellulose, lignin, hemicelluloses, pentose, gums and pectin. High fiber content in sweet basil leaves was also reported [16]. Some fibers obtained from algae such as carrageenan or seed such as Guar gum [17] have been used for technological purposes in meat products. Fernández-Ginés, *et al.* [18] reported that lemon albedo contain a high potential source of dietary fiber which can be used as functional ingredient for cooked sausages. The addition of 7.5 % of albedo to bologna can induce a decrease in residual nitrite levels. The importance of dietary fiber in nutrition and health is well established [16] This result suggested that sweet basil leaves can be used to promote the nutritional value of pork emulsion sausages.

3.2 Color values of pork emulsion sausages added with and without SBP

Table 2 Color values of pork emulsion sausages added with and without sweet basil leaves powder (SBP) at different levels at day 0 of refrigerated storage

SBP (%)	Color values*		
	L^*	**a^***	**b^***
Control	70.20±1.07^a	2.80±0.20^a	16.10±0.40^c
0.25	69.10±1.10^a	2.25±0.40^a	16.55±0.25^c
0.50	66.80±0.80^b	2.15±0.55^a	18.26±0.31^b
0.75	66.50±0.98^b	-1.58±0.22^b	19.35±0.65^a
1.00	66.25±1.02^b	-1.75±0.10^b	20.58±0.70^a

* Mean ± SD (n = 3).

** Different superscripts in the same column indicate the significant differences ($p < 0.05$).

Color values expressed as L^*, a^* and b^* of pork sausages added with and without SBP (0.25-1.0%) at day 0 of refrigerated storage are shown in **Table 2.** After addition of SBP at all levels, the changes in L^* (lightness), a^* (redness) and b^* (yellowness) values of pork sausages, compared to the control ($p<0.05$) were observed. Control sample (without SBP addition) has higher L^* but lower b^* values than samples added with SBP ($p<0.05$). However, the lower a^* value (-1.75 and -1.58) of SBP samples (0.75 and 1.0%) compared with control sample was observed ($p<0.05$). The decreased lightness and redness values in SBP samples might be due to the slight increase in yellowness color of SBP at high concentration (0.50-1.0%) used. The negative effect of natural extract on color of sausage products has been reported by Balange and Benjakul [11]. Sebranek, *et al.* [19] reported that the addition of rosemary extracts can inhibit lipid oxidation and improve the color stability of pork sausage. Therefore, the use of SBP at low content had no impact on color of the resulting sausages, while high SBP addition (0.75-1.0%) showed the detrimental effect on color to some degree.

3.3 Effect of SBP addition on lipid oxidation of pork emulsion sausages during refrigerated storage

3.3.1 Changes in peroxide values (PV)

Effect of SBP (0.25, 0.50, 0.75 and 1.0 %) addition on lipid oxidation of pork emulsion sausages during refrigerated storage for 21 days is depicted in **Fig. 1A.** Generally, no difference in PV among all samples at day 0 of refrigerated storage was observed **(Fig. 1A).** A sharp increase in PV was found in all samples up to 14 days of refrigerated storage (p<0.05) **(Fig. 1A)**. Thereafter, PV in all samples was slightly decreased at the end of storage (p<0.05). The increase in PV of samples added with and without SBP indicated that the samples were in propagation stage of lipid oxidation with the lower rate of decomposition of hydroperoxide

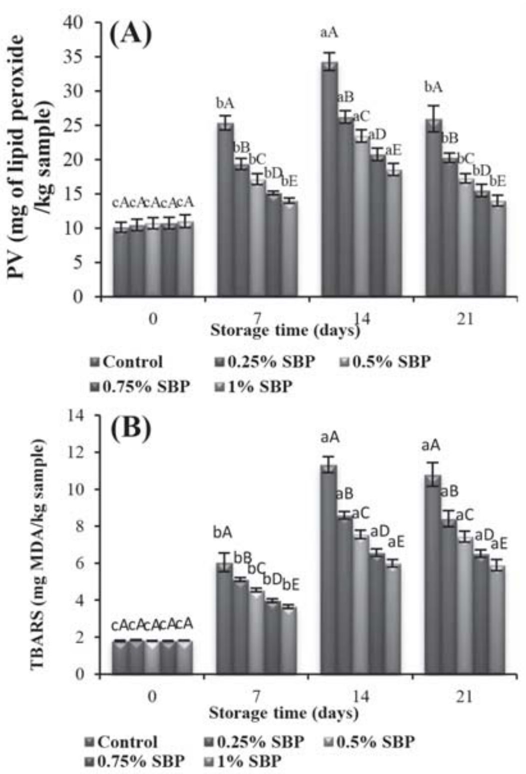

Fig. 1 Peroxide value (PV) (A) and thiobarbituric acid-reactive substance (TBARS) (B) of pork emulsion sausages added with and without sweet basil leaves powder (SBP) at different levels (0.25, 0.5, 0.75 and 1.0 % SBP) during refrigerated storage for 21 days. Bars represents the standard deviation (*n* = 3). Different lowercase letters within the same treatment (same sweet basil leaves powder (SBP) level) indicate the significant differences ($p < 0.05$). Different uppercase letters within the same storage time indicate the significant differences ($p < 0.05$)

form [20]. Decreasing in PV of all samples at the end of storage might be due to the decomposition of hydroperoxide formed into the secondary oxidation products. Hydroperoxides underwent decomposition, yielding a Variety of decomposition products, including aldehydes, ketone, acid, etc. [20]. Nevertheless, sample added with showed the lower rate of increasing in PV, compared with control sample, especially when high contents were used ($p<0.05$). It was noted that efficacy in preventing lipid oxidation of SBP was a dose-independent. The results indicated that SBP samples were more effective in retarding the formation of hydroperoxide, compared with control sample. SBP showed the radical scavenging activity via hydrogen donating and reducing power, thereby terminating the propagation. Therefore, SBP can be used as antioxidant in pork emulsion sausage.

3.3.2 Changes in TBARS values

Effect of various contents of SBP (0.25-1.0 %) on TBARS values of pork emulsion sausages is shown in **Fig. 1B.** No marked differences in TBARS value of the sausages were observed in all samples at day 0 of storage ($p>0.05$) **(Fig. 1B)**. Thereafter, TBARS values in all samples sharply increased up to day 14 of storage ($p<0.05$) and remained unchanged at the end of storage **(Fig. 1B)**. No changes in TBARS at the end of storage was probably due to their reaction with free amino acids, proteins and peptides present in the sausages to form Schiff's base [21]. In addition, volatile oxidation products with low molecular weight could be lost during extended storage. At day 0 of storage, TBARS values of all sample ranged from 1.80 to 1.85 mg MDA/kg of sample, indicating that the lipid oxidation occurred during the processing and cooking of the sausages. Control samples showed the higher formation of TBARS throughout the storage of 21 days, compared with other samples ($p<0.05$). With the addition of SBP (0.25-1.0 %), the formation of TBARS in sausage was retarded effectively. Among all samples, sample added with 1.0 % SBP had the lower formation of TBARS, compared to other samples ($p<0.05$). It was noted that efficacy in retardation of TBARS by SBP was achieved in dose dependent manner. This result was well correlated with PV of SBP samples. Thus, SBP (0.25-1.0 %) was effective in retarding lipid oxidation in pork emulsion sausage during the refrigerated storage for 21 days. Furthermore, delaying lipid oxidation can have a significant contribution towards prevention of nutritional loss and lowering the risk of health problem [20].Ryu, *et al.* [22] reported that the addition of 0.5 % (w/w) grape skin and seed pomace powder in cooked pork sausages have decreased in the lipid oxidation susceptibility.

3.4 Effect of SBP addition on textural properties of pork emulsion sausages during refrigerated storage

Texture profile analysis of the pork emulsion sausages added with and without SBP (0.25-1.0 %) at day 0 and 21 of refrigerated storage is shown in Table 3. At day 0 of storage, there was no difference in all textural parameters among all samples ($p>0.05$) except hardness of sausages added with SBP (0.25-1.0 %) were higher than control sample ($p<0.05$). Among all samples containing SBP at various contents (0.25-1.0 %), there was no difference in force required to compress sample to attain a given deformation (hardness), capability in breaking down the internal structure (cohesiveness) and the required energy to chew the sample to the point required for swallowing it (chewiness). Hardness value of all samples increased at day 21of storage ($p<0.05$), while there was no change in gumminess, chewiness, springiness and cohesiveness for all samples ($p>0.05$). The results indicated that hardening texture occurred at day 21 of storage, which was probably due to the decrease in moisture content of sausage samples (data not shown). However, at the end of storage (day 21), samples added with SBP showed the higher hardness value, compared to control sample ($p<0.05$). The higher hardness in the samples containing

Table 3 Textural properties of pork emulsion sausages added with and without sweet basil leaves powder (SBP) at different levels during refrigerated storage for 21 days

Storage time (day)	SBP (%)	Texture profile analysis (TPA)*				
		Hardness (N)	Springiness	Cohesiveness	Gumminess	Chewiness (N)
0	Control	30.10±1.22^{bB**}	0.82±0.05^{aA}	0.38±0.01^{aA}	20.32±0.66^{aA}	20.55±1.20^{aB}
	0.25	34.68±1.12^{aB}	0.82±0.01^{aA}	0.38±0.01^{aA}	20.50±0.48^{aA}	21.10±0.80^{aB}
	0.50	34.90±0.48^{aB}	0.81±0.01^{aA}	0.39±0.01^{aA}	20.45±0.55^{aA}	21.50±0.45^{aB}
	0.75	35.60±1.50^{aB}	0.82±0.01^{aA}	0.39±0.01^{aA}	21.50±0.80^{aA}	22.35±1.56^{aB}
	1.0	36.25±1.05^{aB}	0.83±0.02^{aA}	0.39±0.01^{aA}	21.62±0.70^{aA}	22.24±1.82^{aB}
21	Control	45.15±1.56^{bA}	0.81±0.01^{aA}	0.39±0.01^{aA}	20.65±0.99^{aA}	23.88±1.00^{aA}
	0.25	48.28±1.35^{aA}	0.81±0.01^{aA}	0.39±0.02^{aA}	20.23±0.60^{aA}	23.80±0.05^{aA}
	0.50	49.35±1.60^{aA}	0.81±0.01^{aA}	0.40±0.01^{aA}	20.58±0.44^{aA}	24.40±0.22^{aA}
	0.75	49. 44±2.40^{aA}	0.82±0.01^{aA}	0.40±0.02^{aA}	21.50±1.60^{aA}	24.20±0.56^{aA}
	1.0	49.65±1.22^{aA}	0.82±0.02^{aA}	0.40±0.01^{aA}	21.60±1.40^{aA}	25.12±1.20^{aA}

* Mean ± SD (*n* = 3). **Different lowercase letters within the same column in the same storage time indicate the significant differences ($p < 0.05$). Different uppercase letters within the same column in the same SBP level indicate the significant differences ($p < 0.05$).

SBP might be due to the higher fiber content in the samples compared with control sample. Choi, *et al.* [23] reported that quality characteristics of reduced-fat chicken sausages with 1 and 2% apple pomace fiber had significantly higher hardness than the control without apple pomace dietary fiber. Higher hardness value of South African hake (*Merluccius capensis*) sausage added with chicory root inulin(dietary fiber) than control sample [24] was observed. The result suggested that textural properties of pork emulsion sausage could be stabilized over the time of storage with the addition of SBP.

3.5 Effect of SBP addition on sensory properties of pork emulsion sausages during refrigerated storage.

Color, odor, taste, texture, appearance and overall likeness of the pork sausages added with and without SBP (0.25-1.0 %) at day 0 and 21 of storage were scored by 50-untrained panelists as shown in **Table 4.** Generally, no difference in all attributes among all samples ($p>0.05$) was observed except odor and texture likeness of control sample was lower than SBP samples ($p<0.05$) at day 0 of storage. Thus, the addition of SBP at various levels to pork emulsion

Table 4 Likeness score of pork emulsion sausages added with and withoutsweet basil leaves powder (SBP) at different levels during refrigerated storage for 21 days

Storage time (days)	SBP levels (%)	Likeness score*					
		Color	Odor	Taste	Texture	Appearance	Overall
0	Control	7.50±0.10aA**	7.00±0.15bA	7.80±0.12aA	7.00±0.15bA	7.37±0.50aA	7.50±0.56aA
	0.25	7.50±1.20aA	7.45±0.25aA	7.90±0.10aA	7.52±0.20aA	7.40±0.66aA	7.56±0.82aA
	0.50	7.48±0.50aA	7.50±0.36aA	7.89±0.26aA	7.56±0.30aA	7.43±0.52aA	7.49±0.59aA
	0.75	7.55±1.80aA	7.54±0.44aA	7.90±0.35aA	7.50±0.26aA	7.45±0.55aA	7.52±0.56aA
	1.0	7.50±1.00aA	7.50±0.50aA	7.85±0.66aA	7.50±0.30aA	7.44±0.80aA	7.55±0.70aA
21	Control	7.20±0.50aA	5.10±0.40bB	5.52±0.14bB	6.50±0.30aB	6.98±0.50aA	6.88±0.65aA
	0.25	7.45±0.20aA	6.80±0.10aB	6.80±0.28aB	6.78±0.30aB	7.10±0.45aA	6.84±0.50aA
	0.50	7.40±0.21aA	6.80±0.20aB	6.85±0.36aB	6.80±0.28aB	7.20±0.55aA	6.90±0.67aA
	0.75	7.42±0.20aA	6.80±0.10aB	6.85±0.50aB	6.80±0.40aB	7.08±0.58aA	6.86±0.55aA
	1.0	7. 50±0.24aA	6.85±0.04aB	6.82±0.20aB	6.82±0.20aB	7.10±0.70aA	6.87±0.54aA

* Mean ± SD (n = 3).

** Different lowercase letters within the same column in the same storage time indicate the significant differences ($p < 0.05$). Different uppercase letters within the same column in the same SBP level indicate the significant differences ($p < 0.05$).

sausages had no impact on sensory properties of all sa ples. The incorporation of other natural antioxidants such as chia seed extract (*Salvia hispanica*) (1, 1.5 and 2 %) [25] into emulsion sausages also had no impact on consumer likeness. At the end of storage, color, appearance and overall likeness of all samples remained unchanged (Table 4). However, the decrease in odor, taste and texture likeness for the sausage samples were found ($p<0.05$). The decreased odor, taste and texture likeness scores of sausage samples at day 21of storage was probably due to the presence of some lipid oxidation products in the sausages, which caused the off odor, taste and texture in the resulting sausages. Nevertheless, control sample had lower odor (5.10) and taste (5.52) likeness scores than did SBP samples ($p<0.05$). This was in accordance with the intensive oxidation taken place in the control sample at extended storage **(Fig. 1A** and **B).** SBP samples containing phenolic compound might prevent the coalescence of emulsion through its protective role in retardation of the oxidative damage to the protein, which act as an emulsifier. Proteins have emulsifying properties, yielding the stable meat emulsion. The oxidative damage of proteins has an impact on protein solubility, leading to aggregation and complex formation due to cross links, thus impairing their emulsifying property [26]. Phytochemicals in plant extracts might have increased the emulsion stability in the sausage through their protective role on proteins against oxidation [20] Thus, the addition of SBP was able to maintain sensory property of pork emulsion sausage during refrigerated storage for 21 days. Therefore, SBP can be incorporated into pork emulsion sausages without having any detrimental effect on the organoleptic quality of products.

4. Conclusion

Pork emulsion sausages treated with SBP (0.25-1.0 %) had lower L^* and higher b^* values, however, panelist could not detect any difference in the color of sausages treated with SBP, compared to the control. SBP was able to prevent lipid oxidation of emulsion sausages in dosedependent manner. Addition of SBP had no detrimental effect on the organoleptic properties. Thus, SBP at least 0.25 % can be used as an effective natural antioxidant in the pork emulsion sausages during refrigerated storage for 21 days.

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