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Research Note

Effects of the Addition of *Ecklonia cava* Powder on the Selected Physicochemical and Sensory Quality of White Pan Bread

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ABSTRACT: Physicochemical properties and consumer perception of white pan bread as influenced by the addition of *Ecklonia cava* powder (ECP) were investigated. Freeze-dried *Ecklonia cava* were ground, sieved through a laboratory sieve and a fraction with particles less than 250 μm was used. Amount of ECP added (0∼3%) to the bread was found to affect the bread quality significantly ($P<0.05$). pH, bread height, and volume of the control was significantly higher than others ($P<0.05$) and decreased significantly ($P<0.05$) with the addition of ECP. Moisture content showed no significant differences ($P>0.05$). There were distinctive color changes with the addition of the powder: L^*- and a^*-values decreased but b^*-value increased significantly ($P<0.05$). The hardness of bread was found to increase but both cohesiveness and springiness showed a reverse trend with the addition of the powder. Consumer acceptance test indicated that ECP content 1% on wheat flour could be the recommended supplementation level for the consumers without sacrificing sensory quality.

Keywords: *Ecklonia cava*, white pan bread, physicochemical properties, consumer acceptance

INTRODUCTION

Bread as a critical staple food, is one of the oldest processed cereal foods and the most popular foods globally (1). The major ingredient in bread-making is wheat flour, by far the most important cereal. In wheat bread-baking, viscoelastic dough is prepared by mixing wheat flour, water, salt, and yeast, which is then fermented and baked (2). Complex chemical, biochemical, and physical transformations occur, which affected by the various flour constituents during all steps of bread-baking.

Rapidly growing concerns about healthy diets nowadays have led us to demand for wheat based products with value-added ingredients. In an attempt to fortify quality of common bread, several food ingredients such as rosemary extract (3), coriander leaf powder (4), ramie powder (5), ginseng powder (6), and intermediated pearled wheat fraction (7) to name a few, have been incorporated into wheat flour at different levels, and their quality has been studied.

Ecklonia cava, brown algae belongs to the family of Laminariaceae, grows abundantly in the coast of Jeju island and southern coast of Japan (8), and has distinctive seaweeds smell and taste. Marine algae contain higher contents of polysaccharides, minerals, and vitamins than the land-grown plants (9). Many researchers demonstrated that *E. cava* extracts exhibit antioxidant activity (10), cytotoxic activity (11), anti-allergic activity (12), and anti-inflammatory activity (13).

Little to no information is available on the effect of *E. cava* powder (ECP) on the physicochemical and sensory properties to white pan bread. Therefore, the objective of this study was to (1) examine the selected physicochemical properties and consumer acceptances as influenced by the level of ECP incorporation in bread-making, and (2) determine the appropriate level of incorporation based on the sensory acceptance.

MATERIALS AND METHODS

Materials

E. cava was procured from Nakgimall (Jeongnam, Korea), which had collected from the coastal area of Muan, Korea. For preparing freeze-dried sample, a laboratory scale freeze-drying device (PPU-1100, Tokyo Rikakikai Co., Tokyo, Japan) was used. Sample was first pre-frozen at −35°C in a freezer (VLT 1450-3-D-14, Thermo Electron Corp., Asheville, NC, USA) on dishes for 24 h. Then, the samples were freeze-dried without heating under 8.5 Pa vacuum (condenser temperature of 25°C) for 48 h. Dehydrated samples were milled using an ana-

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lytical mill (M20, IKA, Staufen, Germany) with different particle size sieves (D-55743, FRITSCH, Idar-Oberstein, Germany) to yield particle sizes of less than 250 μm. The powder was placed in a desiccator at 25°C before use.

The bread flour (strong flour, 1st grade; CJ Corp., Yangsan, Korea), dry yeast (Saf-instant, S.I.Lesaffe, France), sugar (CJ Corp., Incheon, Korea), salt (CJ Corp., Sinan, Korea), salt-free butter (Seoul Milk Coop., Yongin, Korea), and eggs were purchased from a local market.

Breadmaking

Bread was baked according to the straight dough method, and the recipe for the dough is listed in Table 1. The control dough was made with 250 g of wheat flour. The levels of added freeze-dried ECP were 1, 2, and 3% in wheat flour, which were determined based on the preliminary sensory acceptances from several trial experiments. The dough was optimally mixed and then placed in a thermostatically controlled proofing oven for 30 min at 30°C, and 80% relative humidity. The dough was then divided into 3 pieces followed by rounding and molding, and then placed in a baking pan for 15 min. The dough was kneaded again for 1 min, and replaced in the proofing oven for 30 min at 35°C, and 85% relative humidity. Loaves were baked at 160°C for 25 min. Breads were cooled down to 25°C for 1 h before use.

Determination of selected physicochemical properties

The pH of each sample was measured using a pH meter (pH/Ion 510, Oakton Instruments, Vernon Hills, IL, USA). The moisture content, expressed in percent wet basis (% w.b.), was measured by the gravimetric method using a laboratory convection oven (WFO-700W, Tokyo Rikakikai Co.) at 105°C for 24 h. Loaf height was measured using a caliper.

Surface color at the middle of each crumb was measured with a Chromameter (model CR-200, Minolta Co., Osaka, Japan) calibrated with a white tile (Y=94.2, x=0.3131, and y=0.3201). L^* (lightness), a^* (greenness [−] to redness [+], and b^* (blueness [-] to yellowness [+]) values were recorded. Textural properties such as hardness, cohesiveness, and springiness were measured by using a computer-controlled Advanced Universal Testing System (model LRX*Plus*, Lloyd Instrument Limited, Fareham, Hampshire, UK) at 25°C. Each sample was compressed twice to 30% of their original height at 60 mm/min speed and 100 N compression load using a cylindrical-shaped probe (12 mm in diameter). All measurements were conducted 5 times except for texture, where eight replicates were carried out at 25°C.

Table 1. Baking formula based on wheat flour weight

Ingredients (g)	*E. cava* powder level (%)			
	0	1	2	3
Wheat flour	250	247.5	245	242.5
E. cava powder	0	2.5	5	7.5
Water	155	155	155	155
Sugar	20	20	20	20
Butter	20	20	20	20
Yeast	6.5	6.5	6.5	6.5
Salt	4.5	4.5	4.5	4.5
Non-fat dry milk	7.5	7.5	7.5	7.5
Total	463.5	463.5	463.5	463.5

Consumer test

Each sample was also evaluated by 30 consumer panelists. Four samples were presented in random order and were asked to evaluate the consumer acceptance of color, flavor, taste, hardness, and overall acceptability. Consumer participants were asked to evaluate the breads for preference using the nine point hedonic scale (14) (9=like extremely, 8=like very much, 7=like moderately, 6=like slightly, 5=neither like nor dislike, 4=dislike slightly, 3=dislike moderately, 2=dislike very much, and 1=dislike extremely). Panelists received a tray containing the samples (randomly coded using a three-digit number), a glass of water, and an evaluation sheet. Participants were instructed on how to evaluate the sample, and were not required to expectorate, or to consume the entire volume served. There was an inter-stimulus interval of 30 s imposed between samples, to allow time to recover from adaptation. Participants were advised to rinse their palates between samples. Enough space was given to handle the samples and the questionnaire, and the evaluation time was not constrained. No specific compensation was given to the participants.

Statistical analysis

The statistical analyses were performed using SAS version 9.2 (SAS Institute Inc., Cary, NC, USA). An analysis of variance (ANOVA) was performed using the general linear models (GLM) procedure to identify significant differences among the samples. Mean values were compared using Duncan's multiple range test at 5% level.

RESULTS AND DISCUSSION

pH, moisture content, and bread height

The bread formula used in this study contained ECP. The scope of this work was to increase the functionality of bread by adding ECP, and at the same time maintaining a good bread quality. The amount of ECP was increased from 0, 1, 2, and 3% of the wheat flour and breads with those blends are called control, ECP1, ECP2, and ECP3 (Table 1).

Table 2. pH, moisture content, and bread height of white pan bread as affected by *E. cava* powder

Property	*E. cava* powder level (%)			
	0	1	2	3
pH	5.30±0.04[a]	5.20±0.03[b]	5.04±0.04[c]	4.81±0.03[d]
Moisture content (%, w.b.)	44.01±6.88[a]	43.56±5.66[a]	42.10±5.09[a]	40.59±3.23[a]
Bread height (mm)	113.38±1.78[a]	94.72±1.02[b]	88.75±2.43[c]	79.89±0.59[d]

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

The effect of the ECP supplementation on bread characteristics, such as pH, moisture content, and bread height is summarized in Table 2. pH ranged from 4.81 to 5.30, decreased significantly with the addition of ECP ($P<0.05$). Similar reduction of pH was found for bread made with cranberry powder due to the acidic characteristic of the powder itself (15). Moisture content, measured 1 h after baking, showed no significant differences among the control and the three different treatments ($P>0.05$).

The weight of dough after the first aging was 442.1 g, 440.5 g, 438.1 g, and 437.2 g for control, ECP1, ECP2, and ECP3, respectively. Increasing ECP contents led to smaller loaf volumes and lower bread height ($P<0.05$) (Fig. 1). The control bread had the largest loaf volume and accordingly, the highest bread height; this is due to the fact that the ECP diluted the viscoelastic properties of gluten, which required sustaining the volume of bread after baking (16). Moon et al. (17) explained that the increased fiber quantity resulted in the reduction of bread volume. The decrease in volume can also be explained by a weakening of gluten matrix, which is losing the ability to retain gases created during aging in the presence of fibers (18,19). Adding gluten enhancing material such as vital gluten can be helpful to improve the insufficient formation of gluten network (20). Our data showed decreased loaf volume which was similar to the previous findings with green tea powder (21), barley flour (22), and chestnut flour (23).

Fig. 1. Appearance of white pan bread as influenced by *E. cava* powder addition.

Color and texture

Color, together with texture and flavor is an important characteristic of bread affecting consumer preferences (2). The ECP used in the present study was a fine and green color. Therefore, it is well expected that bread with ECP having different color from the control. The use of ECP caused an increase in darkness of bread crumb ($P<0.05$). Comparison of bread color between the control and bread with three levels of ECP is listed in Table 3 (also see Fig. 1). With an increase in ECP in bread, a decrease in brightness was apparent among the three samples ($P<0.05$). For the bread with more amount of ECP, the L^*- and a^*-value reduced but the b^*-value increased significantly ($P<0.05$). This means decreased brightness and increased green and yellow color.

Hardness is one of the common indices to determine bread quality (2). The hardness gradually increased from 0.153 kg_f to 0.236 kg_f for the control and ECP2, respectively with no significant difference ($P>0.05$). ECP3 showed the highest hardness of 0.583 kg_f and was significantly different among other samples ($P<0.05$). Similar increasing trend (abrupt increase after the gradual increase) of hardness as influenced by the ECP was also noted for sponge cakes (24). Hardness can be attributed due to the fact that the ECP inhibit the formation of bubbles inside of dough, and resulted in compact or

Table 3. Color and texture properties of white pan bread as affected by *E. cava* powder

Property		*E. cava* powder level (%)			
		0	1	2	3
Texture	Hardness (kg_f)	0.153±0.049[b]	0.186±0.032[b]	0.236±0.057[b]	0.583±0.093[a]
	Cohesiveness	0.554±0.014[a]	0.536±0.081[ab]	0.482±0.028[b]	0.307±0.034[c]
	Springiness (mm)	12.785±1.046[a]	12.653±0.540[a]	12.089±0.211[ab]	11.498±0.961[b]
Color	L^*-value	83.38±0.83[a]	73.16±2.42[b]	69.66±1.31[c]	68.20±1.23[c]
	a^*-value	−0.60±0.04[a]	−2.29±0.05[b]	−2.35±0.08[b]	−3.61±0.13[c]
	b^*-value	13.13±0.36[c]	22.13±1.77[b]	26.61±1.03[a]	26.95±1.11[a]

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

Table 4. Consumer acceptance of white pan bread as affected by *E. cava* powder

Attribute	*E. cava* powder level (%)			
	0	1	2	3
Color	5.29±1.66[b]	6.16±1.37[a]	6.42±1.20[a]	5.84±2.12[ab]
Flavor	5.55±1.45[a]	5.81±1.45[a]	5.06±1.46[ab]	4.65±1.60[b]
Taste	5.90±1.56[a]	5.97±1.43[a]	5.03±1.83[b]	4.00±1.73[c]
Hardness	5.87±2.00[a]	5.94±1.26[a]	5.39±1.33[ab]	4.77±1.56[b]
Overall acceptability	5.94±1.82[a]	6.00±1.59[a]	5.23±1.65[a]	4.10±1.42[b]

[a–c]Means (±standard deviation) within the same row bearing unlike letters are significantly different (P<0.05).

dense structure inside of the bread (23,25,26). In addition, similar results were found by other researchers that the inverse relation between bread volume and hardness, with increasing amount of ECP lead to decreasing loaf volume and increasing hardness value (17,23,27,28). On the other hand, both cohesiveness and springiness showed a reverse trend (Table 3).

Consumer acceptance

Thirty consumer panelists evaluated 4 samples for the consumer attributes of color, flavor, taste, texture, and overall acceptability. The overall bread quality perceived with ECP is presented in Table 4. There were significant differences among the four bread variants depending on the level of ECP incorporation in all attributes (P<0.05). ECP1 received the highest scores for all the attributes (P<0.05) except for color, which had no significant difference as compared with ECP2 (P>0.05). For example, flavor, taste, harness, and overall acceptability for ECP1 had received the highest score of 5.81, 5.97, 5.94, and 6.00, respectively. ECP3 was not favored by most of the consumer panelists probably due to its stronger aroma and darker color as conventionally the consumers preferred plain white bread. The results showed how the incorporation of ECP into wheat flour in bread-making influenced the selected physicochemical properties, and consumer acceptances. ECP content 1% on wheat flour could be the recommended supplementation level for the consumers without sacrificing sensory quality.

AUTHOR DISCLOSURE STATEMENT

The authors declare no conflict of interest.

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