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Research Note

Effect of *Ecklonia cava* Powder on Color and Texture of Sugar-Snap Cookies

Myeong Ju Park and Jun Ho Lee*

Department of Food Science and Engineering, Daegu University

Abstract

Freeze-dried *Ecklonia cava* powder was incorporated into cookie dough at 5 levels (0%, 1.5%, 3%, 4.5%, and 6%, w/w) by replacing equivalent amount of wheat flour of the cookie dough. After aging and sheeting, cookies were baked at 185°C for 14 min in a convection oven. The baked cookies were cooled to room temperature for 30 min and packed in airtight bags prior to all measurements. Lightness (*L**) decreased significantly as the *E. cava* powder content increased ($p<0.05$) and a decreasing trend in both redness (*a**-value) and yellowness (*b**-value) was observed. On the other hand, firmness increased significantly with an increase in *E. cava* powder content ($p<0.05$). Increases in *E. cava* powder concentration up to 6% in the cookie formulation significantly increased the intensities of all sensory attributes such as color, flavor, taste, and firmness ($p<0.05$). Correlation analysis indicated that the *E. cava* concentration correlated significantly with most of the properties except for *a**-value ($p<0.01$, 0.05, or 0.001). Properties such as firmness and sensory color and firmness correlated positively while *L**- and *b**-values correlated negatively with *E. cava* concentration. Sensory color correlated negatively with *L**- and *b**-values. Sensory firmness correlated positively with mechanically measured firmness.

Key words: cookies, *Ecklonia cava* powder, physicochemical properties, sensory properties

Introduction

Ecklonia cava, a brown algae belongs to the family of Laminariaceae, grows abundantly in the coast of Jeju Island in South Korea as well as southern coast of Japan (Kim et al., 2006; Le et al., 2009), and has distinctive seaweeds smell and taste. Although it is not yet available in Europe, *E. cava* is popular in both countries as food, animal feed, fertilizers, and a folk medicine (Le et al., 2009; Lee et al., 2010b).

Marine algae are composed of higher contents of polysaccharides, minerals, and vitamins as compared to the land-grown plants (Lee et al., 2006) and can be a good source for therapeutic purpose (Le et al., 2009). Many of them were reported to possess many biological activities, and an increasing amount of evidence has demonstrated that *E. cava* extracts exhibit antioxidant activity (Heo et al., 2003; Kim et al., 2004; Li et al., 2009), cytotoxic activity (Kang et al., 2006; Kim et al., 2006), anti-HIV-1 activity (Artan et al., 2008), anti-allergic activity (Kim et al., 2008; Shim et al., 2009), anti-inflammatory activity (Jung et al., 2009), and antidiabetic effects (Kang et al., 2010). This makes *E. cava* good candidate for a new novel food material or ingredient that can be incorporated into various food manufacturing processes. Despite these advantages, *E. cava* has not yet been used as a popular food ingredient and food application is limited. Therefore, the development of value-added food products utilizing the *E. cava* could lead to the production of novel products, with improved functional properties and nutritional value.

Cookies are widely accepted in many countries and have been one of the most favored baking products, which are consumed as a snack, refreshment, or dessert (Lee et al., 2010a). If a cookie is developed with the incorporation of *E. cava*, it can offer a valuable vehicle for supplementing above functional properties. Despite previous investigations related to the applications of various ingredients in cookie making, no study has been reported on the effect of *E. cava* powder on the quality of cookies to the best of our knowledge in the literature. An attempt was made to develop a value-added food product; *E. cava* powder was added in a model system of cookie as a healthy food ingredient and physicochemical properties such as color and texture as well as sensory attributes such as color, flavor, taste, and firmness were evaluated, and their correlation was also investigated.

Corresponding author: Jun Ho Lee, Dept. of Food Science and Engineering, College of Engineering, Daegu University, Gyeongsan, Gyeongbuk 712-714, Korea
Tel: 82-53-850-6535; Fax: 82-53-850-6539
E-mail: leejun@daegu.ac.kr
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Materials and Methods

Preparation of raw materials

E. cava was procured from Nakji-Mall.com (Mokpo, Jeonnam, Korea), which was collected from the western coastal area of Muan, Korea from December to February, 2009 and kept in a -35°C freezer (VLT 1450-3-D-14, Thermo Electron Corp., Asheville, NC, USA) before use. The frozen samples were lyophilized using a freeze-dryer (PPU-1100, Tokyo Rikakikai Co., Japan) at a vacuum pressure of 8.5 Pa to a final moisture content of approximately 4.40%, moisture-free basis (MFB), which was determined by the gravimetric method at 105°C, till the weight reached a constant value. Dehydrated samples were then milled using an analytical mill (M20, IKA, Staufen, Germany) with different particle size sieves (D-55743, FRITSCH, ldar-Oberstein, Germany) to yield particle sizes between 150 and 250 μm. *E. cava* powders were then placed in a desiccator containing silica gel prior to cookie making which took place within a day.

The soft wheat flour (ranked 1st; CJ Corp., Seoul, Korea), granulated sugar (CJ Corp., Incheon, Korea), margarine (Seoul Milk Coop., Yongin, Gyeonggi-do, Korea), and sodium bicarbonate (Yuchung Foods Co., Ltd., Daegu, Korea) were procured from a local market and stored at room temperature before use. One hundred grams of the soft wheat flour contained 77 g of carbohydrates, 5 g of protein, 1.5 g of lipids, and 10 mg of sodium.

Cookie baking

A Kitchen Aid mixer (model 5K5SS, Whirlpool Corp., St. Joseph, MI, USA) with a flat beater attachment was used. Margarine and sugar were creamed for 3 min with scraping down every minute. Deionized water was then added, and mixing was continued for 2 min with intermediate scraping. At the end, the cream was scraped down; wheat flour, appropriate amount of *E. cava* powder (by substituting 0-6% based on the total weight of the soft wheat flour and *E. cava* powder mixture according to the formulation given in Table 1), and sodium bicarbonate were added, followed by mixing for 2 min with scraping down every 30 s. Dough pieces were slightly flattened with the palm of the hand and sheeted to a thickness of 0.67 cm with the help of a rolling pin. Cookie dough was cut with a circular cookie cutter (inside diameter 4.3 cm). Dough pieces were weighed and immediately baked for 14 min at 185°C in a multi-functional convection oven (KXS-4G+H, SALVA, Barcelona, Spain) on a stamped steel baking tray with baking paper. Baked cookies were removed from the oven and cooled to room temperature for 30 min and packed in an airtight bag for further quality assessment.

Table 1. Cookie dough composition, substituted with different percentages of *E. cava* powder

Ingredients (g)	*E. cava* powder level in cookies (%)				
	0	1.5	3	4.5	6
Soft wheat flour	200	197	194	191	188
E. cava powder	0	3	6	9	12
Granulated sugar	144	144	144	144	144
Margarine	90	90	90	90	90
Deionized water	24	24	24	24	24
Sodium bicarbonate	4	4	4	4	4
Total	462	462	462	462	462

Color and texture analyses

The color of the *E. cava* powder was evaluated using a colorimeter (model CM-600d, Minolta Co., Osaka, Japan), and reported as CIE L^*- (lightness), a^*- (redness), and b^*- (yellowness) values. Measurements were repeated five times on five randomly selected cookies for each condition and mean values were compared.

Firmness of ten cookies was evaluated measuring the peak breaking force (N) using the three-point break (triple beam snap) technique with a computer-controlled Advanced Universal Testing System (model LRX*Plus*, Lloyd Instrument Ltd., Fareham, Hampshire, UK) at room temperature. The crosshead speed was 1 mm/s and span between the two platforms was 40 mm.

Sensory analysis

A panel of 8 assessors (5 females, 3 males aged between 22 and 28 years old) were selected, screened and recruited among the students in the Department of Food Science and Engineering at Daegu University (Gyeongbuk, Korea). On each day, assessors received a total of five samples and a 2 min interval was allowed between each sample to reduce the likelihood of carryover. Each assessor was provided with water and asked to cleanse their palate between testings. Sample attributes were scored on 9-point category scales, wherein 9 = extremely strong, 8 = very much strong, 7 = moderately strong, 6 =slightly strong, 5 = neither strong nor weak, 4 = slightly weak, 3 = moderately weak, 2 = very much weak, and 1 = extremely weak. Flavor, taste, and hardness were evaluated under red fluorescent light while color was done under regular fluorescent light.

Table 2. Effect of *E. cava* powder incorporation on color characteristics of cookies

E. cava powder (%)	Color parameter		
	*L**-value	*a**-value	*b**-value
Control	64.98±2.25[a]	7.83±5.43[a]	32.90±2.52[a]
1.5	55.83±1.60[b]	0.32±0.37[b]	27.74±1.39[b]
3	51.31±1.84[c]	-2.42±0.34[c]	24.82±0.91[c]
4.5	48.47±2.43[d]	-2.97±0.35[c]	23.48±4.43[c]
6	44.27±1.26[e]	-2.43±0.24[c]	21.02±0.79[d]

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

Statistical analysis

The statistical analysis was done using the SAS Statistical Analysis System for Windows v9.1 (SAS Inst. Inc., Cary, N.C., U.S.A.). The means were compared with Duncan's Multiple Range test at the 5% level of significance and Pearson correlation coefficients were also determined.

Results and Discussion

Physicochemical properties

Changes of color parameters (*L**-, *a**-, and *b**-value) as influenced by *E. cava* powder content are given in Table 2. Lightness (*L**) decreased significantly as the *E. cava* powder content increased (p<0.05). The *L**-value of the control was 64.98, which was significantly higher than others (p<0.05) and the value is comparable with the one reported by others (Singh et al., 2003; Lee et al., 2009). Similarly, a decreasing trend in *L**-value of sponge cakes was reported when *E. cava* powders were added (Lee & Heo, 2010), and for noodle dough containing enzymatic extracts from *E. cava* (Heu et al., 2010). In addition, a decreasing trend in both redness (*a**-value) and yellowness (*b**-value) was noticed. These changes in color characteristics are inherent with distinctive color characteristics of *E. cava* powder used in the formulation whose *L**, *a**, and *b**-values are 59.21, -6.08, and 12.84, respectively (Lee & Heo, 2010), and are partially due to the degradation of color pigments during baking at such high temperature. These changes in color characteristics of cookies can also be seen from the photos taken for comparison (Fig. 1).

Changes of cookie firmness as influenced by *E. cava* powder incorporation are shown in Fig. 2. Firmness increased significantly with increase in *E. cava* powder content (p<0.05). The firmness of the control increased by up to 78.09% with 6% of *E. cava* powder addition. Similar increases in firmness were reported for sponge cakes made with *E. cava* powder (Lee & Heo, 2010). The results are also in good accordance with the increases in firmness of cookies prepared with resistant starch (Kang & Kim, 2005), sea tangle powder (Cho et al., 2006), garlic powder (Lee et al., 2007), and ginseng powder (Kim & Park, 2006; Kang et al., 2009). However, it should also be noted that cookie firmness decreased with incorporation of other types of food ingredients such as potato peel (Han et al., 2004), black rice flour (Lee & Oh, 2006a), brown rice flour (Lee & Oh, 2006b), garlic juice (Shin et al., 2007), and strawberry powder (Lee & Ko, 2009).

Sensory characteristics

A 9-point category scale was used to determine which cookies incorporated with different levels of *E. cava* powder had strong or weak sensory properties by the semi-trained

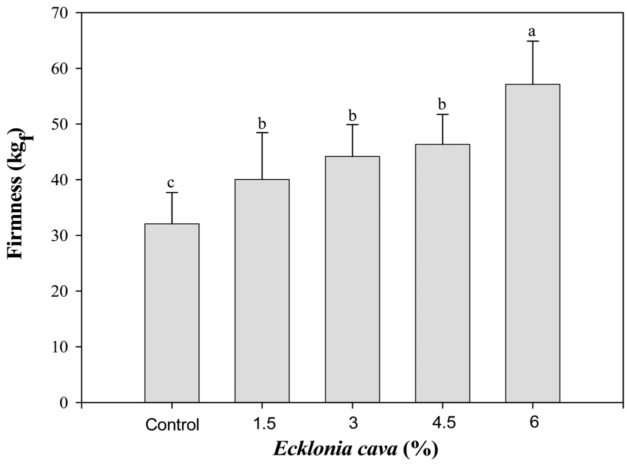

Fig. 2. Cookie firmness as influenced by *E. cava* powder addition. Means without a common letter are significantly different (p<0.05).

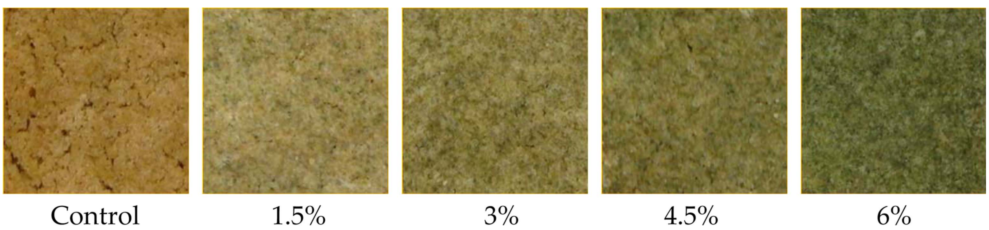

Fig. 1. Appearance of cookies as influenced by *E. cava* powder addition.

Table 3. Sensory evaluation of cookies as affected by *E. cava* powder

Attributes	*E. cava* powder level in cookies (%)				
	0	1.5	3	4.5	6
Color	1.63±0.74[e]	3.50±0.93[d]	5.25±1.04[c]	6.63±0.52[b]	8.38±0.52[a]
Flavor	1.75±1.04[d]	3.88±0.83[c]	5.00±1.31[b]	6.38±1.19[a]	7.25±1.04[a]
Taste	1.63±1.19[d]	4.00±1.14[c]	5.88±1.81[b]	6.25±1.39[b]	8.13±1.13[a]
Firmness	3.00±1.07[d]	4.88±0.83[c]	7.13±0.99[ab]	6.13±1.25[b]	7.88±1.46[a]

[a-e]Means within the same row without a common letter are significantly different (p<0.05).

Table 4. Correlation between physicochemical and sensory properties for cookies incorporated with different levels of *E. cava* powder

Attribute		Physicochemical					Sensory
		E. cava concentration	Color parameters			Firmness	Color
			*L**	*a**	*b**		
Physicochemical	*L**	-0.973**					
	*a**	NS	0.930*				
	*b**	-0.972**	0.999***	0.932*			
	Firmness	0.973**	-0.963**	NS	-0.961**		
Sensory	Color	0.999***	-0.982**	NS	-0.981**	0.978**	
	Firmness	0.902*	-0.949*	-0.900*	-0.957*	0.924*	0.921*

NS Not significant, * Significant at p<0.05, ** Significant at p<0.01, *** Significant at p<0.001.

panel. Table 3 presents the mean scores of sensory tests results on selected attributes including color, flavor, taste, and firmness. Intensity scores for cookies showed that sensory color, flavor, taste, and firmness attributes were significantly affected by different levels of *E. cava* powder incorporated in the formulation of cookies (p<0.05). The control received the least intensity scores in all attributes and the values were significantly lower than those of cookies containing *E. cava* powder regardless of the concentration (p<0.05). On the other hand, the 6% sample received the highest mean scores in all attributes and the values were significantly higher than those of 4.5% sample except for flavor (p<0.05). Increases in *E. cava* powder concentration up to 6% in the cookie formulation significantly increased the intensities of all sensory attributes such as color, flavor, taste, and firmness (p<0.05). Similar results were reported for sponge cakes containing various levels of *E. cava* powder (Lee & Heo, 2010).

Correlation between properties

Table 4 presents the correlation between physicochemical and sensory properties for cookies incorporated with different levels of *E. cava* powder. The *E. cava* concentration correlated significantly with most of properties except for *a**-value (p<0.01, 0.05, or 0.001). Properties such as firmness and sensory color and firmness correlated positively while *L**- and *b**-values correlated negatively with *E. cava* concentration. Sensory color correlated negatively with *L**- and *b**-values. Sensory firmness correlated positively with mechanically measured firmness. It is concluded that mechanically measured firmness and *L**- and *b**-values may be considered as reliable indicators of sensory color and firmness which are important quality criteria for the consumers.

References

Artan M, Li Y, Karadeniz F, Lee SH, Kim MM, Kim SK. 2008. Anti-HIV-1 activity of phloroglucinol derivative, 6,6'-bieckol, from *Ecklonia cava*. Bioorg. Medic. Chem. 16: 7921-7926.

Cho HS, Park BH, Kim KH, Kim HA. 2006. Antioxidative effect and quality characteristics of cookies made with sea tangle powder. Korean J. Food Culture 21: 541-549.

Han JS, Kim JA, Han GP, Kim DS. 2004. Quality characteristics of functional cookies with added potato peel. Korean J. Food Cookery Sci. 20: 63-69.

Heo SJ, Jeon YJ, Lee J, Kim HT, Lee KW. 2003. Antioxidant effect of enzymatic hydrolyzate from a kelp, *Ecklonia cava*. Algae 18: 341-347.

Heu MS, Yoon MS, Kim HJ, Park KH, Lee JH, Jo MR, Lee JS, Jeon YJ, Kim JS. 2010. Improvement on the antioxidant activity of instant noodles containing enzymatic extracts from *Ecklonia cava* and its quality characterization. Korean J. Fish Aquat. Sci. 43: 391-399.

Jung WK, Ahn YW, Lee SH, Choi YH, Kim SK, Yea SS, Choi I, Park SG, Seo SK, Lee SW, Choi IW. 2009. *Ecklonia cava* ethanolic extracts inhibit lipopolysaccharide-induced cyclooxygenase-2 and inducible nitric oxide synthase expression in BV2 microglia via the MAP kinase and NF-κB pathways. Food Chem. Toxicol. 47: 410-417.

Kang HJ, Choi HJ, Lim JK. 2009. Quality characteristics of cookies with ginseng powder. J. Korean Soc. Food Sci. Nutr. 38: 1595-1599.

Kang NE, Kim HYL. 2005. Quality characteristics of health concerned functional cookies using crude ingredients. Korean J. Food Culture 20: 331-336.

Kim HY, Park JH. 2006. Physicochemical and sensory characteristics of pumpkin cookies using ginseng powder. Korean J. Food Cookery Sci. 22: 855-863.

Kim JA, Lee JM, Shin DB. 2004. Changes of antioxidant activities of *Ecklonia cava* with harvesting period. Food Sci. Biotechnol. 13: 362-366.

Kim MM, Ta QV, Mendis E, Rajapakse N, Jung WK, Byun HG, Jeon YJ, Kim SK. 2006. Phloratannins in *Ecklonia cava* extract inhibit matrix metalloproteinase activity. Life Sci. 79: 1436-1443.

Kim SK, Lee DY, Jung WK, Kim JH, Choi IH, Park SG, Seo SK, Lee SW, Lee CM, Yea SS, Choi YH, Choi IW. 2008. Effects of *Ecklonia cava* ethanolic extracts on airway hyperresponsiveness and inflammation in a murine asthma model: role of suppressor of cytokine signaling. Biomed. Pharm. 62: 289-296.

Le QT, Li Y, Qian ZJ, Kim MM, Kim SK. 2009. Inhibitory effects of polyphenols isolated from marine alga *Ecklonia cava* on histamine release. Proc. Biochem. 44: 168-176.

Lee JH, Heo SA. 2010. Physicochemical and sensory properties of sponge cakes incorporated with *Ecklonia cava* powder. Food Eng. Prog. 14: 222-228.

Lee JH, Ko JC. 2009. Physicochemical properties of cookies incorporated with strawberry powder. Food Eng. Prog. 13: 79-84.

Lee JH, Lee HY, Sung CY. 2010a. Effect of broccoli powder incorporation on physicochemical properties of cookies. Food Eng. Prog. 14: 60-64.

Lee JO, Kim KH, Yook HS. 2009. Quality characteristics of cookies containing various levels of aged garlic. J. East Asian Soc. Dietary Life 19: 71-77.

Lee JS, Oh MS. 2006a. Quality characteristics of cookies with black rice flour. Korean J. Food Cookery Sci. 22: 193-203.

Lee MH, Oh MS. 2006b. Quality characteristics of cookies with brown rice flour. Korean J. Food Culture 21: 685-694.

Lee SH, Kim KN, Cha SH, Ahn GN, Jeon YJ. 2006. Comparison of antioxidant activities of enzymatic and methanolic extracts from *Ecklonia cava* stem and leave. J. Korean Soc. Food Sci. Nutr. 35: 1139-1145.

Lee SH, Ko SC, Kang SM, Cha SH, Ahn GN, Um BH, Jeon YJ. 2010b. Antioxidative effect of *Ecklonia cava* dried by far infrared radiation drying. Food Sci. Biotechnol. 19: 129-135.

Lee SJ, Shin JH, Choi DJ, Kwen OC. 2007. Quality characteristics of cookies prepared with fresh and steamed garlic powder. J. Korean Soc. Food Sci. Nutr. 36: 1048-1054.

Li Y, Qian ZJ, Ryu BM, Lee SH, Kim MM, Kim SK. 2009. Chemical components and its antioxidant properties of vitro: An edible marine brown alga, *Ecklonia cava*. Bioorg. Med. Chem. 17: 1963-1973.

Shim SY, Quang-To L, Lee SH, Kim SK. 2009. *Ecklonia cava* extract suppresses the high-affinity IgE receptor, FceRI expression. Food Chem. Toxicol. 47: 555-560.

Shin JH, Lee SJ, Choi DJ, Kwen OC. 2007. Quality characteristics of cookies with added concentrations of garlic juice. Korean J. Food Cookery Sci. 23: 609-614.

Singh J, Singh N, Sharma TR, Saxena SK. 2003. Physicochemical, rheological and cookie making properties of corn and potato flours. Food Chem. 83: 387-393.