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Physicochemical Qualities and Consumer Perception of Tomato Sponge Cakes

- Research Note -

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Abstract

The effects of differing baking ingredient formulations on physicochemical qualities and consumer preferences were investigated using sponge cakes incorporated with tomato powder, a healthy and beneficial food ingredient, as a model system. Tomato powder was incorporated into cake batter at four different amounts (0%, 10%, 20%, and 30%, w/w) by replacing equivalent amount of wheat flour. After appropriate mixing, sponge cakes were baked and cake quality attributes were evaluated after cooling. Specific volume decreased with an increase in the tomato powder substitution, although not significantly ($p>0.05$). On the other hand, baking loss increased from 10.3 (control) to 13.4 (30% sample) as the tomato powder level increased in the formulation. Lightness (L^*) decreased significantly from 79.5 to 74.1 whereas the firmness significantly increased with the higher incorporation of tomato powder ($p<0.05$). The consumer preferences on color, taste, and flavor, but not softness, were significantly affected by the amount of tomato powder incorporated in the sample ($p<0.05$). With respect to overall acceptability, the 20% sample received the highest mean score of 5.1, although this was not significantly different from the 10% sample or control ($p>0.05$). The incorporation of tomato powder, up to 20%, in the formulation of sponge cakes did not significantly influence the consumers' acceptability in all attributes tested.

Key words: sponge cake, tomato powder, physicochemical, consumer preference

INTRODUCTION

The tomato (*Lycopersicon esculentum*) is one of the major agricultural products commonly consumed and is an important part of the human diet. Tomatoes contain high amounts of folate, vitamins A and C, and carotenoids (1). In fact, lycopene is the major carotenoid in the tomato (2) and is well known to protect against oxidative damage (3,4). According to previous studies, tomato consumption and prostate cancer are inversely related (5). In addition, tomato extracts were reported to contain antioxidant and hepatoprotective effects (2).

As many consumers are interested in safe, convenient, and health-promoting food products, much attention was recently given to develop healthy functional food products. Among them, sponge cakes are one of many favored baking products whose properties can be easily improved by incorporating various kinds of food ingredients. As reported in numerous studies, the quality of sponge cakes is based on powder preparations of various functional food ingredients such as *Dioscorea japonica* (6,7), onion (8), *Pleurotus eryngii* mushroom (9), chitosan (10), mulberry leaf (11), *Capsosiphon fulvescens* (12), ginseng (13), persimmon leaf (14), *Gastrodiae rhizoma* (15), *Grifola frondosa* (16), red ginseng marc (17), rosemary (18), bamboo leaf (19), *Brassica compestris* (20), and *Ecklonia cava* (21).

Identifying ways to incorporate tomatoes in bakery products, as a value-added food component and a healthy food ingredient, could prove beneficial. Because baked foods are consumed worldwide, they can be good candidates for carriers of bioactive components and dietary fiber (22). Despite previous investigations, information regarding the potential for incorporation of tomato powder in bakery products, such as sponge cakes, and the contribution towards physicochemical properties and consumer acceptance are scant. Therefore, the objectives of this study were to: 1) evaluate the impact of baking on selected physicochemical properties and consumer preferences for sponge cakes incorporated with different levels of tomato powders; 2) provide valuable consumer-based experimental data in developing new types of value-added or functional foods.

MATERIALS AND METHODS

Preparation of raw materials

The soft wheat flour (CJ Corp., Seoul, Korea), granulated sugar (CJ Corp., Incheon, Korea), butter (Seoul Milk Coop., Yongin, Gyeonggi-do, Korea), baking pow-

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der (Yuchung Foods Co., Ltd., Daegu, Korea), roasted salt (Bora Food Co., Ltd., Naju, Jeonnam, Korea), powdered skim milk (Seoul Dairy Co-op, Yangju, Gyeonggi-do, Korea), and eggs were purchased from a local market and stored at room temperature before use. One hundred grams (dry weight basis) of the soft wheat flour contained 77 g of carbohydrates, 5 g of protein, 1.5 g of lipids, and 10 mg of sodium.

Fresh tomatoes were also obtained from a local market. After washing and removing the stem, tomatoes were sliced, placed into a deep freezer (VLT 1450-3-D-14, Thermo Electron Corp., Asheville, NC, USA) at -35°C for 24 hr, and lyophilized using a freeze dryer (FDU-1100, Tokyo Rikakikai Co., Tokyo, Japan) at a vacuum pressure of 8.5 Pa. Dehydrated tomatoes were analytically milled (DA-282, Daesung Artlon Co., Ltd., Paju, Gyeonggi-do, Korea) at maximum speed for 90 sec and sieved to yield particle sizes less than 250 μm. Tomato powders were then placed in a desiccator containing silica gel, within a day, prior to making the sponge cake.

Cake preparation

Formulations used for the sponge cakes are given in Table 1. Sponge cakes were prepared by partial substitution, up to 30% (wt.), of tomato powder based on the total weight of the soft wheat flour and tomato powder mixture. A sponge cake prepared without tomato powder was used as a control cake.

A single-bowl mixing procedure was used. Eggs, butter, sugar, and about 60% of the other ingredients were mixed for 3 min at speed 1 using a Kitchen Aid mixer (5K5SS, KitchenAid Inc., St. Joseph, MI, USA). The remaining ingredients were added and the batter mixture was further mixed for 4 min at speed 4, and for an additional 1 min at speed 2. 600 g of cake batter was placed into a metallic, lard-coated circular pan (210 mm diameter × 40 mm height), and baked for 35 min at 185°C. Six cakes of each batter were baked, and each formulation was prepared in duplicate. Cake quality attributes were evaluated after a 3 hr cooling period at room temperature.

Table 1. Formulation of sponge cakes on substitution of tomato powder for flour

Ingredients (g)	Control	Percentage of substitution (%)		
		10	20	30
Flour	200	180	160	140
Sugar	220	220	220	220
Egg	110	110	110	110
Butter	100	100	100	100
Powdered skim milk	16	16	16	16
Baking powder	6	6	6	6
Salt	4	4	4	4
Water	144	144	144	144
Tomato powder	0	20	40	60

Physicochemical measurements of sponge cakes

The volume of the cake was determined by seed displacement (23). After removal from the pan, the cake was weighed and the specific volume was calculated by the ratio of volume to weight. The baking loss was calculated using the equation below (24):

$$\text{Baking loss } (\%) = \frac{W_{batter} - W_{cake}}{W_{batter}} \times 100$$

Color was measured using a spectrophotometer (Minolta CM-600d, Minolta Co., Ltd., Osaka, Japan). Crumb color was checked at 5 different points on each cake and results were expressed in the CIE $L^*a^*b^*$ color space. Crumb firmness was measured using an Advanced Universal Testing System (LRXPlus, Lloyd Instrument Ltd., Fareham, Hampshire, UK) and an aluminium 12.45 mm diameter cylindrical probe. During the test, the probe speed was 1 mm/sec and the compression distance was 6 mm. The peak force was measured in kg_f. A total of 30 measurements were taken.

Consumer testing

The consumer-acceptance test was conducted on 40 adults who were informed that the sponge cakes were made by adding various amounts of tomato powder. All samples were labeled with randomly generated three-digit numbers and four samples were presented in random order. Participants were asked to smell before tasting each sample of cake. After evaluating each sample, participants judged color, flavor, taste, softness, and overall acceptability using a structured numeric scale of seven points (7-point hedonic scale), wherein 7=like very much, 6=like moderately, 5=like slightly, 4=neither like nor dislike, 3=dislike slightly, 2=dislike moderately, and 1=dislike very much. Consumers received a tray containing the samples, a glass of water, and an evaluation sheet. Participants were asked to rinse their palates between samples and break for 30 sec. Enough space was given to handle the samples and the questionnaire, and the evaluation time was not constrained.

Statistical analysis

The statistical analysis was done using the SAS Statistical Analysis System for Windows v9.1 (SAS Inst. Inc., Cary, NC, USA). The means were compared with Duncan's Multiple Range test ($p<0.05$).

RESULTS AND DISCUSSION

Selected physicochemical properties

Table 2 presents selected physicochemical properties of sponge cakes as influenced by tomato powder sub-

Table 2. Selected physicochemical properties of sponge cakes as influenced by tomato powder substitution

Property	Sample			
	Control	10%	20%	30%
Specific volume (mL/g)	4.5±0.2[NS]	4.4±0.0	4.3±0.1	4.2±0.3
Baking loss (%)	10.3±1.9[NS]	12.9±3.0	13.1±0.7	13.4±1.0

[NS]Not significantly different ($p>0.05$).

stitution. Specific volume decreased with the increase in the tomato powder substitution, though not significantly ($p>0.05$). A similar decrease was found for sponge cakes made with *Capsosiphon fulvescens* powder (12), *Brassica compestris* (20), and erythritol (25). This is probably due to the lower relative gluten content in the formulation from replacement of the flour with tomato powder, thus reducing the gas holding capacity of the batter (12). Baking loss, on the other hand, appeared to increase from 10.30 (control) to 13.40 (30% sample) as the tomato powder level increased in the formulation. A similar finding was reported for the sponge cakes made with *Ecklonia cava* powder (21). The baking loss was caused by the vaporization of moisture in the batter as the heat was transferred during baking process (12).

Table 3 shows the color characteristics of sponge cakes influenced by the tomato powder. Lightness (L^*) decreased significantly, from 79.50 to 74.09, as the tomato powder level increased in the formulation ($p<0.05$), owning to the distinctive color characteristics of tomato powder. Similar decreases in L^* are caused by the incorporation of other food ingredient powders such as *Capsosiphon fulvescens* (12), *Grifola frondosa* (16), paprika (26), and red ginseng marc (17). Redness (a^*) and yellowness (b^*) increased significantly as the tomato powder increased ($p<0.05$). In a parallel study with ginseng powder, as the amount incorporated into the formulation increased, L^* decreased while a^* and b^* increased significantly ($p<0.05$) (13).

Firmness of sponge cakes increased significantly as the tomato powder content increased in the formulation ($p<0.05$) (Fig. 1). Increase in tomato powder level from 0 to 30% resulted in a 100.66% increase in the firmness, suggesting that the tomato powder hindered the incorporation and maintenance of bubbles in the cake batters, resulting in the compact structure inside the cake (8,9,11). Other food ingredients, such as black rice flour (27), *Pleurotus eryngii* mushroom powder (9), wheat-rice composite flour (28), and *Capsosiphon fulvescens* powder (12), also caused similar increases in the firmness of sponge cakes.

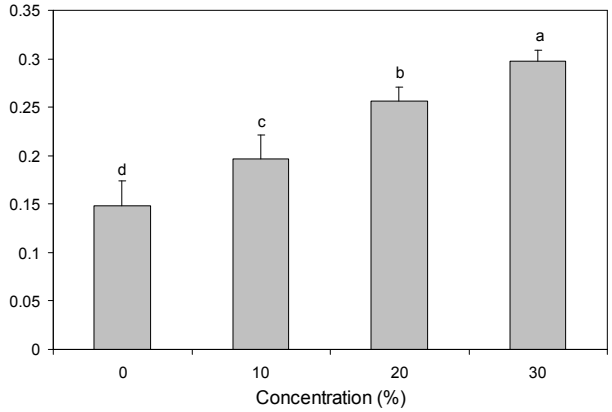

Fig. 1. Crumb firmness as influenced by tomato powder substitution. [a-d]Means bearing unlike letters are significantly different ($p<0.05$).

Table 3. Color characteristics of sponge cakes as influenced by tomato powder substitution

Sample	Color characteristics		
	L^*-value	a^*-value	b^*-value
Control	79.5±1.6[a]	-7.4±0.2[d]	24.2±1.0[d]
10%	72.8±0.9[b]	0.7±0.5[c]	42.5±2.0[c]
20%	74.8±0.9[b]	4.2±0.6[b]	44.1±2.0[b]
30%	74.1±0.8[b]	7.5±0.6[a]	47.4±1.3[a]

[a-d]Means (±standard deviation) within the same column bearing unlike letters are significantly different ($p<0.05$).

Consumer preference

A 7-point hedonic scale was used to determine which sponge cakes, incorporated with different levels of tomato powder, the majority of consumers preferred. Table 4 shows the mean scores of consumer acceptance results for the following attributes: color, taste, softness, flavor, and overall acceptability. In terms of color, the control, 10%, and 20% samples received the comparatively favorable mean scores of 5.48, 4.85, and 4.83, respectively with no significant difference ($p>0.05$). The 30% sample received the lowest mean score of 3.95 with respect to color among all samples tested ($p<0.05$). In fact, color

Table 4. Mean scores of consumer acceptance results (7-point hedonic scale) for sponge cakes incorporated with different levels of tomato powder

Sample	Consumer attributes				
	Color	Taste	Softness	Flavor	Overall acceptability
Control	5.48[a]	4.88[a]	4.73[a]	4.53[a]	4.98[a]
10%	4.85[a]	4.68[ab]	4.80[a]	4.75[a]	4.85[a]
20%	4.83[a]	4.88[a]	4.73[a]	4.93[a]	5.08[a]
30%	3.95[b]	4.00[b]	4.65[a]	3.75[b]	3.65[b]

[a,b]Different letters within the same column indicate significant difference ($p<0.05$).

acceptance appeared to decrease as the percent of tomato incorporation increased in the formulation. Similar results were reported for sponge cakes containing various levels of yacon powder (29).

The consumer preferences on taste and flavor were also significantly affected by the amount of tomato powder incorporated in the sample ($p<0.05$). While the scores of taste and flavor acceptability insignificantly varied from 4.00 to 4.88 and 3.75 to 4.93, respectively, the 30% samples received significantly lower scores ($p<0.05$). The consumer preference on softness was not significantly influenced by the amount of tomato powder incorporated in the sample ($p>0.05$).

With respect to overall acceptability, the 20% sample received the highest mean score of 5.08; however, this was not significantly different from the control and 10% sample ($p>0.05$). The 30% sample received the lowest mean score of 3.65, significantly lower compared to other samples ($p<0.05$). Interestingly, the incorporation of up to 20% tomato powder in the formulation of sponge cakes did not significantly influence the consumers' acceptability in all attributes tested. Therefore, incorporation of 10% tomato powder in the formulation of sponge cakes would be recommended while taking advantages of the health benefits of tomatoes without sacrificing the quality acceptance by the consumers.

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