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RESEARCH ARTICLE

Potential anti-oxidative properties and quality characteristics of korean traditional rice cake added with pistachio (*Pistacia vera* L.) as inner beauty material

Ji Ahn Han[1], Ki Han Kwon[2,*]

[1]Major of Rice Cake Manufacturing Management, Department of Business Administration, Graduate School, Sungkyul University, Gyeonggi-do 14097, Republic of Korea, [2]College of General Education, Kookmin University, Seoul 02707, Republic of Korea

ABSTRACT

In modern society, interest in health is increasing, and more consumers are taking care of their health due to COVID-19. As a result, immunity enhancement and antioxidant foods help to promote health, and the intake rate is increasing. Therefore, the purpose of this study was to investigate quality characteristics and antioxidant activity by adding 0%, 3%, 6%, 9% and 12% pistachios to rice cake, a traditional Korean food. The moisture content and pH decreased as the amount of pistachio added and the chromaticity L and a values tended to decrease, but the b values increased. It was confirmed that the polyphenol, ABTS a DPPH significantly increased as the amount of pistachio added increased. As a result of confirming the functionality and overall preference, it is suggested that the 9% content is the best, and this experiment is expected to improve the quality of rice cake and improve the nutritional balance, so that it can become an antioxidant functional food. As far as we know, it is the first study to prove that pistachios and rice cakes are combined, suggesting that rice cakes with added pistachios, a physiologically active substance, are healthful foods.

Key words: Pistachio (*Pistacia vera* L.); Korean rice cake; Anti-oxidative properties; Inner beauty material

INTRODUCTION

In modern society, as the perception of dietary life changes, more and more consumers are thinking about their health. Foods with high fat and sugar content and flour foods were frequently consumed, but now they are changing to a high protein, low sugar, and low salt diet. Accordingly, the demand of slow food is increasing rather than fast food, and consumption of healthy food is increasing due to changes in food culture trends such as well-being food and ethnic food. Wheat contains gluten, an insoluble protein, which makes people with celiac disease unable to absorb nutrients secondary to inflammation. People suffering from celiac disease have symptoms such as abdominal pain and diarrhea due to damage to the lining of the intestine when eating flour food. It is said that the overreaction of the immune system caused by protein causes symptoms such as shortness of breath and rhinitis, which can be life-threatening due to changes in heart rate and loss of consciousness (Kupfer and Jabri, 2012; Catassi et al., 1994). Although the number of people with symptoms varies from country to country, it is estimated that patients with celiac disease will be in the range of about 0.3 to 1%, and those with potential will be around 10 to 15% (Jeremy, 2007). Rice is used as a staple food in many countries, including Asia and Southeast Asia, as well as Korea, and is counted as one of the world's three largest food resources, including wheat and corn (Ahn and Ha, 2010). There may be some differences in rice depending on the variety and growing area. White rice is a small amount other than starch, but contains protein, fat, fiber, iron, phosphorus, ash, minerals, calcium, and vitamins B1 and B2 (Mahender et al., 2016). Rice is a complex carbohydrate, and because it secretes a lot of lipase, it promotes fat breakdown, gives a feeling of satiety, slows digestion and absorption, and prevents blood sugar from rising rapidly. Therefore, it is said to be effective in preventing obesity, high blood pressure and diabetes. Antioxidants in rice include polyphenol compounds such as caffeic acid, ferulic acid, p-coumaric acid, and sinapic acid anthocyanin compounds. And it is emerging as a health food material that is effective for improving liver function, antioxidant activity, cholesterol lowering, antithrombotic

***Corresponding author:**
Ki Han Kwon, College of General Education, Kookmin University, Seoul 02707, Republic of Korea. **E-mail**: kihan.kwon@kookmin.ac.kr

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effect, antihypertension, blood sugar improvement, and preventing chronic diseases (Ahn and Ha, 2010; Ardiansyah et al., 2006; Qureshi et al., 2000). Therefore, unlike wheat, it does not cause problems such as gluten intolerance and celiac disease, and has nutrition and efficacy, so it is considered to be a good substitute for wheat.Pistachio is a type of nut and is a member of the Anacardiaceae family, originated in Central and West Asia, and has excellent resistance, so it can live in extreme environments such as hot, dry drought or salty conditions (Behboudian et al., 1989; Bellomo and Fallico, 2007). Pistachios are grown in Syria, Iran, Greece, Italy, Turkey, China, and the United States (Arizona, New Mexico, California) (Bellomo and Fallico, 2007; (FAO 1997); Gentile et al., 2007). Pistachio is green and purple due to lutein and anthocyanin content, and contains concentrations of thiamine, pyridoxine, γ-tocopherol, mainly carotene lutein, and zeaxanthin. (Dreher, 2012; Bullo´ et al., 2015; Stuetz et al., 2017; Alasalvar and Bolling, 2015). High in protein, dietary fiber, monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), polyphenol, phytosterol, xanthophyll carotenoid, flavonoid, proanthocyanidin, flavonol, flavanone, isoflavone, stilbene. As important phenolic acid and hydrolyzable tannin antioxidants, the chemoprotective and cardioprotective properties of cancer have been reported (Bullo´et al., 2011; Bolling et al., 2011). Pistachios contain adequate amounts of all essential amino acids, so FAO and WHO have reported that they can meet the recommended intake of essential amino acids for adults. In addition, it is rich in potassium among minerals and exhibits high bioavailability of phosphorus, magnesium, calcium, vitamin A, vitamin E, vitamin C, vitamin K, vitamin B, and phytochemicals (Sathe et al., 2009; USDA, 2013; Mandalari et al., 2013; Bullo´ et al., 2015; Schlörmann et al., 2015). Pistachio was recently ranked as the first of the 50 foods with the highest antioxidant potential (Halvorsen et al., 2006). Pistachio, which is also favorite as a snack, has a low sodium content, which helps control appetite, and gives a feeling of satiety, helping to control weight when dieting. In addition, consumption of high-carb white bread, boiled rice, pasta, and mashed potatoes with a high glycemic index, along with pistachios, decreased the total postprandial glycemic response by 20-30% and decreased carbohydrate absorption. Therefore, taking it with meals can help lower saturated fat and cholesterol and reduce the risk of heart disease. Clinical studies have shown that it has beneficial effects on blood lipids, reduces oxidative and inflammatory stress, helps vascular health and blood sugar control, and has antioxidant and anti-inflammatory activity (Josse et al., 2007; Kendall et al., 2011; Dreher, 2012; Musarra-Pizzo et al., 2020). As a result of experiments in animals and humans, daily consumption of pistachio can improve obesity, type 2 diabetes, and metabolic abnormalities. In addition, according to a study, a study found that eating pistachios at least three times a week at the recommended amount per serving lowered the risk of death by 39%, and showed that the mortality rate from cancer and cardiovascular disease was also reduced (Sabatè and Ang, 2009; Carughi et al., 2016; Parham et al., 2013; Ibarrola-Jurado et al., 2013; Guasch-Ferré et al., 2013; Terzo et al., 2018; De Souza et al., 2017;). Therefore, health-conscious consumers are increasing, and now with the spread of COVID-19, more consumers are taking into consideration nutrition and efficacy. In other words, in order to develop rice cake, a traditional Korean food, as a functional food, the purpose of this study is to investigate the quality characteristics and antioxidant activity of rice cake by adding pistachio, which is helpful for high carbohydrates.

MATERIALS AND METHODS

Materials

The rice used in the experiment (Company: Gyodong rice mill) was non-glutinous rice in Ganghwa-gun, Incheon, and was purchased from Garak Alpha Mart in Seokchon-dong in May 2020. Pistachio (Company: Boram Foods, Origin: California, USA) powder was ordered online. Sugar made rice cakes using (CJ Cheiljedang Co., Ltd., Songpa, Republic of Korea) and salt (origin: sea salt, Sinan-gun, Jeollanam-do, Republic of Korea).

Production of Korean Rice cake

Wash rice 5 times and soak for 7 hours, then drain through a sieve for 30 minutes. Put 500 g of rice, 5 g of salt, and pistachio powder in a roll-mill and grind it finely once, then add water and grind it finely again, and then pass it once in 20 mesh. Then add sugar and pass through 20mech 1 time, then put it in a steamer to flatten it, put it on a steamer, cover with a wet cotton cloth, and steam for 8 minutes. After blowing hot steam for 1 minute with a fan, it was packaged using a Daehwan packaging machine (DH-306) and then frozen at -40°C in a two-stage compression rapid freezer. Experiments were carried out under the same conditions, and pistachios were added at concentrations of 0%, 3%, 6%, 9%, and 12%.

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 then taking the supernatant, and then measuring the pH in 3 repetitions per sample with a pH meter (pH-240L, NeoMet, Istek, Seoul, Republic of Korea).

Measurement of chromaticity

After removing the wrapping paper of the sample, using a Minolta chroma meter, the L* value indicating the brightness value, the a* value indicating the redness, and the b* value indicating the yellowness were measured three times, respectively. A standard color plate (Y = 92.8, x = 0.3134, y = 0.3193) was used for standardization of the Minolta chroma meter.

Measurement of texture

After removing the wrapping paper of the sample, it was measured from top to bottom (right angle) using an Instron 3343 (US/MX50, A&D Co., MA, USA) measuring device. Hardness, cohesiveness, springiness, gumminess, chewiness, and adhesiveness were measured three times.

Antioxidant effect of Korean rice cake supplemented with Pistachio

Sample extraction

Rice cake with different pistachio content was ground using a mortar and then weighed 4 g in a 100 ml Erlenmeyer flask. After that, 40 ml of distilled water was added and mixed well. The temperature of the water bath (BS-31, JEIO TECH. CO.,LTD, Seoul, Republic of Korea) was set to 100° C. and the components were extracted by heating for 60 minutes. After centrifuging the extract at 12,000 rpm for 20 minutes (MICRO 17R; Hanil, Incheon, Republic of Korea), the supernatant was taken and used to measure antioxidant activity.

Total phenol and contents

Samples were extracted in the same way as for antioxidant activity. The total polyphenol content was measured by modifying the Folin-Ciocalteau method (Taga et al., 1984). First, Sodium Carbonate (Na_2CO_3) was diluted with distilled water to prepare 700 mM, and 2 N Folin & Ciocalteu's pehnol reagent (47641-100ML-F, Sigma-Aldrich, St Louis, MO, USA) was diluted with 1 N. The sample diluted by concentration was added 100 µl to the test tube, and 1 N Folin & Ciocalteu's phenol reagent was added 200 µl and mixed well. After adding 700 µl of 700 mM Na2CO3, mixing, and reacting at room temperature for 30 minutes, absorbance was measured at 650 nm with a UV spectrophotometer (Optizen POP, Mecasys CO.,LTd, Daejeon, Republic of Korea). For the content of total polyphenol, 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.

Total polyphenol content ($\mu g GAE/g$)

$$\frac{(A-B)}{C} \text{ dilution factor Sampling solvent volume } (ml)$$

$$\div \text{ sample weight } (g)$$

A: Absorbance after reaction of sample solution
B: y rice cake of Gallic Acid Standard Curve
C: Slope of Gallic Acid Standard Curve

Total flavonoid content

Samples were extracted in the same way as for antioxidant activity. The total amount of flavonoid was measured by applying the (Jia et al., 1999) method. In the glass test tube, 125 µl of the sample diluted with different consistencies got 150 µl distilled water and 75 µl of 5% NaNO2 each aliquoted and reacted at room temperature for 6 minutes. After that 10% $AlCl_3$ was aliquoted 150 µl each and reacted at room temperature for 5 minutes. Finally, 1 N NaOH was aliquoted 750 µl each and reacted at room temperature for 15 minutes, and then measured for absorptivity at 492 nm with UV spectrophotometer (Optizen POP, Mecasys CO.,LTd, Daejeon, South Korea).

The total flavonoid amount calibration plot was made with Quercetin (Q4951-10G, Sigma-Aldrich, St Louis, MO, USA) as standard material (0, 0.01625, 0.03125, 0.0625mg/ml) and drew the total flavonoid amount from this.

Total flavonoid content ($\mu g QE/g$)

$$\frac{(A-B)}{C} \text{ dilution factor Sampling solvent volume } (ml)$$

$$\div \text{ sample weight } (g)$$

A: Absorbance after reaction of sample solution
B: y rice cake of Quercetin Standard Curve
C: Slope of Quercetin Standard Curve

ABTS radical scavenging activity

ABTS radical scavenging activity 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 so that the absorbance value was 0.7 at 734 nm. After mixing 190 µl of ABTS solution and 10 µl of 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 following formula.

$$\mathit{ABTS\ Radical\ Scavenging}\ (\%)$$

$$\frac{\begin{array}{c}\text{Control Absorbance}) - \\ \text{(sample sphere absorbance)}\end{array}}{\text{(Contro Absorance)}} \times 100$$

DPPH free-radical scavenging activity

DPPH radical scavenging activity were measured according to the method used (Hatano et al., 1989). In the control group, 12 μl of the solvent from which the extract was extracted, and in the experimental group, 12 μl of each sample, 6 μl of ethanol, and 222 μl of DPPH (0.18 mM 1,1-diphenyl-2-picrylhydrazyl(DPPH)/ethanol) solution were added and mixed. After reacting at room temperature for 30 minutes, absorbance was measured at 517 nm with a Versamax microplate reader (Molecular Devices, California, USA).

$$\textit{DPPH Radical Scavenging}\ (\%) = \frac{(\text{Control Absorbance}) - (\text{sample sphere absorbance})}{(\text{Contro Absorance})} \times 100$$

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%.

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. For statistical processing, Excel 2020 (Microsoft, Redmond, WA, USA) was used. The measurement data was performed by a paired t-test, and statistically significant differences were determined when the significance probability was p<0.05 at the 95% confidence interval.

RESULTS AND DISCUSSION

Physicochemical properties of korean rice cake added with pistachio

The water content, pH, chromaticity and Texture of Korean rice cake supplemented with Pistachio are shown in Table 1. The water content of the Korean rice cake supplemented with pistachio was 38.85±0.03 when pistachio content was 0%, while it was 38.25±0.02 (p<0.001), 36.74±0.03 (p<0.001), 35.68±0.01 (p<0.001) and 33.47±0.02 (p<0.001) at 3%, 6%, 9% and 12% Therefore, it was found that as the pistachio content increased, the moisture content decreased. The pH was 6.73±0.06 when the Pistachio content was 0%, while it was 6.7±0.02, 6.71±0.01, 6.63±0.02 (p<0.05) and 6.58±0.01 (p<0.01) at 3%, 6%, 9%, and 12% respectively, thus showing a decrease, increase, and decrease again. The L value was 85.7±0.2 when the pistachio content was 0%, while it was 78.8±1.2 (p<0.001), 76.5±2 (p<0.001), 73.9±0.9 (p<0.001) and 71.6±1.2 (p<0.001) at 3%, 6%, 9% and 12%, each appeared to decrease. The a value, which indicates redness, was -1.1±0 when the pistachio content was 0% while it was -2.5±0.2 (p<0.001), -2.6±0.4 (p<0.01), -2.9±0.8 (p<0.01) and -2.8±0.2 (p<0.001) at 3%, 6%, 9% and 12% respectively, It showed a tendency to decrease as the addition amount increased. The b value, which indicates yellowness was 5.9±0, when the pistachio content was 0%, while it was 16.8±0.6 (p<0.001), 21.2±0.6

Table 1: Changes in water content, pH, chromaticity and Texture of Rice cake supplemented with Pistachio

	Concentration (%)				
	0	3	6	9	12
Water content1)	38.85±0.03	38.25±0.02***	36.74±0.03***	35.68±0.01***	33.47±0.02***
pH1)	6.73±0.06	6.70±0.02	6.71±0.01	6.63±0.02*	6.58±0.01**
L	85.7±0.20	78.8±1.20***	76.5±2.00***	73.9±0.90***	71.6±1.20***
a	-1.10±0.00	-2.50±0.20***	-2.60±0.40**	-2.90±0.80**	-2.8±0.2***
Chromaticity1)					
b	5.90±0.00	16.8±0.60***	21.20±0.6***	22.9±2.10***	27.6±0.80***
W	68.0±0.10	28.2±3.00***	12.9±3.10***	5.30±5.30**	-11.3±1.80***
c	6.00±0.1	17.0±0.60***	21.3±0.60***	23.0±2.10***	27.8±0.80***
h	101.0±0.20	98.5±0.80**	97.0±1.10**	97.2±1.40**	95.9±0.40***
Hardness	0.51±0.02	0.35±0.01***	0.35±0.02***	0.25±0.03***	0.37±0.01***
Cohesiveness	0.55±0.04	0.62±0.16	0.53±0.10	0.52±0.04	0.49±0.03
Springness	1.03±0.05	1.18±0.15	1.16±0.16	1.01±0.01	1.05±0.09
Gumminess	0.28±0.01	0.22±0.06	0.18±0.03**	0.13±0.01***	0.18±0.01***
Chewiness	0.29±0.02	0.26±0.10	0.22±0.06	0.13±0.01***	0.19±0.00***
Adhesiveness	0.13±0.02	0.08±0.01**	0.09±0.00**	0.06±0.01**	0.11±0.02

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.

(p<0.001), 22.9±2.1 (p<0.001) and 27.6.9±0.08 (p<0.001) at 3%, 6%, 9% and 12%, respectively, It was found that the b value increased as the pistachio content increased. A total of six textures were tested for Hardness, Cohesiveness, Springness, Gumminess, Chewinness, and Adhesiveness. The Hardness 0.51±0.02 when the pistachio content was 0%, while it was 0.35±0.01 (p<0.001), 0.35±0.02 (p<0.001), 0.25±0.03 (p<0.001) and 0.37±0.01 (p<0.001) at 3%, 6%, 9% and 12%. Hardness was the highest in the control group, and it seemed to decrease as the concentration increased, but it was found to increase again by 12%. The Cohesiveness 0.55±0.04 when the pistachio content was 0%, while it was 0.62±0.16, 0.53±0.1, 0.52±0.04 and 0.49±0.03 at 3%, 6%, 9% and 12%. It appeared to increase at 3%, but then decreased again from 6%. The Springness 1.03±0.05 when the pistachio content was 0%, while it was 1.18±0.15, 1.16±0.16, 1.01±0.01 and 1.05±0.09 at 3%, 6%, 9% and 12%. It seemed to increase as the added amount of pistachio increased, but then decreased again. The Gumminess 0.28±0.01 when the pistachio content was 0%, while it was 0.22±0.06, 0.18±0.03 (p<0.01), 0.13±0.01 (p<0.001) and 0.18±0.01 (p<0.001) at 3%, 6%, 9% and 12%. The Chewinness 0.29±0.02 when the pistachio content was 0%, while it was 0.26±0.1, 0.22±0.06, 0.13±0.01 (p<0.001) and 0.19±0 (p<0.001) at 3%, 6%, 9% and 12%. It appeared to decrease, but again increased by 12%. The Adhesiveness 0.13±0.02 when the pistachio content was 0%, while it was 0.08±0.01 (p<0.01), 0.09±0 (p<0.01), 0.06±0.01 (p<0.01) and 0.11±0.02 at 3%, 6%, 9% and 12%. It showed a difference according to the pistachio content and showed a tendency to increase again at 12%.

Analysis of total phenol and flavonoid contents in Korean rice cake supplemented with Pistachio

The total phenol and flavonoid content of Korean rice cake supplemented with pistachio are shown in Table 2. The total phenol con-tent was 40±0.27 at 0%, while it was 92.97±6.18 (p<0.001), 144.88±4.32 (p<0.001), 151.84±2.83 (p<0.001) and 192.53±8.21 (p<0.001) at 3%, 6%, 9% and 12%, respectively, showing a significant increase. It was reported that the total polyphenol content of rice cake without aronia powder was 4.55 mg GAE/g, but the total polyphenol content of rice cake without pistachio powder in this experiment was 40.00 μg GAE/g. Therefore, it was confirmed that there was about a 10-fold difference in the experimental results of this study (Hwang and Hwang, 2015). Another study confirmed the presence of total polyphenols in pistachios, and it was found that the phenol content was low when roasted (Abe et al., 2010). In this experiment, it is considered that the polyphenol content was high by experimenting without roasting. In addition, (Gentile et al., 2007) studies compared raw pistachios with roasted pistachios and reported a loss with reduced phenolic content and antioxidant capacity. Judging from this, there is a difference between raw pistachios and baked pistachios, and it is expected that there may be differences depending on the production area, harvest time, and storage time. Total flavonoid con-tent was 2.95±1.67 at 0%, while it was -9.6±1.67 (p<0.001), 1±3.48, 3.51±2.56 and 2.67±6.76 at 3%, 6%, 9% and 12%. Although the flavonoid content was rather low, the pistachio rice cake containing 9% showed the highest. In another study, flavonoid (mg CEb/gDW pistachio hull) was 28.59 ± 0.54, but it was slightly different from this experiment (Seifzadeh et al., 2018) Although the level of flavonoids was rather low even with the increase of the pistachio content, the high polyphenol content suggests that it has an antioxidant function. Nuts are good food for people of all ages and all over the world, and are recommended to be consumed as one of the world's top 10 superfoods. Among nuts, pistachios have a very low glycemic index, and recent clinical studies show that adding pistachios to high glycemic index rice, pasta, and potatoes helps to control blood sugar after a meal (Kendall et al., 2011).

Antioxidant effect of Korean rice cake supplemented with pistachio

The experimental results of ABTS and DPPH methods are shown in Table 3.The antioxidant ef-fect measured

Table 2: Total phenol and total flavonoid contents of rice cake supplemented with Pistachio

	Concentration (%)				
	0	3	6	9	12
Total phenol[1)]	40.0±0.27	92.97±6.18***	144.88±4.32***	151.84±2.83***	192.53±8.21***
Total flavonoid[1)]	2.95±1.67	-9.6±1.67***	1±3.48	3.51±2.56	2.67±6.76

1) Mean±SD
*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 rice cake supplemented with Pistachio

	Concentration (%)				
	0	3	6	9	12
ABTS (%)[1)]	3.14±0.34	8.14±0.74***	10.67±0.35***	11.79±1.18***	19.4±0.7***
DPPH (%)[1)]	7.81±1.45	9.78±1.46	13.25±1.64*	13.4±1.36**	16.46±1.35**

1) Mean±SD
*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 4: Sensory evaluation of rice cake supplemented with Pistachio.

	Concentration (%)				
	0	3	6	9	12
Color1)	2.37±0.12	3.53±0.15***	3.70±0.10***	4.13±0.06***	3.93±0.06***
Flavor1)	2.90±0.10	3.33±0.06***	3.77±0.06***	3.87±0.06***	3.67±0.06***
Texture1)	3.17±0.12	3.63±0.23*	3.77±0.12***	3.93±0.15***	3.33±0.12*
taste1)	3.07±0.10	3.37±0.12*	3.57±0.25*	3.73±0.21**	3.60±0.10**
Overall preference1)	3.07±0.12	3.37±0.15*	3.70±0.17**	3.90±0.10***	3.63±0.06***

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.

by ABTS method was 3.14±0.34 when the concentration of pistachio was 0%, while it was 8.14±0.74 ($p<0.001$), 10.67±0.35 ($p<0.001$), 11.79±1.18 ($p<0.001$) and 19.4±0.7 ($p<0.001$) at 3%, 6%, 9% and 12%, showing a significant increase compared to 0%. With the DPPH method, the antioxidant effect was 7.81±1.45 at 0%, while it was 9.78±1.46, 13.25±1.64 ($p<0.05$), 13.4±1.36 ($p<0.01$) and 16.46±1.35 ($p<0.01$) at 3%, 6%, 9% and 12%, showing a significant increase compared to 0%. The antioxidant activity of pistachio extract was analyzed as it was associated with oxidative damage in cancer and neurodegenerative diseases. Regarding the active oxygen scavenging activity of the extract, the DPPH (67.95 ± 1.13 ~ 80.55 ± 0.12%) and ABTS (86.92 ± 0.10 ~ 92.04 ± 1.06 %) of the pistachio red peel extract were found to have significantly higher levels and were found to have a strong effect (Gezici, 2019). In addition, a study of antioxidants in wheat bread using the nuts walnuts and hazelnuts found that polyphenols, flavonoids and ABTS levels increased with increasing amounts added (Pycia and Ivanišová, 2020). Although rice has an antioxidant function, it is expected that it will be in the spotlight as a functional health food by adding nut pistachio, a physiologically active substance, and it is suggested that it will be good as a meal replacement or snack. In addition, it can be said that it is a food that people suffering from gluten intolerance can eat comfortably.

Sensory evaluations of Korean rice cake supplemented with Pistachio

Table 4 shows the sensory evaluation results of Korean rice cake added with Pistachio. Evaluation items were evaluated for color, flavor, texture, taste, and overall preference. According to the results of our study, the preference for appearance increased as the pistachio content increased, and the sample added with 9% showed the highest preference.

CONCLUSION

Therefore, in this paper, quality characteristics, antioxidant experiments, and preference surveys of pistachio-added rice cakes were conducted. As a result of the experiment by adding pistachios to rice cakes, polyphenols with antioxidant properties were found to be high, but flavonoids were found to be low. In addition, the polyphenol, ABTS, and DPPH antioxidant function test results of pistachio-added rice cake showed that there was not much difference between 6% and 9%, but there was a large difference between 3% and 6% and 9% and 12%. As a result of sensory evaluation, color, flavor, texture, taste, and overall preference all showed that rice cakes containing 9% pistachios were the most preferred. The rice cake with added pistachio used in this study is expected to be a health functional food due to a change in health-oriented thinking. Rice, the main ingredient of rice cake, is carbohydrate and has high blood sugar, but adding pistachio can be an advantage in blood sugar control. In addition, it is suggested that foreigners can enjoy rice cake, a traditional Korean food with added pistachio.

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Conflice of Interest

The authors declare no conflict of interest.

REFERENCES

Abe, L. T., F. M. Lajolo and M. I. Genovese. 2010. Comparison of phenol content and antioxidant capacity of nuts. Food Sci. Technol. 30: 254-259.

Ahn, J. Y. and T. Y. Ha. 2010. Nutritional superiority of Korean rice. Food Preserv. Proc. Ind. 9: 60-64.

Ardiansyah., H. Shirakawa, T. Koseki, K. Ohinata, K. Hashizume and M. Komai. 2006. Rice bran fractions improve blood pressure, lipid profile, and glucose metabolism in stroke-prone spontaneously hypertensive rats. J. Agric. Food Chem. 54: 1914-1920.

Ardiansyah, H. Shirakawa, T. Koseki, K. Ohinata, K. Hashizume and M. Komai. 2006. Rice bran fractions improve blood pressure, lipid profile, and glucose metabolism in stroke-prone spontaneously hypertensive rats. J. Agric. Food Chem. 54: 1914-1920.

Behboudian, M. H., R. R. Walker and E. Törökfalvy. 1986. Effects of water stress and salinity on photosynthesis of pistachio. Sci. Hortic. 29: 251-261.

Bellomo, M. G. and Fallico, B. 2007. Anthocyanins, chlorophylls and xanthophylls in pistachio nuts (*Pistacia vera*) of different geographic origin. J. Food Compost. Anal. 20: 352-359.

Bolling, B. W., C. Y. O. Chen, D. L. McKay and J. B. Blumberg. 2011. Tree nut phytochemicals: composition, antioxidant capacity, bioactivity, impact factors. A systematic review of almonds, Brazils, cashews, hazelnuts, macadamias, pecans, pine nuts, pistachios and walnuts. Nutr. Res. Rev. 24: 244-275.

Bullo, M., M. Juanola-Falgarona, P. Herna´ndez-Alonso and J. Salas-Salvado. 2015. Nutriton attributes and health effects of pistachio nuts. Br. J. Nutr. 113: S79-S93.

Bullo, M., R. Lamuela-Raventós and J. Salas-Salvadó. 2011. Mediterranean diet and oxidation: Nuts and olive oil as important sources of fat and antioxidants. Curr. Top. Med. Chem. 11: 1797-1810.

Carughi, A., M. J. Feeney, P. Kris-Etherton, V. Fulgoni, C. W. C. Kendall, M. Bulló and D. Webb. 2016. Pairing nuts and dried fruit for cardiometabolic health. Nutr. J. 15: 23.

Catassi, C., I. M. Rätsch, E. Fabiani, M. Rossini, F. Bordicchia, F. Candela, G. V. Coppa and P. L. Giorgi. 1994. Coeliac disease in the year 2000: Exploring the iceberg. Lancet. 343: 200-203.

De Souza, R. G. M., R. M. Schincaglia, G. D. Pimente and J. F. Mota. 2017. Nuts and human health outcomes: A systematic review. Nutrients. 9: 1311.

Dreher, M. L. 2012. Pistachio nuts: composition and potential health benefits. Nutr. Rev. 70: 234-240.

FAO. 1997. FAOSTAT Statistical Database. Food and Agriculture Organization, Rome, Italy.

Gentile, C., L. Tesoriere, D. Butera, M. Fazzari, M. Monastero, M. Allegra and M. A. Livrea. 2007. Antioxidant activity of sicilian pistachio (*Pistacia vera* L. Var. Bronte) nut extract and its bioactive components. J. Agric. Food Chem. 55: 643-648.

Gezici, S. 2019. Cancer preventive and neuroprotective potentials of red hulls, kernels and oleo-gum resins from Pistachio. Int. J. Agric. Environ. Food Sci. 3: 137-143.

Guasch-Ferré, M., M. Bulló, M. Á. Martínez-González, E. Ros, D. Corella, R. Estruch, M. Fitó, F. Arós, J. Wärnberg, M. Fiol, J. Lapetra, E. Vinyoles, R. M. Lamuela-Raventós, L. Serra-Majem, X. Pintó, V. Ruiz-Gutiérrez, J. Basora and J. Salas-Salvadó. 2013. Frequency of nut consumption and mortality risk in the PREDIMED nutrition intervention trial. BMC Med. 11: 164.

Halvorsen, B. L., M. H. Carlsen, K. M. Phillips, S. K. Bøhn, K. Holte, D. R. Jacobs and R. Blomhoff. 2006. Content of redox-active compounds (ie, antioxidants) in foods consumed in the United States. Am. J. Clin. Nutr. 84: 95-135.

Hatano, T., R. Edamatsu, M. Hiramatsu, A. Mori, Y. Fujita, T. Yasuhara and T. Okuda. 1989. Effects of the interaction of tannins with co-existing substances. VI.: Effects of tannins and related polyphenols on superoxide anion radical, and on 1, 1-Diphenyl-2-picrylhydrazyl radical. Chem. Pharm. Bull. 37: 2016-2021.

Hwang, Y. R. and E. S. Hwang. 2015. Quality characteristics and antioxidant activity of Sulgidduk prepared by addition of aronia powder (*Aronia melanocarpa*). Korean J. Food Sci. Technol. 47: 452-459.

Ibarrola-Jurado, N., M. Bulló, M. Guasch-Ferré, E. Ros, M. A. Martínez-González, D. Corella, M. Fiol, J. Wärnberg, R. Estruch, P. Román, F. Arós, E. Vinyoles, L. Serra-Majem, X. Pintó, M. Covas, J. Basora and J. Salas-Salvadó. 2013. Crosssectional assessment of nut consumption and obesity, metabolic syndrome and other cardiometabolic risk factors: The PREDIMED study. PLoS One. 8: e57367.

Jeremy, W. 2007. Coeliac disease. Medicine. 35: 226-230.

Jia, Z., M. Tang and J. Wu. 1999. The determination of flavonoid contents in mulberry and they scavenging effects on super-oxide radicals. Food Chem. 64: 555-559.

Josse, A. R., C. W. Kendall, L. S. Augustin, P. R. Ellis and D. J. Jenkins. 2007. Almonds and postprandial glycemia-a doseresponse study. Metabolism. 56: 400-404.

Kendall, C. W. C., A. R. Josse, A. Esfahani and D. J. A. Jenkins. 2011. The impact of pistachio intake alone or in combination with high-carbohydrate foods on post-prandial glycemia. Eur. J. Clin. Nutr. 65: 696-702.

Kupfer, S. S. and B. Jabri. 2012. Pathophysiology of celiac disease. Gastrointest. Endosc. Clin. N. Am. 22: 639-660.

Mahender, A., A. Anandan, S. K. Pradhan and E. Pandit. 2016. Rice grain nutritional traits and their enhancement using relevant genes and QTLs through advanced approaches. *Springerplus*. 5: 2086.

Mandalari, G., C. Bisignano, A. Filocamo, S. Chessa, M. Sarò, G. Torre, R. M. Faulks and P. Dugo. 2013. Bioaccessibility of pistachio polyphenols, xanthophylls, and tocopherols during simulated human digestion. Nutrition. 29: 338-344.

Musarra-Pizzo, M., R. Pennisi, I. Ben-Amor, A. Smeriglio, G. Mandalari and M. T. Sciortino. 2020. *In vitro* Anti-HSV-1 activity of polyphenol-rich extracts and pure polyphenol compounds derived from pistachios kernels (*Pistacia vera* L.). Plants. 9: 267.

Parham, M., S. Heidari, A. Khorramirad, M. Hozoori, F. Hosseinzadeh, L. Bakhtyari and J. Vafaeimanesh. 2013. Effects of pistachio nut supplementation on blood glucose in patients with Type 2 diabetes: a randomized crossover trial. Rev. Diabet. Stud. 11: 190-196.

Pycia, K. and E. Ivanišová. 2020. Physicochemical and antioxidant properties of wheat bread enriched with hazelnuts and walnuts. Foods. 9: 1081.

Qureshi, A. A., H. Mo, L. Packer and D. M. Peterson. 2000. Isolation and identification of novel tocotrienols from rice bran with hypocholesteroleic, antioxidant, and antitumor properties. J. Agric. Food Chem. 48: 3130-3140.

Re, R., N. Pellegrini, A. Proteggente, A. Pannala, M. Yang and C. Rice-Evans. 1999. Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radic. Biol. Med. 26: 1231-1237.

Sabatè, J. and Y. Ang. 2009. Nuts and health outcomes: new epidemiologic evidence. Am. J. Clin. Nutr. 89: 1643S-1648S.

Sathe, S. K., E. K. Monaghan, H. H. Kshiesagar and M. Venkatachalam. 2009. Chemical composition of edible nut seeds and its implications in human health. In: C. Alsalvar and F. Shahidi (Eds.), Tree Nuts Composition, Phytochemicals and Health Effects. Taylor and Francis Group, Florida, USA. pp. 12-29.

Schlörmann, W., M. Birringer, V. Böhm, K. Lober, G. Jahreis, S. Lorkowski, A. K. Müller, F. Schöne and M. Glei. 2015. Influence of roasting conditions on health-related compounds in different nuts. Food Chem. 180: 77-85.

Seifzadeh, N., M. A. Sahari, M. Barzegar and H. A. Gavlighi. 2018. Concentration of pistachio hull extract antioxidants using membrane separation and reduction of membrane fouling during process. Food Sci. Nutr. 6: 1741-1750.

Stuetz, W., W. Schlormann and M. Glei. 2017. B-vitamins, carotenoids and α-/γ-tocopherol in raw and roasted nuts. Food Chem. 221: 222-227.

Taga, M. S., E. E. Miller and D. E. Pratt. 1984. Chia seeds as a source of natural lipid antioxidants. JAOCS. 61: 928-999.

Terzo, S., G. F. Caldara, V. Ferrantelli, R. Puleio, G. Cassata, F. Mulè and A. Amato. 2018. Pistachio consumption prevents and improves lipid dysmetabolism by reducing the lipid metabolizing gene expression in diet-induced obese mice. Nutrients. 10: E1857.

USDA. 2013. USDA National Nutrient Database for Standard Reference, Release. U.S. Department of Agriculture ARS.