

The Effects of Wild Sage Seed Gum (*Salvia macrosiphon*) on the Rheological Properties of Batter and Quality of Sponge Cakes

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ABSTRACT: The aim of this study was to determine the rheological properties of sponge cake batters and physical (volume, density, moisture content, weight after baking and color) and sensory properties of sponge cake formulated with four different levels of wild sage seed gum (0, 0.5, 0.75 and 1.0 %). Sponge cake batters formulated with gums showed pseudoplastic (shear-thinning) and thixotropic (time-dependent) behavior. The apparent viscosity of cake batter significantly ($P < 0.05$) increased with increasing gum levels. Increasing the level of gum from 0.0 to 1.0 % significantly increased the volume of cake ($P < 0.05$), while the density values was decreased from 345 to 333 kg/m³ with increasing gum levels. The crumb color of samples was affected by the addition of wild sage seed gum. The sponge cake with 1.0 % gum exhibited a color, with L*, a* and b* equal to 86.61, 1.50 and 39.35, respectively. Gum addition increased the volume and porosity of the cakes and resulted in softer products. 1.0 % wild sage seed gum is suggested to use in sponge cakes to obtain the cakes with the acceptable volume, appearance, texture and total acceptance.

Keywords: Image Analysis, Rheological Properties, Sponge Cake, Wild Sage Seed Gum.

Introduction

Food industry is one of the most important industries throughout the world. In this industry, the production of products with a higher level of safety and nutritional value for promoting the human health is regarded as one of the most significant strategies causing the longevity increase and health promotion as well as obviation of hunger (Salehi *et al.*, 2016a). Some food additives such as starches or gums should be added to the bakery food products to obtain the desired quality. Gums are added to the food products mainly for their thickening and gelling properties. In addition to the obvious benefits of taste, texture, mouth feel, moisture control, and water mobility,

they also improve the overall product quality and stability by withstanding the demands of processing, distribution, storage and final preparation (Salehi & Kashaninejad, 2014).

The hydrocolloids extracted from seeds can be used extremely in food formulations because of their appropriate price, easy availability and proper functionality (Zamini *et al.*, 2015). The genus *Salvia* (*Labiatae*) is mucilaginous endemic plant, contains more than 700 species. Wild sage seeds (*Salvia macrosiphon*) are round small seeds, with a mucilage layer which could swell in water, giving viscous suspension properties that are comparable with commercial food hydrocolloids (Salehi & Kashaninejad, 2014). Some potential of the wild sage seed

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gum as a new source of hydrocolloid have been recently investigated by Salehi and Kashaninejad (2015).

In the bakery products, gums has been used to improve mixing and extension of shelf life of the products through moisture retention and prevention of syneresis in frozen foods and pie fillings (Ozkoc & Seyhun, 2015). Several studies have been carried out showing the potential use of hydrocolloids in bread making including wheat bread, whole wheat bread, rye bread, protein-fortified starch bread and frozen bread dough (Gómez *et al.*, 2007). Xanthan gum mixed with other gums is the most widely used in bakery products (Kaur *et al.*, 2015). Sharadanant and Khan (2003) reported that gum acacia increased the loaf volume and improved bread characteristics such as texture, cell wall structure and softness.

Kang *et al.* (1997) reported that many gum types including hydroxypropylmethylcellulose (HPMC), locust bean gum, guar gum, carrageenan, xanthan gum and agar resulted in acceptable breads. Cato *et al.* (2002) found that fine white and ground rice flours gave gluten-free breads of good quality when used in combination with carboxymethylcellulose (CMC) (0.8%) and HPMC (3.3%). In the study of Lazaridou *et al.* (2007), the effects of different gums (pectin, CMC, agarose, xanthan and oat β -glucan) on dough rheology and gluten-free bread quality were investigated. In the study of Özboy (2002) five different commercial food grade gums namely xanthan–guar gum blend, carrageenan gum, guar–carrageenan gum blend, xanthan–carrageenan gum blend and locust bean gum, were added to the corn starch to produce low phenylalanine starch–gum bread for phenylketonuria patients.

There is no available published data on sponge cake formulation containing wild sage seed gum. Therefore, the objective of the present investigation was to determine

the rheological properties of batters and physical, color changes and sensory analysis of sponge cake formulated with four different levels of wild sage seed gum (0, 0.5, 0.75 and 1 %).

Materials and Methods

- Gum extraction

The cleaned wild sage seeds were soaked in distilled water for 20 min at the pH of 7 and temperature of 25°C with water/seed ratio of 20:1. Separation of the hydrocolloid from the swollen seeds was achieved by passing the seeds through an extractor equipped (Panasonic, MJ-J176P, Japan) with a rotating plate that scraped the gum layer on the seed surface (Salehi & Kashaninejad, 2015). The extracted solution was then filtered and dried in an air forced oven at 50°C and finally the powder was milled, packed and kept at cool and dry condition. The dried samples were milled and passed through a 50 mesh sieve.

- Sponge cake preparation

The formulae of sponge cakes at four different wild sage seed gum levels are shown in Table 1. The ingredients used in the formula of sponge cakes were wheat flour, sucrose, sunflower oil, fresh eggs, baking powder, vanilla, wild sage seed gum, water and nonfat dry milk powder. For each cake, 30 g of cake batter was poured into a cake pan and baked at 200°C for 20 min in a oven toaster (Noble, Model: KT-45XDRC). The cooled cakes were packed in polypropylene bags at room temperature before textural analyses (Salehi *et al.*, 2016a; Salehi *et al.*, 2016b).

- The rheological properties of cake batters

The viscosity of sponge cake batters was measured using a rotational viscosimeter (Brookfield, DV2T, RV, USA). The rheological parameters of cake batters at different shear rate of 5, 10 and 20 s⁻¹ were studied using spindle RV-07 at 25°C.

Table 1. Formulation of sponge cakes

Samples	Wild sage seed gum	Wheat flour (gr)	Whole egg (gr)	Sucrose (gr)	Sunflower oil (gr)	Nonfat dry milk (gr)	Baking powder (gr)	Vanilla (gr)	Water (gr)
0.00	0.00 %	100	72	72	57	6	2	0.5	30
0.50	0.50 %	100	72	72	57	6	2	0.5	30
0.75	0.75 %	100	72	72	57	6	2	0.5	30
1.00	1.00 %	100	72	72	57	6	2	0.5	30

- Physical characteristics of cakes

The physical characteristics of cake including volume and density were measured. The volume and density of the sponge cake was determined by the canola displacement method and was averaged from three replications (Salehi, 2017).

The crumb colour of the cake samples from the midsection of the cakes were measured with a HP Scanner (Hp Scanjet 300). The image analyses of sponge cakes were performed using ImageJ software version 1.42e, USA. In the $L^*a^*b^*$ space, L^* is lightness/darkness that ranges from 0 to 100, a^* is redness/greenness that ranges from -120 to 120 and b^* is yellowness/blueness that ranges from -120 to 120 (Salehi & Kashaninejad, 2015).

- Sensory evaluation

The hedonic test was used to determine the degree of overall liking for the sponge cakes. For this study, trained consumers were recruited from the students, staff and faculty members. All consumers were interested volunteers and informed that they would be evaluating sponge cakes. For the sponge cake manufacturing study, 15 consumers received five samples and were asked to rate them based on the degree of liking on a nine-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely). Samples were placed on plates and identified with random three-digit numbers.

- Statistical analysis

Each measurement was conducted in quadruplicate. The experimental data were

subjected to an analysis of variance (ANOVA) for a completely random design using a statistical analysis system (SAS 9.1 Institute, Inc.). Duncan's multiple range tests were used to determine the difference among means at the level of 0.05.

Results and Discussion

- The rheological properties of cakes batter

Rheological information is valuable in product development. A good cake batter must retain sufficient viscosity to prevent the incorporated air bubbles from rising to the surface and being lost during initial heating (Lu *et al.*, 2010). Shear rate dependency of the apparent viscosity of sponge cake batters is shown in Figures 1 and 2. In the present study, the apparent viscosity of cake batters varied from 12.84 to 81.60 Pa.s, depending on the wild sage seed gum levels and shear rate. It was found that the apparent viscosity of cake batters decreased as the shear rate increased (shear thinning or pseudoplastic behavior). The apparent viscosity of cake batters clearly decreased from 77.20 to 41.65 Pa.s with increasing shear rate from 5 to 20 s^{-1} (1.0 % wild sage seed gum). Shear thinning behavior can be explained by the arrangement of microstructure with the flow direction as shear rate increases, thus the apparent viscosity decreases.

The apparent viscosity of cake batter decreased from 46.80 to 41.65 Pa.s during 180 second (shear rate=20 s^{-1} and 1.0 % wild sage seed gum). In addition sponge cake batters formulated with gums showed thixotropic behavior (time-dependent). In the study performed by Chun and Yoo (2004), the sponge cake dispersions showed

a high shear-thinning behavior. Sivaramakrishnan *et al.* (2004) found that the cake dough containing hydroxy propyl methyl cellulose had similar rheological properties as that of wheat flour dough and was suitable for making bread.

In general, the addition of wild sage seed gum to the cake formula led to an increase in the viscosity of cake batters (Figure 2). The batter with 1.0 % wild sage seed gum exhibited the highest viscosity among all cake batters. Higher apparent viscosity might help entrapment of air into the cake batters and causes higher volumes and

porosity values. In low apparent viscosity batters air bubbles could easily rise to the surface and be lost into the atmosphere (Turabi *et al.*, 2010).

- *Physical characteristics of cakes*

The physicochemical, sensory and transport properties of foods are largely dependent on crumb structure. Crumb structure affects appearance of crumb volume and texture of bakery product (Turabi *et al.*, 2010). Changes in cake characteristics with added wild sage seed

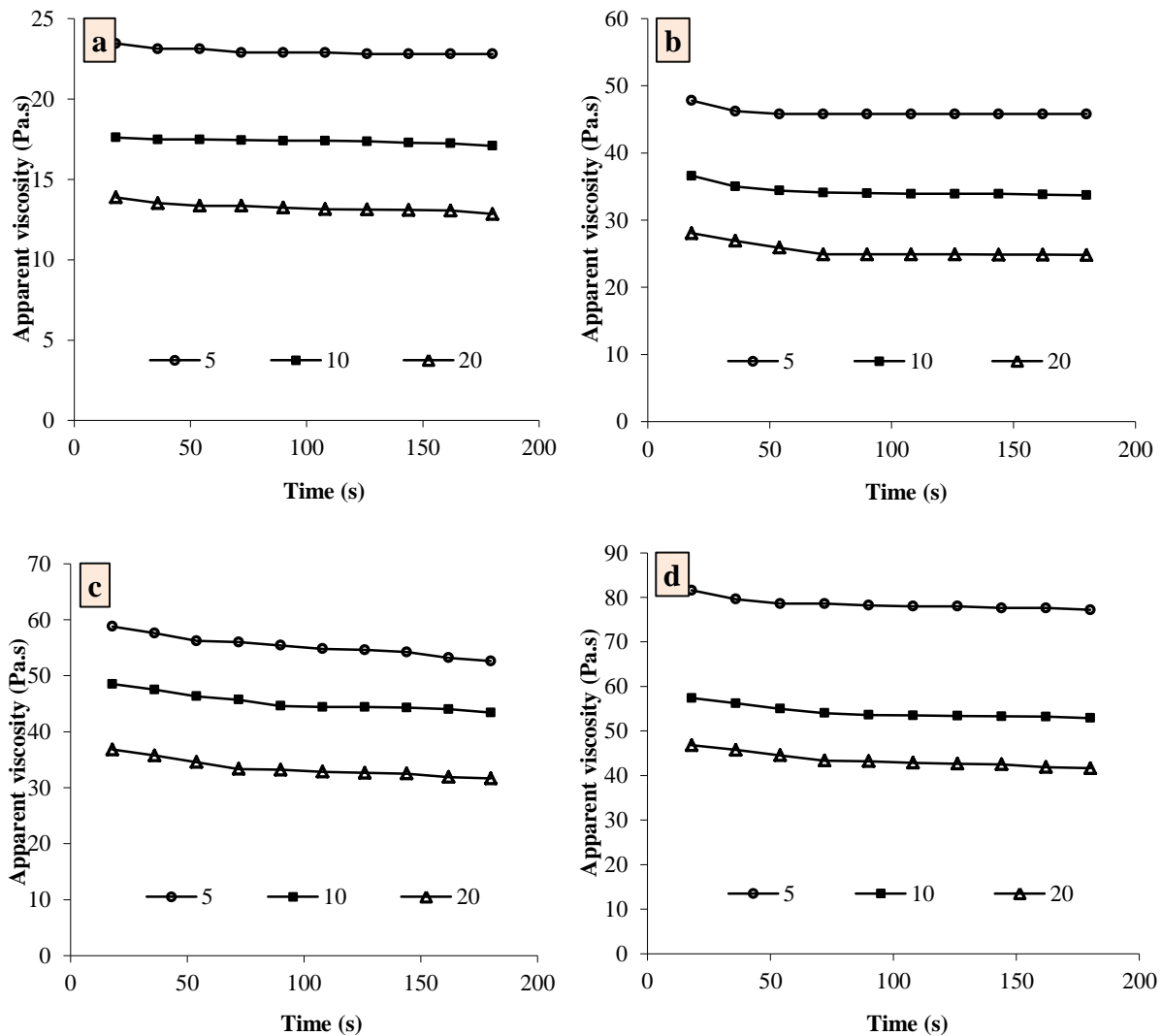


Fig. 1. The rheological properties of sponge cake batters as a function of shear rate (s^{-1}) and time (s) at different concentration of wild sage seed gum; a: 0.0% , b: 0.5% , c: 0.75% and d: 1%.

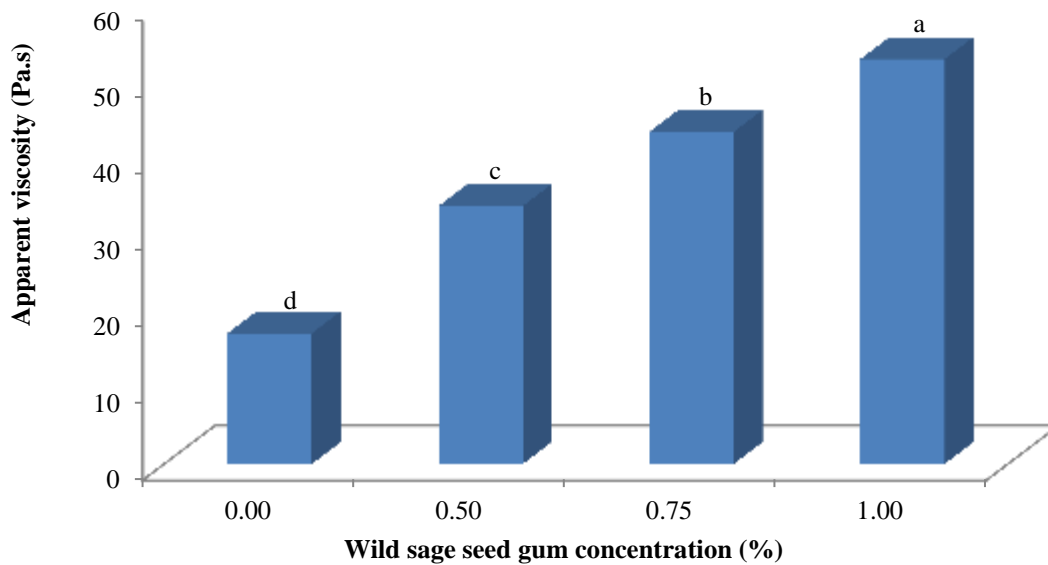


Fig. 2. The apparent viscosity of sponge cake batters (shear rate=10 s⁻¹).
* Means with different letter within columns are significantly different (P<0.05).

gum are shown in Table 2. A significant increase in cake volume was noted with an increase in the gum level. As can be observed from Table 2, the highest volume were obtained for cake containing 1% wild sage gum. The control sample had an average cake volume of 68.16 cm³, increasing to 70.57, 71.54 and 74.04 cm³ for 0.5, 0.75 and 1.0 %, respectively (P<0.05). The density values decreased from 345 to 333 kg/m³ with increasing gum levels from 0.0 to 1.0 % (P<0.05). These results can be related to the rheological properties of the cake batters (Turabi *et al.*, 2010).

In addition, the moisture content and weight after baking values increased from 18.4 to 19.2 % and 23.53 to 24.63 gr, with increasing gum levels from 0.0 to 1.0 %, respectively (P<0.05). Shi and BeMiller (2002) quantified the effect of Hydrocolloids addition on starch suspensions viscosities before pasting. They showed that the effect depended notably on the kind of hydrocolloid added and the origin of the starch suspension used. When wheat starch was tested, xanthan and guar gum, in this order, brought about the highest viscosity

increases, whereas alginate hardly showed any significant increase. This might help to explain the differences in volume of the hydrocolloid-added cakes obtained in this study. The higher viscosity values of xanthan containing batters improved cake structure and this resulted in higher volumes. In the study of Miller and Hosney (1993), it was shown that xanthan gum significantly improved the cake volume.

The results of color measurement of sponge cake with wild sage seed gum are presented in Figure 3. The crumb colour of samples was affected by the addition of wild sage seed gum (P<0.05). The L* (lightness) and a* (redness) indexes values increased from 82.15 to 86.61 and 0.31 to 1.50 with increasing gum levels from 0.0 to 1.0 %, respectively, while b* (yellowness) index values decreased from 43.25 to 39.35 with increasing gum levels from 0.0 to 1.0 % (P<0.05). In general, as the gum level is increased, the crumb colour became brighter. The sponge cake with 1.0 % gum exhibited a color, with L*, a* and b* equal to 86.61, 1.50 and 39.35, respectively.

Table 2. Physical characteristics of sponge cakes with different concentration of wild sage seed gum

Wild sage seed gum (%)	Volume (cm ³)	Density (kg/m ³)	Moisture (%)	Weight after baking (gr)
0.00	68.16±1.32 ^c	345±5.84 ^a	18.4±0.14 ^c	23.53±0.08 ^c
0.50	70.57±0.81 ^b	343±1.11 ^{ab}	18.7±0.11 ^b	24.21±0.19 ^b
0.75	71.54±1.27 ^b	340±3.07 ^b	19.0±0.19 ^{ab}	24.34±0.17 ^b
1.00	74.04±1.57 ^a	333±2.29 ^c	19.3±0.21 ^a	24.63±0.23 ^a

* Means and standard deviations are reported (n = 3).

** Means with different letter within columns are significantly different (P<0.05).

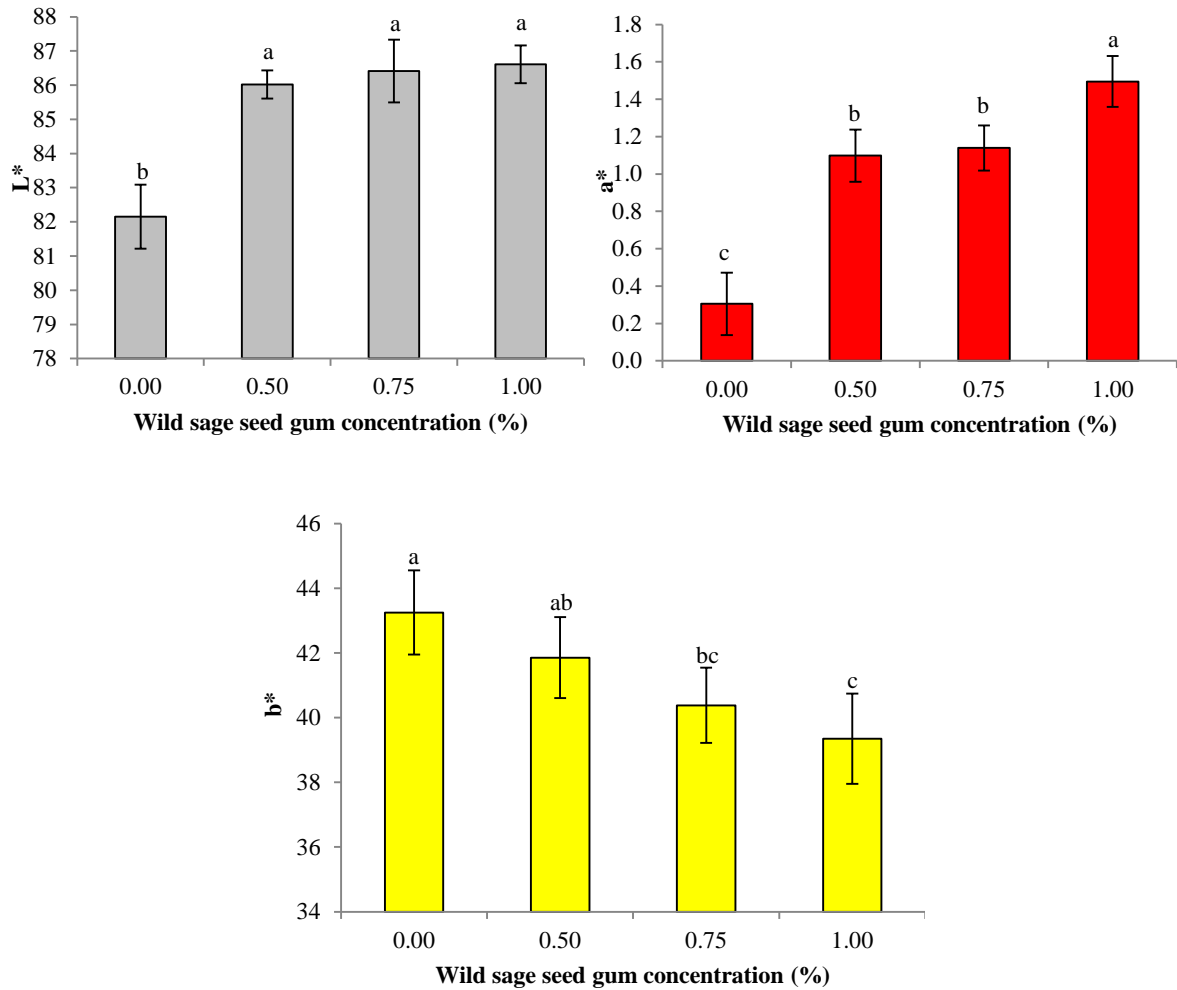


Fig. 3. Crumb color indexes (L* a* b*) of sponge cakes with different concentrations of wild sage seed gum.

* Means ± standard deviation

** Means with different letter within columns are significantly different (P<0.05).

- Sensory evaluation

For measuring product liking and preference, the hedonic scale is a unique scale, providing both reliable and valid results. Statistically significant differences evaluated by the trained consumers were

found in the crumb color, odor desirability, porosity, appearance, flavour, texture and total acceptance scores among the 0, 0.5, 0.75 and 1 % of wild sage seed gum concentration (Table 3). Wild sage seed gum addition increased the volume and porosity

of the cakes and resulted in softer products. The crumb color, porosity, appearance, flavour, texture and total acceptance desirability of sponge cake samples were increased by increasing gum concentration from 0.0 to 1.0 %. However, the sensory characteristics liking scores of 0.0% were lower than those of the other cakes and was darker. According to the sensory analysis results, the addition of 1% wild sage seed gum in sponge cakes formulation is suggested to obtain the cakes with the satisfactory volume, appearance, texture and total acceptance.

Conclusion

In this study a novel formulation of sponge cake production with wild sage seed gum was developed. Sponge cake batters formulated with gums showed shear-thinning and thixotropic behavior. The addition of wild sage seed gum to the cake formula led to an increase in the viscosity of cake batters. A significant increase in cake volume was noted with an increase in the gum concentration. The density values decreased from 345 to 333 kg/m³ with increasing gum concentrations from 0.0 to 1.0 %. The crumb colour of samples was affected by the addition of wild sage seed gum. The sensory characteristics liking results pointed out that the addition of 1% wild sage seed gum in sponge cakes formulation is satisfactory.

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Table 3. Sensory evaluation of sponge cakes containing different concentrations of Wild sage seed gum

Gum concentration	Crumb colour lightness	Odor desirability	Porosity	Appearance	Flavour	Texture	Total acceptance
0.00 %	5.8±1.1 ^b	5.9±1.0 ^a	5.5±1.6 ^b	5.9±1.2 ^b	5.0±1.2 ^b	5.1±0.9 ^b	5.9±1.2 ^c
0.50 %	6.8±1.6 ^{ab}	6.5±2.1 ^a	6.4±1.3 ^{ab}	7.0±1.6 ^a	6.7±0.9 ^a	6.6±0.8 ^a	6.6±1.0 ^{bc}
0.75 %	7.4±1.3 ^a	6.7±1.5 ^a	7.2±1.6 ^a	7.7±0.9 ^a	6.8±1.5 ^a	6.8±1.0 ^a	7.2±1.0 ^{ab}
1.00 %	7.7±1.0 ^a	6.3±2.3 ^a	7.6±1.2 ^a	7.7±1.2 ^a	7.0±1.1 ^a	7.3±1.0 ^a	7.8±0.8 ^a

Nine-point hedonic scale with 1, 5, and 9 representing extremely dislike, neither like nor dislike, and extremely like, respectively.

* Means and standard deviations are reported (n = 3).

** Means with different letter within columns are significantly different (P<0.05).

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