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Effects of xanthan gum on physicochemical and sensory properties of black sesame spreads

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Abstract

Effects of xanthan gum at different levels, i.e. 0.00, 0.04, 0.06, and 0.08% (w/w), on physiochemical and sensory properties of black sesame spreads are examined. Chemical properties, i.e. peroxide, *p*-anisidine, and TOTOX values, of black sesame spreads with xanthan gum are improved, except acid value. The addition of xanthan gum has significant effects on hardness and adhesiveness of various spread samples (P≤0.05). Emulsion stability of black sesame spreads increases significantly with the addition of xanthan gum up to 0.04% (w/w). Appearance texture and overall acceptability of the black sesame spreads were distinctly preferred at 0.04% (w/w) of xanthan gum. In addition, sensory scores color of black sesame spreads with xanthan gum does not differ significantly from the control sample. The findings of this research provide useful information on utilization of xanthan gum for endowing spreads with desirable properties. Furthermore, the research also demonstrates an application of xanthan gum with black sesame possessing high nutritional ingredients to produce healthy food products.

Key words: Xanthan gum, Black sesame, Spreads, Physiochemical properties, Sensory characteristics

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1. Introduction

Sesame (*Sesamum indicum* L.) is one of the most important healthy crops. It is cultivated in tropical regions throughout the world for its edible seeds and oil (Hajimahmoodi *et al.,* 2010). Sesame seeds approximately contain 26.94–27.65% of proteins, 47.79−48.21% of fats, and 8.16–8.95% of carbohydrate (Gandhi and Srivastava, 2007). Nutritionally, sesame seeds are rich in oil with high levels of monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs), lignans, tocopherol and phytosterol (Elleuch *et al.,* 2007). Black and white sesame seeds are popularly consumed and employed in many heathy products in Thailand. Black sesame seeds had a relatively higher antioxidant capacity compared to white sesame seeds (Panzella *et al.,* 2012; Rangkadilok *et al.,* 2010). Regular consumption of sesame seeds provided many nutritional benefits, such as reducing serum cholesterol and enhancing antioxidant capacity in hypercholesterolemia (Chen *et al.,* 2005).

Black sesame seed has many household and industrial applications, such as a nutritious food for human health, and they can be used as an ingredient in salad dressing, bakery decoration, desserts, and spreads. During the past few years, the popularity for the nut and seed spreads has increased considerably. The development of black sesame spreads would potentially increase usage of black sesame seeds in food products and introduce consumers with a healthier, non-animal breakfast snack food. However, a major problem of oil−containing spread products is releasing of oil during storage, affecting long−term product stability (Guneser and Zorba, 2014; Gorrepati *et al.,* 2015). The separated oil contaminates the packaging and reduces marketability, which may lead to decrease in consumer acceptability and acceleration of oil oxidation (Shakerardekani *et al.,* 2013). Conventionally, emulsifying agents are employed to stabilize emulsions and improve the overall texture of the product. Emulsifier could be added at a level of 0.1–3% to prevent oil separation in walnut butter (Shakerardekani *et al.,* 2013). Various gums could be employed for improving stability in emlusions (Sun *et al.,* 2007; Khouryieh *et al.,* 2015; Niu *et al.,* 2017) and sesame spreads (Ereifej *et al.,* 2005)

Xanthan gum is a polysaccharide produced from bacteria fermentation process (*Xanthomonas campestris*). It is widely used as a thickener and fat replacers in various nut butter and sesame spread (Mousazadeh *et al.,* 2014; Emadzadeh *et al.,* 2012; Emadzadeh *et al.,* 2015). Despite the wide availability of sesame spread products, there are limited studies on alleviating oil−separation problems affecting marketability and acceptability of the products. Therefore, the main purpose of this research is to utilize xanthan gum for improving emulsion stability, chemical properties, physicochemical properties, and sensory characteristics of black sesame spread products.

2. Materials and Methods

2.1 Materials

Dried black sesame seeds, sesame oil, water, salt, and sugar were purchased from a local supermarket. Xanthan gum (commercial food grade) was purchased from Chemipan Corporation Co., Ltd. (Thailand). Isooctane, *p*-anisidine, isopropanol, phenolphthalein reagent and toluene were purchased from Sigma-Aldrich Corporation (St. Louis, Missouri., United States of America). Acetic acid, chloroform, potassium iodide, sodium thiosulfate, methanol, sodium hydroxide and hexane were purchased from RCI Labscan Ltd. (Thailand).

2.2 Black sesame spread preparation

Spread samples (100 g each) were prepared in a triplicate. Black sesame seeds (70 g) were roasted using a hot air oven at 125 ± 2°C for 15 min and grinded in a high speed grinder at 1,000 rpm. The black sesame paste was blended with 15 mL of sesame oil by a laboratory blender at high speed for 5 minutes. Subsequently, 10 g of sugar and 1 g of salt were added into the mixture. Xanthan gum dispersion (1 mL) was added to spread samples with final concentrations of 0.00, 0.04, 0.06, and 0.08% (w/w). After the preparation process, all samples were kept at room temperature for 24 h before analyzing.

2.3 Emulsion stability test

Emulsion stability was measured using the reported method (Wu, 2001). Briefly, the prepared samples (11 ± 0.5g) were weighted in test tubes (1.5 cm in diameter and 10 cm in height) and centrifuged at 3,420g for 5 min (Universal 32, Hettich Instruments, Tuttlingen, Germany). The height of the formed free oil-phase was measured using a vernier caliper. Emulsion stability (%) was calculated according to Equation (1).

$$\%\ \text{Emulsion stability} = \frac{Ht - Ho}{Ht} \times 100 \qquad (1)$$

where Ho is the height of oil phase and Ht is the total height of sample in the test tubes.

2.4 Textural analysis

Texture analysis of black sesame spreads were carried out using a TA.XT2i Texture Analyzer (Texture Technologies Corp Ltd. Hamilton, MA) equipped with a 25-kg load cell. Samples (250 ± 0.5 g) were filled into cups (65 mm in diameter and 60 mm in depth), and compression test was carried out using a 45° angle acrylic cone probe (30 mm in diameter and 35 mm in length). The maximum force (N) required for the cone to penetrate a distance of 10 mm into the sample at a crosshead speed of 30 mm/min and a trigger value of 0.04 N were determined as hardness. Adhesiveness was defined as the work necessary to pull the probe away from samples.

2.5 Chemical property analysis

A black sesame sample was extracted by dissolving in hexane (sample:hexane = 1:5 w/v). The mixture was blended by mechanical stirrer at 500 rpm (RW20 digital overhead stirrer, IKA Works, NC, USA), The mixture was filtered, dried with sodium sulfate anhydrous. Finally, the extractant was evaporated by R-300 Rotavapor® rotary evaporator (Buchi Labortechnik AG, Flawil, Switzerland) to produce the oil for further analysis.

Acid value of samples were determined by dissolving 5 g of oil and 2 mL of phenolphthalein solution with 125 mL of a mixed solvent consisting of isopropyl alcohol and toluene at a volume ratio of 1:1. Titrations were performed using accurately standardized 5.6 g/L potassium hydroxide to the end point of definite pink color which persisted at least for 30 s. Acid value was expressed as mg KOH/g sample (AOCS official method Cd 3a-63) (AOCS, 2004).

Peroxides value was measured by dissolving 10 g of oil in a 30-mL solution of acetic acid and chloroform at a volume ratio of 3:2 in a 250-mL Erlenmeyer flask. The mixture was then homogenized and filtered to remove residual oil. Subsequently, 0.5 mL of saturated KI solution was added and the solution was allowed to stand for 1 min with occasional shaking. Afterwards, 30 mL of distilled water was added. This solution was titrated with 0.1 N sodium thiosulfate until the yellow iodine color almost disappeared. Starch indicator solution (2 mL) was added and the titration was continued until the blue color disappeared (AOCS official method Cd 8-53) (AOCS, 1997).

The *p*-anisidine value was measured by dissolving 0.5 g of oil with isooctane in a 25-mL volumetric flask. The absorbance (abs) of the solution was measured at 350 nm with a spectrophotometer (Universal 32, Hettich Instruments, Tuttlingen, Germany). The fat solution with a volume of 5 mL was placed into a test tube and 5 mL of solvent into another test tube using a pipette. Exactly, 1 mL of the *p*-anisidine reagent was placed into each tube. After 10 min, the absorbance at 350 nm of the mixture in the first test tube was measured using the solution from the second test tube as a reference. (AOCS official method Cd 8-90) (AOCS, 1997).

TOTOX value was calculated to assess the total lipid oxidation in sesame spread using Equation (2) (Nawar, 1969).

$$\text{TOTOX value} = 2PV + AV \qquad (2)$$

where PV is peroxide value and AV is the *p*-anisidine value.

2.6 Sensory test

Sensory characteristic and overall acceptability of the control and four variations of black sesame spreads were evaluated by 50 experienced panels after approval from the Ethical Review Committee for Research in Human Subjects, Ministry of Public Health, Thailand (Reference number: 32/2561). Panelists comprised Nutrition and Dietetics students of the Faculty of Science and Technology, Valaya Alongkorn Rajabhat University under the Royal Patronage, Pathum Thani. A tablespoon of each sample was spread on 3 x 3 cm white breads and placed in polypropylene containers (4.5 cm in diameter and 3.3 cm in height) fitted with lids. Sensory test of spreads was performed using the 9-point hedonic test. All samples labeled with 3-digit random code numbers were randomly served to panelists. Samples were presented according to a Latin Square.

2.7 Statistical Analysis

The Completely Randomized Design or CRD was applied to create the different formulations of black sesame spreads for physicochemical property study. The Randomized Complete Block Design (RCBD) was applied for sensory study. Three replications were performed for each sample. The mean values recorded for each test were compared using analysis of variance (ANOVA). Tukey's test was applied to detect the differences among the spread samples ($P<0.05$).

3. Results and Discussion

3.1 Emulsion stability

Instability of emulsions leaded to problems of separated oil contaminating the packaging material, accelerating lipid oxidation and affecting consumer acceptability. (Shakerardekani *et al.,* 2013). The emulsion stability was not significantly different ($P>0.05$) for black sesame spread samples with xanthan gum at 0.02% (w/w) and control sample. The addition of the lowest concentration of xanthan gum does not affect emulsion stability. In contrast, the emulsion stability of black sesame spreads with higher concentrations of xanthan gum at 0.04–0.08% (w/w) was significantly improved. However, the emulsion stability of black sesame spreads containing 0.04, 0.06 and 0.08% (w/w) of xanthan gum was not significantly different (Table 1). Therefore, the minimum xanthan gum concentration of 0.04% (w/w) sufficient to improve emulsion stability of the black sesame spread. Xanthan gum could improve emulsion stability by increasing the viscosity of the water phase and water absorption properties of hydrocolloids and its continuity could hold oil droplets, leading to increased stability of emulsion (Huang *et al.,* 2001). In addition, some xanthan molecules might be adsorbed onto the droplet surfaces, increasing the electrostatic and steric repulsion between

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the droplets and predominating Van der Waals attraction (Qiu *et al.,* 2015). Findings of this result demonstrated that black sesame spreads consisting of 0.04% (w/w) xanthan gum could mitigate oil separation problem in water-in-oil emulsion spreads.

3.2 Texture properties

Results of texture measurements are presented in Table 1. Significant difference (P<0.05) was observed among hardness and adhesiveness values of black sesame spread samples. The hardness increased with increasing xanthan gum concentrations. Increasing viscosity at high xanthan gum concentration might result in hardening of the texture of the spread. A higher hardness value indicated a lower spreadability of the test product. Radočaj *et al*. (2011) showed that the addition of high amounts of a commercial stabilizer significantly lowered the sample spreadability.

Table 1 Emulsion stability and textural properties of black sesame spreads with various xanthan gum concentrations.

Xanthan gum (% (w/w))	Emulsion stability (%)	Hardness (N)	Adhesiveness (N.s)
0.00	77.00 ± 0.01^{b}	0.166 ± 0.320^{c}	2.91 ± 0.495^{c}
0.02	78.00 ± 0.01^{b}	0.336 ± 0.312^{bc}	3.12 ± 0.35b^{c}
0.04	82.00 ± 0.10^{ab}	0.432 ± 0.321^{b}	3.42 ± 0.65^{bc}
0.06	85.00 ± 0.03^{a}	0.534 ± 0.111^{ab}	4.03 ± 0.79^{b}
0.08	87.00 ± 0.04^{a}	0.654 ± 0.142^{a}	6.12 ± 0.91^{a}

* Presented data are average values of three replications ± standard deviation. Different letters within the columns indicate significant difference (P<0.05).

The adhesiveness increased with increasing xanthan gum content. Adhesiveness or stickiness is described as the force required to overcome the attractive forces between the food surface and the surface in which the food sample comes into contact (Glibowski *et al.,* 2008). Radočaj *et al*. (2011) also found that the spread adhesiveness exhibited lower values at higher levels of hemp oil content. Increasing the adhesiveness by increasing xanthan gum might attribute to the high viscosity of the aqueous phase (Gharibzahedi *et al.,* 2013).

3.3 Chemical properties

Chemical properties of black sesame spreads with and without xanthan gum are given in Table 2. The acid value of all black sesame spreads exhibited no statistically significant difference (P>0.05) and the mean value was 1.34−1.41 mg KOH/g. This result indicated that the addition of xanthan gum did not influence the content of free fatty acids as products of hydrolysis. Black sesame spreads with 0.02−0.08% (w/w) xanthan gum displayed the peroxide values that were significantly lower than the control sample (P<0.05). The black sesame spread with 0.08% (w/w) of xanthan gum showed the lowest peroxide value. The black sesame spreads with xanthan gum had *p*−anisidine value that were significantly lower than the control sample (P<0.05). No significant differences in *p*−anisidine were observed in black sesame spreads with xanthan gum concentrations of 0.02, 0.04, 0.06, and 0.08% (w/w). Therefore, xanthan gum did not significantly cause secondary oxidation product content. The TOTOX value of spreads with xanthan gum was significantly lower than the control sample (P <0.05).

Table 2 Chemical properties of black sesame spreads with various xanthan gum concentrations.

Chemical properties	Xanthan gum concentrations (% (w/w))				
	0	0.02	0.04	0.06	0.08
Acid value (mg KOH/g)	1.41±0.02[a]	1.34±0.01[a]	1.39±0.01[a]	1.39±0.01[a]	1.40±0.01[a]
Peroxide value (meq/kg)	8.59±0.32[a]	7.01±0.52[b]	7.00±0.12[b]	6.91±0.52[bc]	6.38±0.41[c]
p-Anisidine value	1.24±0.30[a]	0.41±0.23[b]	0.40±0.03[b]	0.44±0.73[b]	0.42±0.53[b]
TOTOX	15.07±1.61[a]	14.43±1.03[ab]	14.4±.03[b]	14.26±0.22[b]	13.18±0.99[b]

* Presented data are average values of three replications ± standard deviation. Different letters within the rows indicate significant difference (P<0.05).

The peroxide value is an indicator of hydroperoxides generated as primary products of lipid oxidation. Secondary oxidation products were monitored by *p*−anisidine values which revealed the past history of the oil. According to the results, peroxide values in black sesame spread samples with xanthan gum were lower than the control sample. Samples with xanthan gum also exhibited lower *p*−anisidine values when compared to the control sample. Our results indicated that an addition of xanthan gum could improve chemical properties of the black sesame spread products. Water absorption properties of xanthan gum increased the product viscosity, reducing diffusion rate of hydroperoxides and degradation to secondary product of lipid oxidation reaction (Berton−Carabin *et al.,* 2014). Furthermore, higher emulsion stability of spreads decelerated the lipid oxidation rate due to the reduction of oil separation. Thickening effects of xanthan gum also reduced O_2 transfer rate within the emulsions, depleting the starting materials for lipid oxidation reactions (Szterk *et al.,* 2013).

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3.4 Sensory properties

In the development of sesame spread, sensory properties such as aroma, color, spreadability, and texture are important factors determining consumer acceptability. The mean sensory scores of various parameters such as appearance, color, odor, texture, spreadability, and the overall acceptability of the black sesame spread formulations with various contents of xanthan gum are presented in Table 3.

Table 3 Sensory characteristics of black sesame spreads with different xanthan gum concentration.

Sensory Characteristics	**Xanthan gum (%)**				
	0	**0.02**	**0.04**	**0.06**	**0.08**
Appearance	5.62±1.55^{c}	6.40±1.17^{b}	7.42±1.51^{a}	7.23±1.27^{a}	5.62±1.55^{c}
Odor	6.96±0.81^{a}	7.00±0.51^{a}	7.06±1.01^{a}	6.95±1.61^{a}	6.95±0.41^{a}
Texture	6.32±1.60^{c}	6.72±1.60^{c}	7.68±1.31^{a}	7.08±1.29^{b}	6.62±1.53^{c}
Color	5.96±0.81^{a}	6.00±0.51^{a}	6.06±1.01^{a}	5.95±1.61^{a}	5.95±0.41^{a}
Spreadability	6.32±1.60^{b}	7.32±1.60^{a}	7.68±1.31^{a}	5.81±1.29^{c}	5.12±1.53^{c}
Overall acceptability	6.06±1.67^{c}	7.06±1.67^{b}	7.84±1.31^{a}	6.80±1.23^{bc}	6.78±1.25^{bc}

* Presented data are average values of three replications ± standard deviation. Different letters within the rows indicate significant difference (P<0.05).

The score of black sesame spread samples with 0.04 and 0.06 % (w/w) of xanthan gum showed marked preference in appearance. The control sample and the black sesame spread samples with 0.08% (w/w) of xanthan gum had the lowest appearance score. Regarding texture, the scores of black sesame spread formulations with 0.04 and 0.06% (w/w) of xanthan gum were significantly different from others and the control sample with a mean score of 7.68 ± 1.31 and 7.08 ± 1.29, respectively. The spread sample with xanthan gum of 0.04% (w/w) had the highest texture score. Radočaj *et al.* (2011) reported that when xanthan gum concentrations in black sesame spread formulations increased, the products became more cohesive because of water holding properties of xanthan gum. As shown in Table 1, higher xanthan gum concentrations exhibited higher adhesiveness values, relating to the sensory stickiness of black sesame spread. Over 0.04% (w/w) of xanthan gum presented in spreads displayed lowering preference in panelists because samples were too sticky. For the spreadability evaluation, the black sesame spread with 0.04% (w/w) of xanthan gum was the most acceptable one. In contrast, black sesame spread with 0.02% (w/w) of xanthan gum and the control sample possessed lower spreadability scores. Spreadability is an important attributing factor of spread because it is associated with how easy the product could be

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uniformly distributed over a surface. An addition of xanthan gum in the black sesame spread at a mass concentration exceeding 0.04% (w/w) also displayed a lower spreadability score. Higher xanthan gum concentrations leaded to higher hardness values and lower spreadability of the test products (see Table 1).

The results indicated that the addition of xanthan gum did affect the mean scores of appearances, texture, and spreadability. The results indicated that the addition of xanthan gum did not affect odor and color in black sesame spreads. The control sample and black sesame spreads with xanthan gum contents of 0.02, 0.04, 0.06, and 0.08% (w/w) had overall acceptability scores of 6.06 ± 1.67, 7.06 ± 1.67, 7.84 ± 1.31, 6.80 ± 1.23, and 6.78 ± 1.25 respectively. The black sesame spread formulation with 0.04% (w/w) of xanthan gum had the highest overall acceptability score.

The consumers rated all the sensory attributes for all sample between 5 and 7, which were evaluated as ‘‘average” to ‘‘like moderately”, respectively. Black sesame spreads with 0.04% (w/w) of xanthan gum had the highest scores approximately at 7 (“like moderately”) for all parameters except color, which is insignificant between all spread samples (“6: like slightly”). The addition of xanthan gum improved quality of sensory attributes of spreads. The black sesame spread with 0.04% (w/w) of xanthan gum displayed the positive acceptance with the most prominent preference.

4. Conclusions

Black sesame spreads added with xanthan gum was successfully developed. Black sesame spreads with xanthan gum exhibited improved emulsion stability and chemical properties. Based on measured physicochemical and sensory properties, the optimal concentration of xanthan gum in the black sesame spread formulation was 0.04% (w/w).

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