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Quality Attributes of Cookies Prepared with Tomato Powder

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Abstract

This study was conducted to investigate the quality characteristics of cookies added with different levels of tomato powder. Cookies were prepared with five different levels of tomato powder (0, 2.5, 5.0, 7.5, and 10.0%) and the physicochemical properties were examined. The pH of cookie dough decreased significantly by the addition of tomato powder ($p<0.05$). Crude protein and ash content of the cookies containing 5.0, 7.5 and 10.0% tomato powder were significantly higher than those of control and those with 2.5% ($p<0.05$). The spread factor of control cookie was lower than that of cookies containing 5.0, 7.5, and 10.0% tomato powder. The incorporation of tomato powder in cookies lowered the lightness values but increased redness and yellowness values. Rheology testing showed that cookies with 5.0, 7.5, and 10.0% tomato powder had significantly lower hardness value than control. Sensory evaluation revealed that overall desirability scores were not significantly different between control and tomato powder added groups. Therefore, cookies with up to 10.0% added tomato powder would be as acceptable as control cookies without depressing cookie quality.

Key words: tomato powder, cookies, quality

INTRODUCTION

Cookies are widely consumed baked products which can be served from breakfast to bedtime. Cookies are appreciated for their taste, aroma, convenience, and long shelf stability due to low moisture content. Recently, increasing consumer demand for healthier foods has triggered the development of cookies made with natural ingredients exhibiting functional properties and providing specific health benefits beyond those to be gained from traditional nutrients. Different types of cookies containing diverse functional ingredients have been developed. For example, bamboo leaf powder (1), dried red ginseng powder (2), *Angelica* plant powder (3), soybean paste powder (4), *Lycii fructus* powder (5), barely bran (6), potato peel (7), hot water extract of roasted safflower (8), garlics (9), and barley germ (10) were used as cookie ingredients and quality characteristics were investigated.

Tomatoes are an integral part of the human diet rich in several nutrients including vitamin A, vitamin C, potassium, calcium and lycopene. Most tomatoes produced worldwide are used as tomato juice, paste, ketchup and sauce, although a number of tomatoes are commonly consumed fresh (11). Recent studies have indicated that a diet rich in tomatoes and tomato products is associated with a reduced risk of certain cancers (12). The consensus seems to be that lycopene, a major carotenoid present in red tomatoes having antioxidant capacity is a natural cancer-fighting agent (13-17). It is also suggested that complex interactions among multiple nutrients present in tomatoes contribute to its anticancer properties (18).

The objective of this study was to evaluate the effects of tomato powder on the quality characteristics of cookies. Cookies were prepared with tomato powder which was substituted for 0%, 2.5%, 5%, 7.5% and 10% of wheat flour and the physicochemical and sensory properties were investigated.

MATERIALS AND METHODS

Materials

Ingredients for cookies such as wheat flour (CJ Co., Korea), milk (Seoulmilk Co., Korea), sugar (CJ Co., Korea), butter (Seoulmilk Co., Korea), egg and baking powder (Ruf, Germany) were purchased from a local market. Tomato powder (100%) was obtained from Jungshin Co. (Korea) and had the following proximate composition: moisture 14.89%, protein 20.36%, fat 0.35%, and ash 8.97%.

Preparation of cookies

The cookie recipe used in this study is shown in Table 1. Tomato powder was used to replace part of the wheat flour (0%, 2.5%, 5.0%, 7.5% and 10.0%) in a standard cookie recipe. Egg, butter and sugar were creamed in a hand mixer (62680, Proctor-Silex, USA) for 2 min.

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Table 1. Recipes for cookies prepared with tomato powder

Ingredients (%)	Group[1)]				
	T-0	T-2.5	T-5.0	T-7.5	T-10.0
Flour	100.0	97.5	95.0	92.5	90.0
Tomato powder	0.0	2.5	5.0	7.5	10.0
Butter	50.0	50.0	50.0	50.0	50.0
Sugar	40.0	40.0	40.0	40.0	40.0
Egg	20.0	20.0	20.0	20.0	20.0
Baking powder	1.0	1.0	1.0	1.0	1.0

[1)]T-0: 0% substitution for flour, T-2.5: 2.5% substitution for flour, T-5.0: 5.0% substitution for flour, T-7.5: 7.5% substitution for flour, T-10.0: 10.0% substitution for flour.

Flour, tomato powder and baking powder were sifted and added to the liquid ingredients and mixed for 30 seconds. The dough was wraped in plastic wrap and refrigerated for 1 hour until set. The firm dough was then sheeted to a thickness of 5 mm thick with roller and cut with a cookie cutter of 50 mm diameter. The cookies were then transferred to a lightly greased baking tray and baked in an oven (FDO-7103, Daeyoung Co., Korea) at an upper heating temperature of 170°C and lower temperature of 140°C for 14 min. The baked cookies were removed from the baking pan, cooled to room temperature for 1 hr before analyses.

Proximate composition analysis

Moisture, crude protein, crude fat and ash content were determined according to the AOAC method (19).

Physical characteristics

Five grams of cookie dough and 45 mL of distilled water were mixed completely and the pH was measured using a pH meter (inoLab, Germany). Cookie diameter (D) and thickness (T) of six cookies were measured as described in the AACC methods (20). The spread factor was calculated as D/T.

Color measurement

Surface color of cookies was determined by measuring tristimulus L (lightness), a (redness), b (yellowness) values with a colorimeter (JX 777, Juki, Japan) calibrated with a white standard plate (L= +98.5, a= +0.07, b= -0.40).

Texture measurement

The textural characteristics of the cookies were determined using a rheometer (Compac-100, Sun Scientific Co., Japan). Cookies were evaluated by compressing twice to 50% of their original height. The textural variables were hardness, cohesiveness, springiness, chewiness and brittleness. Operating conditions were as follows: test type: mastication, load cell: 10 kg, adaptor type: circle (diameter 5 mm), table speed: 120 mm/min.

Sensory evaluation

Sensory evaluation was conducted after cooling the cookies for 1 hr at room temperature. Cookies were placed on a plastic dish coded by a three-digit random number and offered to 8 trained panelists in an individual booth with lighting. Surface color, tomato smell, tomato taste, hardness, crispness and overall desirability were evaluated using the nine-point scale with 9 indicating strong attributes.

Statistical analysis

All data were recorded as means±standard deviation of at least triplicate measurements. Means were compared with Duncan's multiple range test with $\alpha = 0.05$ and Pearson correlations were performed using SAS (Statistical Analysis System, version 8.12).

RESULTS AND DISCUSSION

Proximate composition

The results of the proximate composition of cookies prepared with tomato powder are shown in Table 2. Moisture content of control was 7.95% and that of cookies containing tomato powder ranged from 7.17 to 7.86%. Crude protein and ash content values of the cookies containing tomato powder of 5.0, 7.5 and 10.0% were significantly higher than those of control and 2.5% added sample ($p<0.05$). This is attributable to the higher pro-

Table 2. Proximate compositions of cookies prepared with tomato powder (% wet basis)

	Moisture	Crude protein	Crude fat	Ash
Wheat flour	12.25±0.19	9.90±0.34	0.99±0.05	0.42±0.10
Tomato powder	14.89±0.01	20.36±0.07	0.35±0.01	8.97±0.01
T-0[1)]	7.95±0.22[c2)]	7.41±0.00[a]	21.35±0.61[a]	0.74±0.09[a]
T-2.5	7.17±0.20[a]	7.65±0.10[a]	22.38±0.79[a]	0.75±0.01[a]
T-5.0	7.47±0.25[ab]	8.56±0.10[b]	21.39±0.55[a]	0.86±0.01[b]
T-7.5	7.86±0.20[c]	9.04±0.11[c]	21.65±1.27[a]	0.95±0.01[c]
T-10.0	7.60±0.20[bc]	9.09±0.21[c]	21.74±0.83[a]	1.09±0.01[d]

[1)]See the legend of Table 1. Each value is mean±standard deviation (SD).
[2)]Means with different letters within a column are significantly different from each other at $\alpha = 0.05$ as determined by Duncan's multiple range test.

tein and ash content of tomato powder than wheat flour. Crude fat contents were 21.35～22.38% and no significant differences among cookies were observed.

Physical characteristics

Fig. 1 shows the results of the pH of cookie doughs containing different levels of tomato powder. The pH significantly decreased with the addition of tomato powder ($p<0.05$), which is mainly due to ascorbic acid present in tomato powder (18). Cookie diameter, thickness and spread factor are shown in Table 3. There were no significant differences in the diameter and thickness of the cookies between those containing up to 5.0% and the control. However, significant differences were found with higher percentages of tomato powder ($p<0.05$). Larger diameter and lower thickness values were observed in the formulations containing 7.5 and 10.0% of tomato powder. Thus, it could be stated that the incorporation of tomato powder in the cookies at the level of 7.5 and 10.0% affected cookie expansion by lowering gas retaining power below that of wheat flour (21). The spread factor of cookies made with 5.0, 7.5 and 10.0% tomato powder was significantly higher than that of control ($p<0.05$), but a trend with the varying levels of tomato powder substitution for flour was not found. Chung and Kwon (21) reported that cookies made with yam powder exhibited a reduction in size and thickness as the content of yam powder increased. According to Kim et al. (10), barley germ increased cookie diameter and spread ratio, whereas decreased thickness and weight as the barley germ substitution level increased, and they have proposed that such increases in diameter and spread ratio may be due to the decrease in cookie dough consistency with increasing level of barley germ in the cookie formula (10). Dissimilar results have been observed by other researchers, who reported that the spread ratio of cookies prepared with bamboo leaf powder decreased with increasing amount of bamboo leaves powder (1). Cho et al. (22) also reported that the addition of sea tangle powder lowered the spread ratio of cookies. From these results, it is suggested that the incorporation of different ingredients into cookie products result in different physical properties. In general, cookie spread or diameter is used as an indicator of cookie quality and cookies with larger spread or diameter are considered more desirable (23).

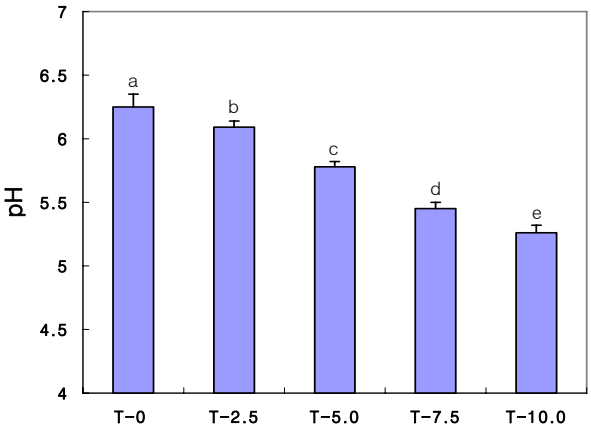

Fig. 1. pH of cookie doughs prepared with tomato powder.

Color measurement

The results of Hunter Lab color value of cookies are shown in Table 4. The L value (lightness) of control cookies was 83.13 and those of tomato powder cookies ranged from 51.82 to 68.79, indicating that lightness decreased with the reduction in the proportion of wheat flour because of the loss of white color of the flour ($p<0.05$). Therefore, it could be expected that cookies would become darker with increasing amount of tomato powder level. The a value (redness) of control cookies was -2.56 and those of tomato powder groups were 12.68～17.58, showing more reddish color than control. This is attributable to the reddish color of tomato powder. The b value (yellowness) of control group was 28.78 and cookies substituted with different levels of tomato powder ranged from 44.12 to 48.40, having more yellowish color than control. Similar results were obtained by Kim et al. (10), who reported that the color of sugar-snap cookies became darker, more red and yellow with increasing amounts of barley germ. Singh et al. (24) reported that lightness value decreased while redness and yellowness values increased as the substitution level of both corn flour and potato flours increased.

Cookie texture

The result of textural properties of cookies including

Table 3. Diameter, thickness and spread factor of cookies prepared with tomato powder

Groups	T-0[1)]	T-2.5	T-5.0	T-7.5	T-10.0
Diameter (mm)	53.39±0.10[a2)]	53.17±0.50[a]	53.72±0.09[ab]	54.22±0.25[b]	56.06±0.54[c]
Thickness (mm)	6.90±0.10[c]	6.87±0.11[c]	6.77±0.12[bc]	6.43±0.06[a]	6.67±0.12[b]
Spread factor (D/T)	7.73±0.10[a]	7.74±0.08[a]	7.94±0.12[b]	8.43±0.09[c]	8.41±0.07[c]

[1)]See the legend of Table 1. Each value is mean±SD.
[2)]Means with different letters within a row are significantly different from each other at $\alpha=0.05$ as determined by Duncan's multiple range test.

Table 4. Colorimetric characteristics of cookies prepared with tomato powder

Group	L	a	b
T-0[1)]	83.13±0.69[d2)]	-2.56±0.19[a]	28.78±1.16[a]
T-2.5	68.79±4.40[c]	12.68±0.39[b]	46.21±2.02[b]
T-5.0	63.21±3.40[bc]	15.70±0.83[c]	48.40±2.42[b]
T-7.5	58.47±6.15[ab]	17.59±0.88[d]	48.02±4.83[b]
T-10.0	51.82±5.78[a]	17.60±1.41[d]	44.12±4.89[b]

[1)]See the legend of Table 1. Each value is mean±SD.
[2)]Means with different letters within a column are significantly different from each other at α=0.05 as determined by Duncan's multiple range test.

hardness, cohesiveness, springiness, chewiness and brittleness are shown in Table 5. The hardness value of control cookie was 60.35, which was not affected by the addition of 2.5% tomato powder, but significantly decreased in the cookies containing 5.0～10.0% tomato powder ($p<0.05$). Similar trends were observed by Han et al. (7) who reported that cookies with added potato peel exhibited softer texture than control. Cohesiveness, springiness and brittleness are not affected by tomato powder addition. Texture is an important aspect of cookie quality and affects consumer acceptance. A number of studies have reported on the texture profile of cookies of which wheat flour was substituted with other substances. For example, Gouveia et al. (25) reported that the incorporation of *Chlorella vulgaris* biomass into butter cookies increased hardness. Kim et al. (9) reported that the addition of garlic had no significant effect on cookie texture. Lee and Oh (26) reported that cookies made with brown rice flour exhibited increased hardness but decreased crispness values compared to control cookies. From these results, it is suggested that the incorporation of different ingredients into cookies exhibited different texture profiles.

Sensory evaluation

Results of sensory evaluation of cookies with added tomato powder are shown in Table 6. The surface color was evaluated to become darker as the tomato powder level increased, which is due to the reddish color of tomato powder. This is in agreement with the result of lightness values shown in Table 4. Scores of tomato smell and taste were higher in cookies added with tomato powder than those of control cookies because tomato powder gave a characteristic smell and taste. The hardness score was higher in control than those of cookies substituted with tomato powder, which is consistent with the result of texture values shown in Table 5. The crispness score was higher in control cookies than those of cookies with tomato powder ($p<0.05$). There were no significant differences in the overall desirability scores between control cookies and tomato powder added cookies. Therefore, replacing up to 10.0% wheat flour with tomato powder would not result in significant dif-

Table 5. Textural properties of cookies prepared with tomato powder

Group	Hardness (kg/cm^2)	Cohesiveness (%)	Springiness (%)	Chewiness (%)	Brittleness (%)
T-0[1)]	60.35±5.21[b2)]	10.22±3.63	19.16±4.51	75.75±15.11[b]	15.82±11.55
T-2.5	59.64±6.29[b]	10.57±2.96	18.21±4.29	81.47±19.31[b]	14.83±8.33
T-5.0	37.73±2.94[a]	13.80±4.61	21.78±4.84	65.05±12.86[ab]	15.44±8.83
T-7.5	38.61±9.07[a]	8.46±5.22	16.78±8.04	41.80±5.22[a]	8.76±7.43
T-10.0	38.98±4.56[a]	10.22±3.63	18.17±5.89	53.70±22.55[ab]	10.91±6.79

[1)]See the legend of Table 1. Each value is mean±SD.
[2)]Means with different letters within a column are significantly different from each other at α=0.05 as determined by Duncan's multiple range test.

Table 6. Sensory scores of cookies prepared with tomato powder

Group	Surface color	Tomato smell	Tomato taste	Hardness	Crispness	Overall desirability
T-0[1)]	2.96±0.87[a2)]	0.88±0.32[a]	0.92±0.27[a]	5.65±0.68[d]	5.46±1.10[c]	5.77±1.21[a]
T-2.5	4.23±0.58[b]	2.12±0.95[b]	2.58±0.98[b]	4.65±0.93[c]	4.69±1.01[b]	5.77±1.10[a]
T-5.0	5.15±0.61c[c]	3.23±1.21[c]	3.92±0.93[c]	4.42±0.94[bc]	4.15±0.96[ab]	6.31±0.92[a]
T-7.5	5.88±0.71[d]	4.12±1.45[d]	4.85±1.28[d]	3.77±0.90[ab]	3.69±1.05[a]	6.23±1.24[a]
T-10.0	7.04±0.82[e]	5.31±1.66[e]	6.38±1.26[e]	3.92±1.41[a]	3.77±1.60[a]	5.69±1.73[a]

[1)]See the legend of Table 1. Each value is mean±SD.
[2)]Means with different letters within a column are significantly different from each other at α=0.05 as determined by Duncan's multiple range test.

Table 7. Correlation coefficients between mechanical parameters and sensory characteristics of cookies prepared with tomato powder

Characteristics		Sensory					
		Surface color	Tomato smell	Tomato taste	Hardness	Crispness	Overall desirability
Mechanical	Hardness	-0.601**	-0.521**	-0.628**	0.493**	0.429**	-0.241
	L	-0.177	-0.550**	-0.512**	0.351	0.131	0.226
	a	0.110	0.337	0.381	-0.590**	-0.251	0.110
	b	0.033	0.063	0.165	-0.643**	-0.261	0.362

** indicates correlation is significant at $p<0.01$ level.

ferences in the acceptability of cookies.

Correlations

Table 7 shows the correlations between mechanical parameters and sensory characteristics for cookies that contained different levels of tomato powder. Mechanical hardness was positively correlated with sensory hardness and crispness, while negatively correlated with surface color, tomato smell and taste ($p<0.01$). Negative correlations were obtained between lightness and tomato smell and taste ($p<0.01$). Sensory hardness is strongly and negatively correlated with redness and yellowness ($p<0.01$).

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