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Development and Quality Assessment of Healthy Bread using Korean Pine Leaf Powder

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Abstract

With the advancement and diversification of the bread industry, eco-friendly products with less sugar and salt, and containing functional ingredients are being developed. To develop healthy bread, Korean pine leaf powder was added in different proportions (0%, 1%, 3%, 5%, and 7%), and the quality characteristics of the bread, namely height, moisture, color value, texture, antioxidant property, and sensory characteristics were evaluated. As the amount of leaf powder was increased in the bread, L-value in the range of 53.45~85.05 (p<0.001) and adhesiveness in the range of 0.13~0.32 mJ (p<0.001) decreased significantly, whereas b-value in the range of 16.75~30.74 (p<0.001), total polyphenol content in the range of 466.83~669.13 ug/mL, ABTS- in the range of 0.46~43.23%, DPPH-radical in the range of 1.39~45.76%, scavenging capacities (p<0.001), color in the range of 3.27~5.40 (p=0.017) and texture in the range of 4.33~4.80 (p=0.006) preferences increased significantly. This study could increase the utilization of Korean pine leaf and the production of healthy food with antioxidant properties.

Key words: bread, Korean pine leaf, quality characteristics, sensory characteristics, functional ingredients

Introduction

The history of Korean bakery industry changed when bread was first introduced in the 1880s by missionaries and diplomats (Lee SH 1990; Lee KH 2014). In the 1980s, franchise bakery market was formed, and in the 2000s, bread became a luxury product and bakery culture diversified (Lee SH 1990; Lee KH 2014). Bread is classified into fermented and non-fermented bread based on whether the fermentation occurs (Lee KH 2014). The fermented bread is produced by adding yeast in the dough for fermentation, and its types include bread, cream bread, and red bean paste bread (Lee KH 2014). The non-fermented bread types include cakes and Korean crackers (Lee KH 2014). With the advancement and diversification of bread industry, eco-friendly products containing functional ingredients and less sugar and salt are being developed (Lee KH 2014). Furthermore, consumers are becoming increasingly health conscious as the national income has improved (Shin & Roh 2000; Lee KH 2014). Therefore, the demand for healthy bread products is steadily increasing (Shin & Roh 2000; Lee KH 2014).

Korean pine leaves have been reported to contain ingredients that help in preventing aging and cancer and have excellent antioxidant and antibacterial effects (Song & Kim 1994; Kim et al. 2012). Cho YJ (2017) reported *Korean pine* leaf extracts to exert anti-inflammatory effects that are caused by inhibition of hyaluronidase; hence, it can be used as a natural functional material to suppress inflammation.

Bread is prepared using flour, yeast, water, and salt as major ingredients, and sugars and edible oil as minor ingredients (Shin & Jung 1998). The resulting dough is fermented and baked, and it contains less than 10% sugar (Shin & Jung 1998). Strong flour is used that contains 11.5~14% protein (Shin & Jung 1998), 40% gluten, with gluten properties, and forms the bread skeleton (Shin & Jung 1998). In a study on a bakery that used functional ingredients, subjects had the highest preference for white bread, cooked bread (Hwang et al. 2006). People aged 20~30 preferred

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green tea products, while those over 30 preferred beans, vegetable, ginseng, oriental medicine, and mushrooms (Lee et al. 2006). Bread containing functional ingredients such as Rubi fructus juice (Kwon et al. 2004), black rice flour powder (Jung et al. 2002), Sea Buckthorn berry powder(Lee & Kim 2020), Mate leaf powder (Lee MH 2018), and Chlorella powder (Kim et al. 2020) has been developed.

This study aimed to develop healthy bread containing Korean pine leaf powder, which is a by-product of Korean pine. Korean pine leaf powder was added in the proportions of 0%, 1%, 3%, 5%, and 7%, and Quality characteristics of bread were evaluated namely height, moisture content, color value, texture, antioxidant property, and sensory characteristics.

Materials and Methods

1. Ingredients

Korean pine leaf powder used in this experiment was provided by Dain Natural (Cheonan, Korea). Wheat flour (Daehan Flour, Seoul, Korea, sugar (Cheiljedang, Seoul, Korea), shortening (Allthebaking, Busan, Korea), yeast (Societe Industrielle Lesaffre, Marcq, France), milk powder (Allthebaking, Busan, Korea), and salt (Chungjungone, Seoul, Korea) were purchased online.

2. Bread preparation

Bread containing Korean pine leaf powder was prepared according to the methods described by Park LY (2015) and Lee MH (2018). *Korean pine* leaf powder was added in the following proportions in preliminary experiments: 0%, 1%, 3%, 5%, and 7%. The amount was later standardized as shown in Table 1.

Dough was prepared using the straight dough method. Wheat flour, Korean pine leaf powder, water, sugar, yeast, and salt were added in a kneader (5K5SSA, Whirlpool Corp., Benton Charter Township, MI, USA), and dough was kneaded at speed 1 for 2 min. To form a lump of dough, shortening was added and dough was kneaded at speed 2 for 3 min. The first fermentation was performed at 27℃ and 75% relative humidity for 15 min in a fermentor (EP-20, Daeyung, Korea). After the first fermentation, the dough was kneaded for 3 min to remove the gas. The second fermentation was performed at 27℃ at 75% relative humidity for 1 h. After the second fermentation, the dough was turned into a round shape. The third fermentation was performed at 27℃ and 75% relative humidity for 15 min. After the third fermentation, the dough was divided into three parts and placed in a mold. The fourth fermentation was performed at 35℃ and 85% relative humidity for 1 h. After the fourth fermentation, the dough was baked in an oven (FDO-7103, Daeyung, Korea), with the temperature at the top being 180℃ and at the bottom being 190℃, for 30 min. After cooling at room temperature for 1 h, it was stored in a sealed container at room temperature for future use in the experiment.

3. Height and moisture of the bread

Height of the bread was measured in the middle by cutting a cross section of the bread using a ruler (Fig. 1).

Moisture content was measured by subjecting the bread to method of heat drying on high pressure in a dry oven (LO-FS150, LK Lab, Namyangju, Korea) at 105℃ according to AOAC (1980).

4. Color values of the bread

The bread was measured by cutting 3 cm×3 cm×3 cm section in half. Color values of the bread were measured by determining the L-value (brightness), a-value (redness), and b-value (yellowness) using a chromometer (CR-170, Minolta, Osaka, Japan). Standard white plate (L=93.00, a=0.3125, and b=0.531) was used as the reference.

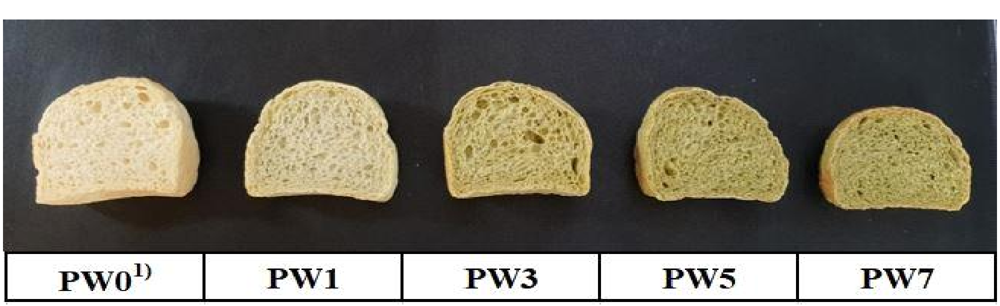

Fig. 1. Bread containing Korean pine leaf powder. [1)] PW0, PW1, PW3, PW5, and PW7 represent addition of 1%, 3%, 5%, and 7% Korean pine leaf powder.

5. Texture characteristics of the bread

Texture characteristics, namely adhesiveness, hardness, springiness, and chewiness, of the bread were measured using a CTX Texture analyzer (CTX, Ametek Brookfield, MA, USA).

Texture profile analysis (TPA) of five sample (3 cm×3 cm×3 cm) was performed. Measurements of the samples were taken under the following conditions: compression 25%, trigger force 10 g, test speed 10 mm/s, sample diameter 30 mm, and sample height 20 mm.

6. Total polyphenol content and ABTS- and DPPH-radical scavenging capacities of the bread

To study the antioxidant capacity of the bread, total polyphenol content, ABTS-radical scavenging capacity, and DPPH-radical scavenging capacity were measured. The wet sample (3 g) was homogenized by adding 27 mL ethanol. To measure the total polyphenol content, 0.4 mL of homogenized sample and 0.4 mL of Folin-Ciocalteu reagent were mixed, and maintained at room temperature for 5 min. Thereafter, 0.4 mL of 10% sodium carbonate was added, and the reaction mixture was maintained at room temperature for 10 min. The absorbance was measured at 765 nm using a spectrophotometer (UV-1800, Shimadzu, Japan). The total polyphenol content was determined using the formula given.

To determine the ABTS-radical scavenging capacity, 7.4 mM ABTS-radical solution and 2.7 mM potassium persulphate solution were mixed in a ratio of 1:1. The mixture was diluted with 50% ethanol so that the absorbance was 0.7~1.0 at 734 nm, which was measured using a spectrophotometer (UV-1800, Shimadzu, Japan). The homogenized sample (0.2 mL) and ABTS-radical solution (0.4 mL) were mixed and maintained at room temperature for 10 min. Thereafter, absorbance was measured at 734 nm using a spectrophotometer (UV-1800, Shimadzu, Japan), and the ABTS-radical scavenging capacity was determined using the following formula.

To determine DPPH-radical scavenging capacity, 0.2 mL of homogenized sample and 0.4 mL of 0.2 mM DPPH-radical solution were mixed and allowed to react for 30 minutes in the dark. The absorbance was measured at 517 nm using a spectrophotometer (UV-1800, Shimadzu, Japan). The DPPH-radical scavenging capacity was determined using the following formula.

7. Sensory characteristics of the bread

Sensory characteristics of the bread were evaluated by 15 food-related workers after the purpose and evaluation method of this study were explained to them (Eulji University Institutional Bioethics Committee Deliberation Exemption Approval Number: EU21-058).

The bread stored at room temperature was cut into 2 cm × 2 cm×1 cm pieces and served on plates with a random check. After evaluating each sample, water was provided as a palate cleanser. The seven-point scale was used to evaluate the following characteristics: color, flavor, texture, taste, and overall preference.

8. Statistical analysis

All the experimental results of this study were measured three times. SPSS 22.0 package (ver. 22.0, Chicago, IL, USA) was used for processing and analyzing the data, which was expressed as mean±standard error (SE). The control group and addition group were analyzed using one-way analysis of variance ($p<0.05$) and least squares method.

Result and Discussion

1. Height and moisture content of the bread containing Korean pine leaf powder

Height and moisture content of the bread are shown in Table 1. The height of the bread was the highest in the 1% additive group (4.98 cm) and the lowest in the 7% additive group (4.53 cm). Compared with the control, the height increased significantly in the 1% additive group, and then decreased with the increase in the amount of leaf powder added ($p<0.001$). The moisture content was the highest in the 3% additive group (37.51%) and the lowest in the 7% additive group (32.95%); there were no significant differences between the groups ($p=0.059$). The moisture content was not significantly changed; however, there was a tendency to decrease except for the 1% additive group.

Similar to our results, the height of *Angelica gigas* Nakai powder bread (Shin & Kim 2008) and *lotus* leaf powder bread (Park et al. 2009) was shown to decrease as the amount of leaf powder was increased. In Green tea bread, the reason for the decrease in volume as the amount added is thought to be that the minerals contained in green tea in inhibit yeast fermentation in the dough and inhibit the formation of gluten. When manufacturing bread by adding other ingredients, depending on the nature of the additive, if there is no substance that can maintain the gluten structure among the additives, it is difficult to maintain the structural strength and the volume decreases

Table 1. List of ingredients used to prepare the bread containing Korean pine leaf powder

Ingredients (g)	PW0[1)]	PW1	PW3	PW5	PW7
Wheat flour	100	99	97	95	93
Korean pine leaf powder	0	1	3	5	7
Water	64	64	64	64	64
Sugar	5	5	5	5	5
Shortening	5	5	5	5	5
Yeast	4	4	4	4	4
Milk powder	3	3	3	3	3
Salt	2	2	2	2	2

1) PW0, PW1, PW3, PW5, and PW7 represent addition of 1%, 3%, 5%, and 7% leaf powder.

(Kang & Nam 1999). Also, In a previous study on Job's Tears powder and green tea powder bread (Park & Lee 1999), it was reported that the moisture decreases as the amount of leaf powder increases due to the interaction between fiber and protein. In this study, except for the 1% additive group, it was found that the lesser the moisture, the smaller the height, suggesting that moisture content affects the height of the bread and the minerals in Korean pine leaf affect volume reduction.

2. Color value of the bread containing Korean pine leaf powder

Color values of the bread are shown in Table 2. The L-value was the highest in the control group (85.05) and the lowest in the 7% additive group (53.45), and it decreased significantly as the amount of leaf powder was increased ($p<0.001$). The a-value was the highest in the control group (−2.50) and the lowest in the 3% additive group (−4.37). Compared with the control, it decreased significantly till the 3% addition group, and then increased ($p<0.001$). The b-value was the highest in the 7% additive group (30.74) and the lowest in the control group (16.75); it increased significantly as the amount of leaf powder was increased ($p<0.001$).

According to previous studies on bread containing greenish powder *Houttuynia cordata* Thunb powder (Park LY 2015) and green tea powder (Im & Kim 1999) as in this study, the L-value and a-value decreased while the b-value increased as the amount of leaf powder was increased; a similar trend was observed in this study. It can be seen that as the color gets darker, the brightness decreases and the yellowness increases.

3. Texture characteristics of the bread containing Korean pine leaf powder

Texture characteristics of bread are shown in Table 3. The adhesiveness was the highest in the control group (0.32 mJ) and the lowest in the 7% additive group (0.13 mJ). Compared with the control, it decreased significantly as the amount of leaf powder was increased ($p<0.001$). The hardness was the highest in the 1% additive group (855.70 g) and the lowest in the 7% additive group (739.23 g). Compared with the control, it increased significantly in the 1% additive group, and then decreased ($p<0.001$). Springiness was the highest in the 1% additive group (9.46 mm) and the lowest in the 7% additive group (8.03 mm);

Table 2. Height, moisture content and Color values of the bread containing Korean pine leaf powder

Sample[1)]	PW0	PW1	PW3	PW5	PW7	*p*-value
Height (cm)	$4.82±0.02^b$	$4.98±0.06^c$	$4.75±0.03^b$	$4.63±0.03^a$	$4.53±0.02^a$	<0.001
Moisture content (%)	36.19±0.45	33.41±2.31	37.51±0.64	36.49±0.42	32.95±0.22	0.059
L-value	$85.05±0.10^d$	$69.25±0.53^c$	$62.81±0.40^b$	$61.05±0.28^b$	$53.45±1.92^a$	<0.001
a-value	$-2.50±0.05^d$	$-3.54±0.02^b$	$-4.37±0.05^a$	$-3.70±0.02^b$	$-3.26±0.10^c$	<0.001
b-value	$16.75±0.08^a$	$20.75±0.06^b$	$26.56±0.16^c$	$30.56±0.30^d$	$30.74±0.15^d$	<0.001

1) PW0, PW1, PW3, PW5, and PW7 represent addition of 1%, 3%, 5%, and 7% leaf powder.
a-d Represents significant differences based on least squares method at $p<0.05$.

Table 3. Texture characteristics of bread containing Korean pine leaf powder

Sample[1)]	PW0	PW1	PW3	PW5	PW7	*p*-value
Adhesiveness (mJ)	0.32±0.01[d]	0.26±0.00[c]	0.25±0.01[c]	0.16±0.00[b]	0.13±0.00[a]	<0.001
Hardness (g)	848.50±4.04[b]	855.70±22.26[b]	839.03±12.22[b]	740.70±18.13[a]	739.23±6.31[a]	<0.001
Springiness (mm)	9.39±0.13[c]	9.46±0.14[c]	8.54±0.01[b]	8.69±0.07[b]	8.03±0.01[a]	<0.001
Chewiness (mJ)	51.89±0.50[a]	55.21±0.72[b]	58.80±0.67[cd]	56.52±1.19[bc]	59.10±0.25[d]	<0.001

[1)] PW0, PW1, PW3, PW5, and PW7 represent addition of 1%, 3%, 5%, and 7% leaf powder.
[a-d]Represent significant differences based on least squares method at $p<0.05$.

significant differences were present between the groups ($p<0.001$). But compared with the control, the values did not show a continuous trend of increase or decrease. Chewiness was the highest in the 7% additive group (59.1 mJ) and the lowest in the control group (51.89 mJ); there was significant difference between the group ($p<0.001$). Compared with the control, chewiness increased as the amount of leaf powder was increased.

In this study, as the amount of Korean pine leaf powder in the bread was increased, the adhesiveness and hardness significantly decreased. However, the springiness and chewiness did not show a specific trend; springiness was lower, and chewiness was higher in the additive groups than in the control group, and there were significant differences between the groups. In *Corni fructus* powder bread (Shin & Shin 2008), the adhesiveness and hardness significantly decreased as the amount of leaf powder was increased. In *Cudrania tricuspidate* leaf powder bread (Kim & Ju 2016), the hardness and chewiness were observed to increase as the amount of leaf powder was increased. In black soybean powder bread (Im & Kim 2003), adhesiveness and springiness were significantly increased. In medicinal herb composites bread, It is considered that the physical properties of bread are greatly affected by the additive materials and amount added, and are also affected by the moisture and volume of the bread (Kang et al. 2009). According to a study on buckwheat bread with different gluten contents, the buckwheat mixture dough with added gluten had an increased moisture absorption rate, longer dough formation time, decreased weakening, and increased extensibility (Chung & Kim 1998a). When bread was made from buckwheat dough with added gluten, sensory characteristics showed that the crumbliness of the bread was reduced and elasticity was improved (Chung & Kim 1998b). Accordingly, it is believed that there is a relationship between gluten and texture. In this study, as the content of Korean pine leaf powder increased, the gluten content decreased due to a decrease in the ratio of flour content, which is believed to have affected the texture of the bread. In *Aster glehni* powder bread, the lower the springiness, cohesivenss and chewiness compared to the control group, the higher the taste, texture, and overall preference in sensory characteristics (Park JR 2022). On the other hand, in watermelon seed powder bread, the group with the highest texture, taste, and overall preference in the sensory characteristics was medium in springiness, cohesivenss and chewiness (Kim & Suh 2023). Therefore, it can be seen that there are differences in texture characterisstics and sensory characteristics depending on the added material.

4. Total polyphenol content and ABTS- and DPPH-radical scavenging capacities of the bread containing Korean pine leaf powder

Total polyphenol content and ABTS- and DPPH-radical scavenging capacities of the bread are shown in Table 4. Total polyphenol content was the highest in the 7% additive group (669.13 μg/mL) and the lowest in the control group (466.83 μg/mL). Compared with the control it increased significantly as the amount of leaf powder increased ($p<0.001$). ABTS-radical scavenging capacity was the highest in the 7% additive group (43.23%) and the lowest in the control group (0.46%). Compared with the control, it increased significantly as the amount of leaf powder increased ($p<0.001$). DPPH-radical scavenging capacity was the highest in the 7% additive group (45.76%) and the lowest in the control group (1.39%). It increased significantly as the amount of leaf powder was increased ($p<0.001$).

Korean pine leaves contain gallic acid and syringic acid, which have antioxidant effects (Lee et al. 1992; Song & Kim 1994; Cha et al. 2000). Moreover, high total polyphenol content and ABTS- and DPPH-radical scavenging capacities have been reported in Kim et al. (2012) and Jo et al. (2017). In this study, as the amount of Korean pine leaf powder was increased, the

Table 4. Total polyphenol content and ABTS- and DPPH-radical scavenging capacities of bread containing *Korean pine* leaf powder

Sample[1)]	PW0	PW1	PW3	PW5	PW7	*p*-value
Total polyphenol (μg/mL)	466.83±5.32[a]	534.8±3.31[b]	570.37±3.07[c]	576.83±1.73[c]	669.13±1.29[d]	<0.001
ABTS (%)	0.46±0.07[a]	22.08±0.34[b]	26.61±0.4[c]	35.53±0.67[d]	43.23±0.36[e]	<0.001
DPPH (%)	1.39±0.28[a]	23.74±0.30[b]	32.25±0.93[c]	39.33±0.68[d]	45.76±0.83[e]	<0.001

[1)] PW0, PW1, PW3, PW5, and PW7 represent addition of 1%, 3%, 5%, and 7% leaf powder.
[a-e]Represents significant differences based on least squares method at $p<0.05$.

total polyphenol content and the ABTS- and DPPH-radical scavenging capacities significantly increased. Similarly, in *Gynura procumbens* powder bread (Shin et al. 2019) and mugwort powder bread (Woo & Lee 2021), antioxidant activity increased with the increase in the amount of the powder.

5. Sensory characteristics of the bread containing Korean pine leaf powder

Sensory characteristics of the bread are shown in Table 5. Color preference was the highest in the 7% additive group (5.40) and the lowest in the 1% additive group (3.27). Compared with the control, it first decreased in the 1% group and then increased significantly as the amount of leaf powder was increased (p=0.017). It was considered that the bread's color became clearer. As a result, the preference increased as the amount of leaf powder was increased, and the color became darker. Flavor preference was the highest in the 3% additive group (4.67) and the lowest in the control group (3.60). Compared with the control, it increased till the 3% additive group and then decreased; however, there were no significant differences between the groups (p=0.463). It is considered that the flavor preference increased because the flavor become stronger as the amount of leaf powder was increased. It is considered that the bitter taste of the Korean pine leaf powder must have reduced the taste preference as the amount of leaf powder was increased. In the pine needle extract bread, the taste preference was the lowest when 100% extract was added (Kim & Kim 1998). Taste preference was the highest in the 1% additive group (4.53) and the lowest in the control group (3.67). Compared with the control, it increased in the 1% additive group, and then decreased; however, there were no significant differences between the groups (p=0.622). Texture preference was the highest in the 7% additive group (4.80) and the lowest in the control group (3.40). Compared with the control, it increased significantly as the amount of leaf powder increased (p=0.006). It was considered to be influenced by the increase in adhesion, hardness, and chewiness and decrease in springiness as the amount of leaf powder was increased. Overall preference was the highest in the 1% additive group (4.47) and the lowest in the 7% additive group (2.93). Compared with the control, it increased significantly in the 1% additive group and then decreased ($p<0.001$). In the case of whey pan bread, the 50% additive group was the highest (Lee & Lee 2021). But, in the case of mugwort powder white bread, the control group was the highest. This is considered to be due to a strong rejection of the bitter taste of mugwort (Jung IC 2006).

In summary, in this study, the color and taste preferences were the highest in 7% additive group. The flavor and texture

Table 5. Sensory characteristics of white pan bread containing Korean pine leaf powder

Sample[1)]	PW0	PW1	PW3	PW5	PW7	*p*-value
Color	4.27±0.60[abc]	3.27±0.49[ab]	4.53±0.40[abc]	5.00±0.37[bc]	5.40±0.35[abc]	0.017
Flavor	3.60±0.46	4.27±0.41	4.67±0.37	4.60±0.46	4.40±0.52	463
Taste	3.67±0.42	4.53±0.29	4.33±0.43	4.00±0.53	3.80±0.52	0.622
Texture	3.40±0.35[a]	4.33±0.19[b]	4.33±0.23[b]	4.47±0.22[b]	4.80±0.30[b]	0.006
Ovaerall preference	4.13±0.35[b]	4.47±0.27[b]	4.40±0.42[b]	3.07±0.34[a]	2.93±0.40[a]	0.004

[1)] PW0, PW1, PW3, PW5, and PW7 represent addition of 1%, 3%, 5%, and 7% leaf powder.
[a-c]Represents significant differences based on least squares method at $p<0.05$.

preferences were the highest in 3% and 7% additive groups, respectively; however, there were no significant differences between the groups. In addition, the overall preference was the highest in 1% additive group due to the influence of the flavor and texture.

Conclusion

In this study, to develop healthy bread, the Korean pine leaf powder, which is a by-product of *Korean pine*, was added to the bread in the following proportions: 0%, 1%, 3%, 5%, and 7%. Various quality characteristics of the bread were evaluated namely height, moisture content, color values, texture characteristics, antioxidant capacity, and sensory characteristics.

The height of the bread increased significantly in the 1% additive group, and then decreased (p<0.001). The moisture content was a decreasing trend was observed except for 1% additive group, but there was no significant difference between each group (p=0.059). The L-value decreased significantly with the increase in the amount of leaf powder (p<0.001). The a-value increased significantly till the 3% additive group and then decreased (p<0.001). The b-value increased significantly as the amount of addition increased (p<0.001). The adhesiveness decreased significantly as the amount of leaf powder increased (p<0.001). The hardness increased significantly till the 3% additive group and then decreased (p<0.001). The springiness was a significant difference between each group (p<0.001). The chewiness was a significant difference between each group (p<0.001). The total polyphenol content increased significantly with the increase in the amount of leaf powder added (p<0.001). The ABTS-radical scavenging capacity increased significantly as the amount of leaf powder was increased (p<0.001). The DPPH-radical scavenging capacity increased significantly as the amount of leaf powder added was increased (p<0.001). The color preference increased significantly as the amount of leaf powder added was increased (p=0.017). The flavor preference increased till the 3% additive group and then decreased, but there was no significant difference between the groups (p=0.463). The taste preference increased in the 1% additive group and then decreased, but there was no significant difference between the groups (p=0.622). The texture preference increased significantly as the amount of leaf powder was increased (p=0.006). The overall preference increased significantly in the 1% additive group and then decreased (p=0.004).

In this study, healthy bread was developed using *Korean pine* leaf powder, a by-product of Korean pine. The data of our study would contribute to increasing the utilization of Korean pine leaves and the development of healthy foods with good antioxidant properties.

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References

AOAC. 1980. Official Methods of Analysis. 13th ed. pp.3508-3515. Association of Official Analytical Chemists

Cha BC, Lee SB, Rhim TJ, Lee KH. 2000. Antioxidative and hepatoprotective effect of compounds isolated from Galla rhois (*Rhus javanica* Linne). *Korean J Med Crop Sci* 8:157-164

Cho YJ. 2017. Inhibitory effect of *Koreinsis chinensis* leaves extract on proinflammatory responses in lipopolysaccharide-induced Raw 264.7 cells. *J Appl Biol Chem* 60:191-198

Chung JY, Kim CS. 1998a. Development of buckwheat bread: 1. Effects of vital wheat gluten and water-soluble gums on dough rheological properties. *Korean J Soc Food Sci* 14: 140-147

Chung JY, Kim CS. 1998b. Development of buckwheat bread: 2. Effects of vital wheat gluten and water soluble gums on baking and sensory properties. *Korean J Soc Food Sci* 14: 168-176

Im JG, Kim YH. 1999. Effect of green tea addition on the quality of white bread. *Korean J Soc Food Sci* 15:395-400

Im JG, Kim YH. 2003. Quality characteristics of bread prepared by the addition of black soybean powder. *J East Asian Soc Diet Life* 13:334-341

Jo JB, Park HJ, Lee EH, Lee JE, Lim SB, Hong SH, Cho YJ. 2017. Whitening and anti-wrinkle effect of *Pinus koraiensis* leaves extracts according to the drying technique. *J Appl Biol Chem* 60:73-78

Jung DS, Lee FZ, Eun JB. 2002. Quality properties of bread made of wheat flour and black rice flour. *Korean J Food Sci Technol* 34:232-237

Jung IC. 2006. Rheological properties and sensory characteristics of white bread with added mugwort powder. *J East Asian Soc Diet Life* 16:332-343

Kang JS, Kang SK, Kim HS. 2009. Preparation and characteristics of bread by medicinal herb composites with cognitive function. *J Korean Soc Food Sci Nutr* 38:1131-1138

Kang MY, Nam YJ. 1999. Studies on bread-making quality of colored rice (Suwon 415) flours. *Korean J Food Sci* 15:37-41

Kim E, Ju HW. 2016. Quality characteristics of white pan bread with *Cudrania tricuspidata* leaf powder. *Culin Sci Hosp Res* 22:173-186

Kim EJ, Kim SM. 1998. Bread properties utilizing extracts of pine needle according to preparation method. *Korean J Food Sci Technol* 30:542-547

Kim E, Suh SU. 2023. Quality characteristics of white pan bread made with watermelon seed powder. *Culin Sci Hosp Res* 29:27-36

Kim HS, Jung BO, Lee SB, Chung SJ. 2012. Antioxidant and antibacterial activities of *Pinus koraiensis* extracts with chitosan. *J Chitin Chitosan* 17:221-228

Kim YH, Han MR, Yoon SJ. 2020. Quality characteristics and textural properties of dough of white pan bread with added chlorella powder. *Korean J Food Nutr* 33:681-691

Kwon KS, Kim YS, Song GS, Hong SP. 2004. Quality characteristics of bread with *Rubi fructus* (*Rubus coreanus* Miquel) juice. *Korean J Food Nutr* 17:272-277

Lee JS, Kim JM. 2020. Quality characteristics and antioxidant properties of white pan bread added with sea buckthorn (*Hippophae rhamnoids* L.) berry powder. *Korean J Food Nutr* 33:473-482

Lee KH, Lee MH. 2021. The palatability and quality characteristics of whey added pan bread. *Culin Sci Hosp Res* 27:34-44

Lee KH. 2014. Trends and prospects of the bakery industry. *Food Ind Nutr* 19:38-46

Lee MH, Jeong JH, Oh MJ. 1992. Antioxidative activity of gallic acid in acorn extract. *J Korean Soc Food Sci Nutr* 21:693-700

Lee MH. 2018. Quality characteristics of white pan bread added mate (*Ilex paraguariensis*) leaf powder. *Culin Sci Hosp Res* 24:145-155

Lee SH. 1990. Confectionery, baking. *Bull Food Technol* 3:5-17

Lee YS, Hwang YK, Woo IA. 2006. A study on the preference and the actual using patterns of the bakery products using functional ingredients. *Korean J Culin Res* 12:116-130

Park GS, Lee SJ. 1999. Effects of job's tears powder and green tea powder on the characteristics of quality of bread. *J Korean Soc Food Sci Nutr* 28:1244-1250

Park JR. 2022. Quality characteristics of morning bread added with aster glehni powder. *Culin Sci Hosp Res* 28:45-56

Park LY. 2015. Effect of *Houttuynia cordata* Thunb. powder on the quality characteristics of bread. *Korean J Food Sci Technol* 47:75-80

Park SH, Chang KH, Byun GI, Kang WW. 2009. Quality characteristics of bread made with flour partly substituted by lotus leaf powder. *Korean J Food Preserv* 16:47-52

Shin GM, Jung JW. 1998. A study on the utilige of materials of bread. *Korean J Culin Res* 4:389-411

Shin GM, Kim DY. 2008. Quality characteristics of white pan bread by *Angelica gigas* Nakai powder. *Korean J Food Preserv* 15:497-504

Shin GM, Roh SH. 2000. A study on the commonness and difference in patisseries and bread. *Korean J Culin Res* 6:331-349

Shin JW, Shin GM. 2008. Quality of white pan bread as affected by various concentrations of *Corni fructus* powder. *J East Asian Soc Diet Life* 18:1007-1013

Shin YJ, Jegal JM, Lee MH. 2019. Quality and antioxidant properties of white bread with *Gynura procumbens* powder. *Culin Sci Hosp Res* 25:1-11

Song HK, Kim JK. 1994. Essential oil components of leaves and resins from *Pinus densiflora* and *Pinus koraiensis*. *J Korean Wood Sci Technol* 22:59-67

Woo SL, Lee MH. 2021. Quality characteristics and antioxidant of pan bread prepared with mugwort powder. *Culin Sci Hosp Res* 27:153-162

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