Emirates Journal of Food and Agriculture. 2022. 34(7): 605-611
doi: 10.9755/ejfa.2022.v34.i7.2901
http://www.ejfa.me/

RESEARCH ARTICLE

Antioxidant activities and physicochemical property of *Jeolpyeon* added with laver (*Porphyra tenera*)

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ABSTRACT

As the importance of diseases related to aging has been highlighted worldwide, interest in antioxidant functional foods is increasing. In Korea, *P. tenera*, which is rich in polyphenol compounds and is beneficial to health, has been consumed for a long time, and over time, it has been re-examined in the West, and the demand is increasing. However, due to the lack of studies using laver, this paper experimented with adding *P. tenera* to rice cake, a traditional Korean food that lowers the risk and incidence of chronic diseases. As the amount of *P. tenera* added increased, the water content increased, and there was no significant difference in pH. As the added content of *P. tenera* increased, the total phenol content was significantly increased from 31.38 (control) to 40.80 (3% sample), 49.18 (6% sample), 55.04 (9% sample), 55.78 (12% sample), and flavonoids were significantly increased at 13.27 (12% sample). ABTS significantly increased from 4.81 (control) to 9.50 (6% sample), 18.89 (9% sample), and 37.24 (12% sample). The increase in the content of *P. tenera* suggests that the phenol contained in *P. tenera* has an antioxidant effect. In the sensory evaluation, the 12% sample received the highest score of 3.57 in overall preference. Therefore, *P. tenera Jeolpyeon* was confirmed to have excellent antioxidant effect and overall preference, suggesting that it has potential as a health functional food.

Keywords: Laver (Porphyra tenera); Rice cake; *Jeolpyeon*; Antioxidant effects; Physicochemical properties

INTRODUCTION

Laver (*Porphyra tenera*), a type of seaweed, belongs to the red algae, Bangiales Bangiaceae Rhodophyta. When written in Chinese and Korean characters, they are also called *chamgim haewoo, haeui* (海衣), and *haetai* (海苔) (Jimenez-Escrig and Cambrodón, 1999). Good quality *P. tenera* is glossy and has a dark black and blue color, but turns red over time. *P. tenera* has a high content of amino acids such as taurine, alanine, and glutamic acid, which gives it a unique flavor, sweetness, and umami taste. (Kim et al., 2020; Hwang, 2013). The harvest season for laver is from October to March, and the water temperature for the harvest season is between 4.26°C to 20.89°C. At this time, if the water temperature is high, the growth is bad, and in severe cases, the shoot may be lost, so it is greatly affected by the temperature. Also, this is the season when the quality and taste of *P. tenera* are the best, and it is also a seasonal food. (Ministry of Oceans and Fisheries, 2018). *P. tenera* contains about 40% carbohydrate and about 35% protein, and unlike other seaweeds, it contains carbohydrate isofloridoside and free sugar floridoside. It also contains dietary fiber, including hemicellulose, a cell wall component, and insoluble polysaccharides (Kim et al., 2014; Cao et al., 2016). In addition, it has a high content of fiber, iodine, calcium, zinc, manganese, iron, minerals and vitamins, and contains essential amino acids such as leucine, lysine, and valine and various amino acids, and has low calories and fat content (Park et al., 2020; Galland-Irmouli et al., 1999; Burtin, 2003; Bocanegra et al., 2003). Porphyran, a sticky component in *P. tenera*, is an insoluble dietary fiber that has beneficial substances and functional ingredients to lower cholesterol, maintain bioregulation and prevent diseases, and also have antioxidant effects. In an experiment using rats, it was shown that serum cholesterol levels were reduced and that it had an antihyperlipidemic effect, preventing cardiovascular diseases. It has been shown that it can be attributed to the improvement of hyperlipidemia, the anticancer effect of glycoproteins, immune activity, anti-inflammatory action, immune regulation, and prevention of diseases such as disorders of the nervous system, bone, and diabetes (Lee et al., 2010; Cho et al., 1990; Jung et al., 2002; Cao et al., 2016; Bito et al., 2017). *P. tenera*, a red algae, is rich

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Received: 22 December 2021; **Accepted:** 28 June 2022

in polyphenol compounds such as catechin, phlorotanin, and fucoxanthin, and when ingested, it reduces the risk of chronic diseases such as obesity, diabetes, high blood pressure, hyperlipidemia, heart disease and cancer, thereby lowering the risk and incidence of metabolic adult diseases (Dawczynski et al., 2007; Gupta and Abu-Ghannam, 2011; Larsen et al., 2011; Bocanegra et al., 2009). *P. tenera* is a food that has been enjoyed for a long time and is grown in the west coast, south coast and Wando of Jeollanam-do, South Korea, and consumed in China and Japan. As time goes by, attention has been gradually focused on oriental cuisine, and the demand for seaweed is also increasing in Western countries (Kim et al., 2020). *P. tenera* is a fishery product with higher added value as all stages of distribution and export are made in Korea and are grown and processed by fishermen themselves (MOF, 2020). The total production of seaweeds in Korea, such as laver, kelp, seaweed, Hijki, and Ulva (*Enteromorpha*), increased from 938 tons to 318 tons, accounting for 32% of the total production (Statistics Korea, 2015). The export value of *P. tenera* is rising to USD 110 million in 2010, USD 230 million in 2012, USD 300 million in 2015, USD 510 million in 2017, USD 530 million in 2019, and USD 580 million in 2019, It ranked first among seafood products, and P. tenera exports increased every year (MOF, 2020).

There are many semi-processed products that can be obtained from laver such as seasoned laver, dried laver, roasted laver, laver bu-gak, laver confectionery, etc. that are currently being produced in the food industry. In addition to kimbap and sushi, seaweed is also widely used as a garnish on food. However, in order to further develop the seaweed industry, research and development of food using seaweed must be continued. In addition, all human beings are aging over time and all bodily functions gradually weaken. Accordingly, in modern society, there is an increasing number of people who want to take health care and healthy functional foods to prevent aging and diseases due to oxidation in advance. Therefore, this study aims to confirm the quality characteristics and antioxidant activity by adding laver, which is a rich source of health-promoting substances, as a food that can be consumed as a meal substitute or snack among Korean traditional food. As part of this study, rice cake with added seaweed laver is thought to be a nutrient-rich healthy functional food as its quality improves, and it is expected to be well received by consumers.

MATERIALS AND METHODS

Experimental materials

The *P. tenera* used in this study was *P. tenera* Collected in December 2020 using land harvesting during artificial harvesting in Samjosusan, Janghang-eup, Seocheon-si, Chungcheongnam-do, Korea. Rice (Nonghyup, Andong) was used as the main ingredient, and salt (Anju salt, Hanju Co., Ltd., Ulsan) and soybean oil (Company: Dongwon, Gyeonggi, South Korea) were used.

Preparation of Jeolpyeon with added *P. tenera*

P. tenera was prepared by washing 3 times under running water, placing it on a sieve, draining the water for 30 minutes, and then slicing it into small pieces. Wash non-glutinous rice 3 times, soak in water for 6 hours, and sieve through a sieve for 30 minutes to drain the water. Add 2 kg of rice, 24 g of salt, and water, mix, and grind finely once in a roll mill, then add *P. tenera*, grind again, and pass through a 20 mesh once. Place the silicone food mesh in a 40 cm*40 cm stainless steel steamer, put the ingredients, and steam for 20 minutes in the steamer. After putting the steamed rice cakes in the jebyeong-gie (KM-19) and removing the rice cakes, the rice cakes were pulled out again with a *jeolpyeon* mold Lastly, lightly greased with oil.

Measurement of water content

Moisture content was measured with a moisture measuring analyzer (MB45, Ohaus, Parsippany, NJ, USA). First, after removing the wrapping paper of the sample, it was ground with a mortar and 1 g was weighed to measure the moisture content. Moisture content measurement was repeated 3 times per sample.

Measurement of pH

The pH was measured by adding distilled water 10 times the weight of the sample to the sample, homogenizing it with a homogenizer, and taking the supernatant, and repeating 3 times per sample with a pH meter (pH-240L, NeoMet, Istek, Seoul, South Korea).

Measurement of chromaticity

After removing the wrapping paper of the sample, using a Minolta chroma meter (CR-400, Minolta Co., Osaka, Japan), *L* value indicating lightness, *a* value indicating redness, and *b* value indicating yellowness were measured 3 times, respectively. For standardization of the Minolta chroma meter, a standard color plate (Y = 92.8, x = 0.3134, y = 0.3193) was used.

Measurement of texture

After removing the wrapping paper of the sample, measurements were made from top to bottom (right angle) using a measuring device, Instron 3343 (US/MX50, A&D Co., MA, USA). The measurement was conducted repeatedly 3 times for hardness, cohesiveness, springness, gumminess, chewiness, and adhesiveness.

Antioxidant effect of Korean rice cake supplemented with *P. tenera*

Sample extraction

Jeolpyeon with different content of *P. tenera* was ground using a mortar and then weighed 4 g in a 100 ml Erlenmeyer flask.

After that, 40ml of distilled water was added and mixed well. The temperature of the water bath (BS-31, JEIO TECH.CO., LTD, Seoul, South Korea) was set to 100°C, and the sample was heated for 60 minutes to extract the components. After centrifuging the extract at 12,000rpm for 20 minutes (MICRO 17R; Hanil, Incheon, Korea), the supernatant was taken and used to measure antioxidant activity.

Total phenol and flavonoid contents

Samples were prepared in the same way as for antioxidant activity. Total polyphenol content was determined by modifying the FolinCiocalteau method (Taga et al., 1984) First, Sodium Carbonate (Na_2CO_3) was diluted with diluted water to 700mM, and 2N Folin & Ciocalteu's phenol reagent (47641-100ML-F, Sigma-Aldrich, St Louis, MO, USA) was diluted to 1N. 100µl of each diluted sample was added to each test tube, and 200 µl of 1N Folin & Ciocalteu's phenol reagent was added and mixed well. After adding 700 µl of 700mM Na_2CO_3, mixing, and reacting at room temperature for 30 minutes, absorbance was measured at 650nm with a UV spectrophotometer (Optizen POP, Mecasys CO., LTd, Daejeon, South Korea). For the total polyphenol content, a calibration curve was prepared using gallic acid (G7384-100G, Sigma-Aldrich, St Louis, MO, USA) as a standard material, and the total polyphenol content was obtained from this.

$$\text{Total Polyphenol content } (\mu g\ GAE/g) = \frac{(A-B)}{C} \times \text{Dilution multiple} \times \text{Sampling solvent volume } (ml) \div \text{Sample weight } (g)$$

A: Absorbance after reaction of sample solution
B: Y-axis of Gallic Acid Standard Curve
C: Slope of Gallic Acid Standard Curve 6. Flavonoid

The total flavonoid content was measured by applying variation to the method of (Jia et al., 1999) In a glass test tube, 150 µl of diluted water and 75 µl of 5% $NaNO_2$ were added to 125 µl of each diluted sample in a glass test tube, and the mixture was reacted at room temperature for 6 minutes. After that, 150 µl of 10% $AlCl_3$ was added and reacted at room temperature for 5 minutes. Last, 750 µl of 1N NaOH was dispensed and reacted at room temperature for 15 minutes, and absorbance was measured at 492 nm with a UV spectrophotometer (Optizen POP, Mecasys CO., LTd, Daejeon, South Korea). For the total flavonoid content, a calibration curve was prepared using Quercetin (Q4951-10G, Sigma-Aldrich, St Louis, MO, USA) as a standard material, and the total flavonoid content was obtained from this.

$$\text{Total Flavonois content } (\mu g\ QE/g) = \frac{(A-B)}{C} \times \text{Dilution multiple} \times \text{Sampling solventvolume } (ml) \div \text{Sample weight } (g)$$

A: Absorbance after reaction of sample solution
B: Y-axis of Quercetin Standard Curve
C: Slope of Quercetin Standard Curve

ABTS radical scavenging activity

Fee redical 2,2-azinobis (3-ethylbenzothiazoline-6-sulfonic) ABTS was measured by modifying the method of (Re et al., 1999) After mixing 5 ml of 7 mM ABTS and 88 µl of 140 mM potassium persulfate, light was blocked at room temperature for 16 hours to form ABTS cations. This solution was diluted with PBS to obtain an absorbance value of 0.7 at 734 nm. After mixing 190 µl of ABTS solution and 10 µl of the sample, the mixture was reacted at room temperature for 6 minutes, and absorbance was measured at 734 nm with a Versamax microplate reader (Molecular Devices, California, USA). The result was calculated by substituting the data in the following formula.

$$\text{ABTS Radical Scavenging } (\%) = \frac{(\text{Controller Absorption}) - (\text{Sample Absorption})}{(\text{Controller Absorption})} \times 100$$

Sensory evaluation

Major of Rice Cake Manufacturing Management and Major of Medicinal Crop in Sungkyul University consisted of a total of 10 students to evaluate color, Flavor, texture, taste, and overall preference. The rating is on a 5-point scale, with 1 being 'very bad' and 5 being 'very good'. 10 g of the same amount of Korean rice cake stored at refrigerated temperature was served 3 times at 0%, 3%, 6%, 9% and 12%. In order not to affect the evaluation of other samples each time the evaluation was performed, the sample was provided with water, and water was ingested and evaluated for each sample of every evaluation.

Statistical analysis

All tests were performed three times. Descriptive statistics such as mean and standard deviation were calculated to statically analyze the total polyphenol and flavonoid content. To test the statistical significance of the results, a *t*-test was performed.

RESULTS AND DISCUSSION

Physicochemical properties of Jeolpyeon added with *P. tenera*

The water content, pH, chromaticity and Texture of *Jeolpyeon* supplemented with *P. tenera* are shown in Table 1. The water content of the *Jeolpyeon* supplemented with *P. tenera*was 46.45±0.76 when *P. tenera* content was 0%, while it was 49.53±0.30 (p<0.01), 51.95±0.10 (p<0.001), 51.59±0.26 (p<0.001) and 56.09±0.13 (p<0.001) at 3%, 6%, 9% and 12%. Therefore, it was found that the moisture content increased significantly as the *P. tenera* content increased. The same result was also shown in the study of *Jeolpyeon* with *Capsosiphon fulvescens*, *Julpyun* added with Cuccibbong (*Cudrania tricuspidata*) Fruit Puree. This is thought to be because the moisture content of the added subsidiary material affects *Jeolpyeon*(Choi and Choi, 2019; Lim et al., 2021). The pH was 6.84±0.02 when the *P. tenera* content was 0%, while it was 6.80±0.01(p<0.05), 6.81±0.01 (p<0.05), 6.80±0.01 (p<0.05) and 6.84±0.02 at 3%, 6%, 9%, and 12% respectively, thus showing a decrease, increase, and decrease again. In the *Capsosiphon fulvescens Jeolpyeon* study, both the control group and the samples with different amounts of *Capsosiphon fulvescens* showed similar pH, showing a similar trend as in this study (Lim et al., 2021).

The *L* value was 87.4±1.4 when the *P. tenera* content was 0%, while it was 76.2±0.5 (p<0.001), 67.2±0.5 (p<0.001), 68.4±1.5 (p<0.001) and 63.2±1.6 (p<0.001) at 3%, 6%, 9% and 12%, each appeared to decrease. In the study of *Capsosiphon fulvescens Jeolpyeon* and *Eucommia* Early Leaves *Jeolpyeon*, the brightness showed the highest value in the control group and decreased significantly as the amount of addition increased (Kim and Kwon, 2018; Lim et al., 2021). This can be considered to indicate that the brightness of *Jeolpyeon* is lowered as the brightness of *Jeolpyeon* is darkened due to the color of the added subsidiary material.

The *a* value, which indicates redness, was -1.0±0.4 when the *P. tenera* content was 0% while it was -0.8±0.1, -0.6±0.1, -0.7±0.1 and -0.3±0.1 (p<0.05) at 3%, 6%, 9% and 12% respectively, It appeared to increase, but then decreased and increased again. A value was also significantly increased in ganache added with *P. tenera* powder, and it was caused by chlorophyll and carotenoids contained in seaweed (Choe and Oh, 2013; Park et al., 2020). It is considered that the a value of laver, a red algae, increases as the amount of laver added increases under the influence of red pigment.

The *b* value, which indicates yellowness was 5.1±0.4, when the *P. tenera* content was 0%, while it was 13.4±0.8 (p<0.001), 14.4±0.7 (p<0.001), 15.3±0.5 (p<0.001) and 16.2±0.4 (p<0.001) at 3%, 6%, 9% and 12%, respectively, It was found that the b value increased as the *P. tenera* content increased. In Jeolpyeon containing *Cuccibbong* (*Cudrania tricuspidata*) Fruit Puree *Julpyun* and *Capsosiphon fulvescens*, it increased significantly as the amount of *Capsosiphon fulvescens* increased (Choi and Choi, 2019; Lim et al., 2021).

A total of six textures were tested for Hardness, Cohesiveness, Springness, Gumminess, Chewinness, and Adhesiveness. The Hardness 0.52±0.03 when the *P. tenera* content was 0%, while it was 0.42±0.04 (p<0.05), 0.28±0.01 (p<0.001), 0.40±0.04 (p<0.05) and 0.65±0.03 (p<0.01) at 3%, 6%, 9% and 12%. Hardness was highest in the control group and decreased with increasing concentration.

The Cohesiveness 0.60±0.01 when the *P. tenera* content was 0%, while it was 0.50±0.06 (p<0.05), 0.58±0.08, 0.60±0.06

Table 1: Changes in water content, pH, chromaticity and texture of Jeolpyeon supplemented with Laver, *Porphyra tenera*

	Concentration (%)				
	0	3	6	9	12
Water content[1]	46.45±0.76	49.53±0.30**	51.95±0.10***	51.59±0.26***	56.09±0.13***
pH[1]	6.84±0.02	6.80±0.01*	6.81±0.01*	6.80±0.01*	6.84±0.02
L	87.40±1.40	76.2±0.50***	67.20±0.50***	68.40±1.50***	63.2±1.60***
a	-1.00±0.40	-0.80±0.10	-0.60±0.10	-0.70±0.10	-0.30±0.10*
Chromaticity[1] b	5.10±0.40	13.4±0.80***	14.40±0.70***	15.30±0.50***	16.2±0.40***
w	72.20±2.20	36.0±2.70***	24.10±2.10***	22.50±3.10**	14.50±2.30***
c	5.20±0.50	13.40±0.80***	14.40±0.70***	15.30±0.50***	16.20±0.40***
h	100.60±3.30	93.50±0.30*	92.50±0.50*	92.50±0.10*	90.80±0.30**
Hardness	0.52±0.03	0.42±0.04*	0.28±0.01***	0.40±0.04*	0.65±0.03**
Cohesiveness	0.60±0.01	0.50±0.06*	0.58±0.08	0.60±0.06	0.57±0.03**
Springness	1.00±0.00	1.00±0.00	1.00±0.00	1.00±0.00	1.01±0.03
Gumminess	0.31±0.02	0.21±0.04**	0.16±0.02***	0.24±0.01**	0.37±0.02**
Chewiness	0.31±0.02	0.21±0.04**	0.16±0.02***	0.24±0.01**	0.37±0.02*
Adhesiveness	0.16±0.07	0.13±0.05	0.10±0.01	0.14±0.02	0.30±0.01*

1) Mean±SD
* p<0.05 : Means in a column are significantly different at 5% significance level by *t-test*.
** p<0.01 : Means in a column are significantly different at 1% significance level by *t-test*.
***p<0.001 : Means in a column are significantly different at 0.1% significance level by *t-test*.

and 0.57±0.03 (p<0.01) at 3%, 6%, 9% and 12%. It seemed to decrease, but it increased at 6% and then decreased again at 12%. The Springness 1.00±0.00 when the *P. tenera* content was 0%, while it was 1.00±0.00, 1.00±0.00, 1.00±0.00 and 1.01±0.03 at 3%, 6%, 9% and 12%. It was the same up to 3%, 6%, and 9% including the control group, but increased at 12%. The Gumminess 0.31±0.02 when the *P. tenera* content was 0%, while it was 0.21±0.04 (p<0.01), 0.16±0.02 (p<0.001), 0.24±0.01 (p<0.01) and 0.37±0.02 (p<0.01) at 3%, 6%, 9% and 12%. It seemed to decrease, but it was found to increase again from 6%. The Chewinness 0.31±0.02 when the *P. tenera* content was 0%, while it was 0.21±0.04 (p<0.01), 0.16±0.02 (p<0.001), 0.24±0.01 (p<0.01) and 0.37±0.02 (p<0.05) at 3%, 6%, 9% and 12%. It seemed to decrease, but it was found to increase again from 9%. The Adhesiveness 0.16±0.07 when the *P. tenera* content was 0%, while it was 0.13±0.05, 0.10±0.01, 0.14±0.02 and 0.30±0.01 (p<0.05) at 3%, 6%, 9% and 12%. There was a difference according to the *P. tenera* content, and it increased again from 9%, and 12% showed the highest value.

Analysis of total phenol and flavonoid contents in Jeolpyeon supplemented with *P. tenera*

The total phenol and flavonoid content of *Jeolpyeon* supplemented with *P. tenera* are shown in Table 2. The total phenol content was 31.38±0.54 at 0%, while it was 40.80±2.14 (p<0.01), 49.18±0.68 (p<0.001), 55.04±0.27 (p<0.001) and 55.78±2.09 (p<0.001) at 3%, 6%, 9% and 12%, respectively, and the total polyphenol contents increased significantly with the increase of the *P. tenera* content. As confirmed by this experiment, it is determined that antioxidant efficacy can be expected when fresh *P. tenera* is added. The total flavonoid content was shown to be N.D. in 3% and 6% including the control group, but was significantly increased by 13.27±5.11 (p<0.01) in 12%. Experimental results confirmed that *P. tenera Jeolpyeon* has polyphenol and flavonoid content, suggesting that it has antioxidant properties. Red seaweeds including Laver are reported to be rich in phenolic compounds such as catechin, phlorotanin, and fucoxanthin, confirming their antioxidant activity (Yan et al., 1996; Yan et al., 1999; Ganesan et al., 2008). In addition, it was confirmed that the total polyphenols and flavonoids were significantly increased in the study of cookies and ganache by adding the same substances as in this experiment (Hwang and Tai, 2014; Lee et al., 2017; Park et al., 2020). Therefore, the total phenol content and flavonoids in this experiment were confirmed to have antioxidant function, suggesting that they are closely related.

Antioxidant effect of Jeolpyeon supplemented with *P. tenera*

The experimental results of ABTS methods are shown in Table 3. The antioxidant ef-fect measured by ABTS method was 4.81±0.71 when the concentration of *P. tenera* was 0%, while it was 4.36±1.45 (p<0.001), 9.50±1.70 (p<0.001), 18.89±1.42 (p<0.001) and 37.24±1.79 (p<0.001) at 3%, 6%, 9% and 12%, showing a significant increase compared to 0%. In the study of bergamot (*Citrus bergamia*), Habanero pepper (*Capsicum chinense* Jacq.) extra virgin olive oil, the ABTS experiment showed that it had antioxidant properties (Giuffrè et al., 2018; Giuffrè et al., 2019; Valencia- Cordova et al., 2021). In addition, as a result of an experiment using a substance similar to this study, it was confirmed that the ABTS activity increased significantly as the amount of laver added increased (Hwang and Tai, 2014; Lee et al., 2017; Park et al., 2020). Therefore, this experiment of *P. tenera Jeolpyeon* was confirmed to have antioxidant function. Because our body has antioxidant enzymes, it plays a role in protecting skin cells, cell membranes, and intracellular substances from oxidative damage caused by free radicals. However, as the antioxidant enzyme decreases rapidly with age and the ability to respond to free radicals and lipid peroxide decreases, body organs and cells gradually decline (Hong,

Table 2: Total phenol and total flavonoid contents of *Jeolpyeon* supplemented with *Laver, Porphyra tenera*

	Concentration (%)				
	0	3	6	9	12
Total phenol[1]	31.38±0.54	40.80±2.14**	49.18±0.68***	55.04±0.27***	55.78±2.09***
Total flavonoid[1]	N.D.[#]	N.D.	N.D.	3.23±5.38	13.27±5.11**

1) Mean±SD
[#]N.D. : Not Detected
*p<0.05 : Means in a column are significantly different at 5% significance level by *t-test*.
***p<0.001 : Means in a column are significantly different at 0.1% significance level by *t-test*.

Table 3: Antioxidant effect of *Jeolpyeon* supplemented with *Laver, Porphyra tenera*

	Concentration (%)				
	0	3	6	9	12
ABTS (%)[1]	4.81±0.71	4.36±1.45	9.50±1.70*	18.89±1.42**	37.24±1.79***

1) Mean±SD
**p<0.01 : Means in a column are significantly different at 1% significance level by *t-test*.
***p<0.001 : Means in a column are significantly different at 0.1% significance level by *t-test*.

Table 4: Sensory evaluation of *Jeolpyeon* supplemented with *Laver, Porphyra tenera*

	Concentration (%)				
	0	3	6	9	12
Color[1]	3.6±0.1	3.03±0.12**	3.13±0.15*	3.6±0.2	3.87±0.12*
Flavor[1]	2.9±0.1	3.03±0.06*	3.03±0.12	3.4±0.17**	3.27±0.15
Texture[1]	3.23±0.21	2.97±0.23	3.17±0.06	3.53±0.23	3.63±0.15
Taste[1]	2.93±0.29	3.17±0.15	3.07±0.06**	3.53±0.25	3.33±0.21
Overall preference[1]	2.97±0.25	3.10±0.10	3.03±0.06	3.50±0.1	3.57±0.25

1) Mean±SD
*p<0.05 : Means in a column are significantly different at 5% significance level by t-test.
**p<0.01 : Means in a column are significantly different at 1% significance level by t-test.

2009). Among polyphenols and flavonoids, which are known as representative antioxidants, polyphenols are good for preventing aging due to their antioxidant action because they change free radicals in our body into harmless substances. It is also reported to lower the risk in a variety of diseases because it has an excellent ability to protect cell building proteins and enzymes, including DNA damaged by exposure to free radicals (Bravo, 1998). Flavonoid has the effect of preventing and delaying aging because it prevents oxidative stress by removing lipid oxidation and free radicals (Lee et al., 2007; Kim et al., 2014). Accordingly, an increasing number of consumers are consuming beauty and pharmaceutical products, including foods with antioxidant functions, in order to live a long, healthy life and maintain youthfulness, and research using antioxidants is being actively conducted.

Sensory evaluations of Jeolpyeon supplemented with *P. tenera*

Results of the sensory evaluation are shown in Table 4. Evaluation items were evaluated for color, flavor, texture, taste, and overall preference. In this experiment, the *P. tenera* addition amount was set to 0%, 3%, 6%, 9%, and 12%. As a result, the higher the *P. tenera* content, the higher the preference for appearance, and the sample with 9% added flavor showed the highest perference. Preference for texture was highest when *P.tenera* was added upto 12%, and the taste was most preferred with *P.tenera* added by 9%. The overall preference, including total color, aroma, texture, and taste, was found to be the most preferred with *P.tenera* added by 12%. Therefore, by the data on the efficacy and overall preference with *P.tenera*, it is desirable to add *P.tenera* upto 12% to make it buyable as a health functional food.

CONCLUSION

In this paper, quality characteristics, total polyphenols, flavonoids, ABTS and preference of *Jeolpyeon* containing *P. tenera*were investigated. As a result of the experiment, polyphenols with antioxidant properties were significantly increased, but there was no significant difference between 9% and 12%, and flavonoids were confirmed to be increased at 12%.The experimental results of ABTS radical scavenging activity of *Jeolpyeon* with *P. tenera*added showed that 3% of the sample was lower than that of the control group, but it was gradually increased at 6%. As a result of sensory evaluation, color, texture, and overall preference were 12% higher, and flavor and taste were 9% higher. As a result of looking at antioxidant functionality and preference, it is considered that the section containing 12% of *P. tenera*is the most suitable. *Jeolpyeon* with *P. tenera* used in this study supplements nutrients that may be lacking in rice, the main ingredient of rice cakes, and as the number of consumers who want to live a health-oriented life increases, it is expected to become a health functional food. In addition, *P. tenera* is an ingredient that is of interest in the West, and it is thought that it will be widely known and enjoyed by foreigners by adding it to *Jeolpyeon*, a traditional Korean food.

Funding

This research received no external funding.

ACKNOWLEDGMENTS

We would like to acknowledge our colleagues in Major of Rice Cake Manufacturing Management, Department of Business Administration, Graduate School, Sungkyul University, Anyang, Republic of Korea.

Conflice of interest

The authors declare no conflict of interest.

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